OCTOBER 2018, REVISED JANUARY 2019

SANTA MARGARITA RIVER
WATERSHED MANAGEMENT AREA

Water Quality Improvement Plan

Submitted by

COUNTY OF RIVERSIDE, COUNTY OF SAN DIEGO, RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT, CITIES OF MENIFEE, MURRIETA, TEMECULA, AND WILDOMAR

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CERTIFICATION STATEMENT

SANTA MARGARITA RIVER WATERSHED MANAGEMENT AREA
WATER QUALITY IMPROVEMENT PLAN

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

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Santa Margarita Watershed Management Area
Water Quality Improvement Plan

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Appendix 4B – Watershed Management Area Analysis

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Appendix 5B – Santa Margarita Region Hydromodification Management Plan

Appendix 5C – County of San Diego Hydromodification Management Plan

Appendix 5D – Consolidated Monitoring Plan Volume II, Quality Assurance Project Plan

Appendix 5E – Toxicity Identification Evaluation /Toxicity Reduction Evaluation Implementation Work Plan

Appendix 5F – San Diego County Municipal Copermittees Sediment Monitoring Plan-Final

Appendix 5G – Riverside County Flood Control & Water Conservation District Low Impact Development (LID) Demonstration Facility Monitoring Plan and Quality Assurance Project Plan (QAPP)

List of Acronyms

AWM	Agriculture, Weights, and Measures Department
BMI	Benthic Macro-Invertebrate
BMP	Best Management Practice
BURC	Beneficial Use Risk Category
CA	California
CEDEN	California Environmental Data Exchange Network
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CIP	Capital Improvement Program
CIWQS	California Integrated Water Quality System
COA	Conditions of Approval
CRAM	California Rapid Assessment Method
CSCI	California Stream Condition Index
CTR	California Toxics Rule
DEH	Department of Environmental Health
DO	Dissolved Oxygen
DWQ	Division of Water Quality
ERP	Enforcement Response Plan
GIS	Geographic Information System
HMP	Hydromodification Management Plan
HPWQC	Highest Priority Water Quality Condition
HSPF	Hydrological Simulation Program FORTRAN
IBI	Index of Biotic Integrity
IC/ID	Illegal Connection/Illicit Discharge
IDDE	Illicit Discharge Detection and Elimination
IRWMP	Integrated Regional Water Management Program
JRMP	Jurisdictional Runoff Management Program
LAMP	Local Agency Management Program
LID	Low Impact Development
LIP	Local Implementation Plan
LOE	Lines of Evidence
LTEA	Long-Term Effectiveness Assessment

LTMS	Long Term Monitoring Station
MAP	Monitoring and Assessment Plan
MBAS	Methylene Blue Active Substances
MCL	Maximum Contaminant Level
MCTSSA	Marine Corps Tactical Systems Support Facility
MEP	Maximum Extent Practicable
M-K	Mann-Kendall
MLOE	Multiple Lines of Evidence
MS4	Municipal Separate Storm Sewer System
NAL	Non-storm Water Action Level
NEPA	National Environmental Policy Act
NGO	Non-Governmental Organization
NNE	Nutrient Numeric Endpoint
NPDES	National Pollutant Discharge Elimination System
NRMP	Nutrient Reduction and Management Plan
NTR	National Toxics Rule
NWI	National Wetland Inventory
OAL	Office of Administrative Law
OWTS	Onsite Wastewater Treatment System
PDP	Priority Development Project
POTW	Publicly Owned Treatment Works
PWQC	Priority Water Quality Condition
QAPP	Quality Assurance Project Plan
RCFCWCD	Riverside County Flood Control and Water Conservation District
ROWD	Report of Waste Discharge
RTA	Rapid Trash Assessment
RWQCB	Regional Water Quality Control Board
SAL	Stormwater Action Level
SCCWRP	Southern California Coastal Water Research Project
SMARTS	Stormwater Multiple Applications and Report Tracking System
SMC	Stormwater Monitoring Coalition
SMR	Santa Margarita River
SMRNIG	Santa Margarita River Nutrient Initiative Group
SPAWAR	Space and Naval Warfare Systems Command

SQO	Sediment Quality Objective
SSO	Sanitary Sewer Overflow
SUSMP	Standard Urban Stormwater Mitigation Plan
SUSTAIN	System for Urban Stormwater Treatment and Analysis Integration
SWAMP	Surface Water Ambient Monitoring Program
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMAR	Transitional Monitoring and Assessment Report
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TST	Test of Significant Toxicity
TUc	Chronic Toxicity Unit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USMC	U.S. Marine Corps
VNS	Visited Not Sampled
WDR	Waste Discharge Requirement
WLA	Waste Load Allocation
WMA	Watershed Management Area
WMAA	Watershed Management Area Analysis
WQBEL	Water Quality-Based Effluent Limitation
WQI	Water Quality Index
WQO	Water Quality Objective

Executive Summary

The Counties of Riverside and San Diego, the Riverside County Flood Control and Water Conservation District (RCFCWCD), and the Cities of Murrieta, Temecula, and Wildomar (collectively known as Copermittees) as well as the City of Menifee have prepared this Water Quality Improvement Plan to comply with requirements in their Municipal Separate Storm Sewer System (MS4) Permit (Order No. R9-2013-0001 as amended by Order No. R9-2015-0001 and Order No. R9-2015-0100; Permit) and to protect the beneficial uses of the receiving waters in the Santa Margarita River (SMR) watershed. The SMR watershed is unique as the least disturbed watershed along the Southern California coast, and the SMR is the longest free flowing, undammed river in the region. The SMR watershed supports a wide variety of beneficial uses related to water supply, agriculture, industry, and aquatic life. Habitat conservation and connectivity within the watershed are important issues to the Copermittees. The major surface water bodies in the SMR watershed are:

- Murrieta Creek;
- Temecula Creek;
- Santa Margarita River; and
- Santa Margarita River Estuary (SMR Estuary).

The Water Quality Improvement Plan was developed in three phases as outlined below, and will be implemented following the process outlined in **Figure ES-1**.

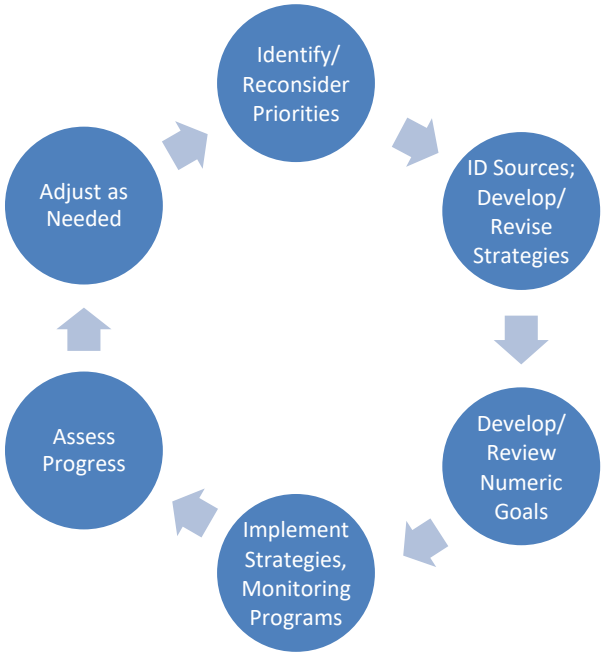

Figure ES-1. Water Quality Improvement Plan Implementation Process

1. The first phase identified the priority and highest priority water quality conditions for the watershed, along with potential water quality improvement strategies (Permit Provision B.2).
2. The second phase identified numeric goals for the highest priority water quality conditions in the watershed, strategies that the Copermittees and the City of Menifee will implement to achieve the numeric goals, and schedules for implementing strategies and attaining goals (Permit Provision B.3).
3. The third phase included development of a monitoring and assessment program to provide feedback to program managers.

During implementation, adaptive management will be utilized to assess progress towards goals and adjust the implementation process as needed.

Chapter 1 provides a brief overview of the SMR watershed and describes the extensive stakeholder process that contributed to the development of the Water Quality Improvement Plan. A Consultation Committee consisting of representatives from the San Diego Regional Water Quality Control Board (Regional Water Board), the environmental community, the development community, and at-large members provided important feedback during development. The public participation process involved the following activities:

- A widely distributed data request to solicit data from the public;
- The public were invited to Consultation Committee meetings, where they received updates on project progress and had the opportunity to provide comments;
- Updates on Water Quality Improvement Plan progress were provided through other watershed meetings that are open to the public; and
- Comments received from the public and the Consultation Committee were considered during the development of the Water Quality Improvement Plan.

PRIORITY WATER QUALITY CONDITIONS

Chapter 2 describes the process to determine priority water quality conditions (PWQCs) for the SMR watershed. To facilitate data analysis for the water quality prioritization process, the watershed was divided into three subwatersheds. The Upper, Middle, and Lower SMR Subwatersheds were delineated based on their hydrologic boundaries (Figure 1-1). The process to determine the PWQCs considered all available data and information on receiving water conditions, Clean Water Act Section 303(d) List of Water Quality Limited Segments (303(d) listings), Total Maximum Daily Loads (TMDLs) (established or in development), known impacts to beneficial uses, MS4 contributions to water quality conditions, local knowledge about watercourse function, environmental values, community goals, habitat preservation, and input from members of the public and Consultation Committee. Data collected were used to conduct extensive analyses regarding the comparison between historic and current water quality conditions, constituent exceedances, beneficial use impacts, as well as contributions from MS4s to receiving waters. Wet and dry weather conditions were considered independently, as water quality priorities can vary with season. All of these analyses contributed to developing the list of PWQCs. Results show that on the whole, water quality during both dry and wet weather conditions observed in the watershed are trending towards improvement.

The highest priority water quality condition (HPWQC) was selected from the list of PWQCs. The HPWQC provides the basis for selecting watershed strategies and developing goals and schedules during the subsequent phases of Water Quality Improvement Plan development. The HPWQC was determined by evaluating each PWQC against ten criteria related to the extent and impact of the condition. Each PWQC was also evaluated for potential improvements in conditions of receiving water and MS4 discharge quality that can be achieved. Based on the assessment, eutrophication was identified as the highest priority to address. (See **Table ES-1**)

Eutrophication was identified as the HPWQC largely due to 303(d) listings for nutrients, an existing TMDL in Rainbow Creek, the TMDL Alternative (under development) for nutrients and biostimulatory substances in the SMR Estuary and the watershed, the potential impact on beneficial uses from those conditions, the nutrient objective exceedances observed throughout the watershed, and the extent of potential improvements that could be achieved in the condition of the Watershed Management Area (WMA) and discharge quality from MS4s. The eutrophication HPWQC includes two components: 1) eutrophication impacts (elevated algal biomass) and 2) nutrient loading to waterbodies with an adopted TMDL or listed as impaired, including dry weather nutrient loading from both Middle, and Lower SMR Subwatersheds to address the TMDL Alternative for the SMR Estuary, and dry and wet weather nutrient loading to Rainbow Creek to address the Rainbow Creek Nutrient TMDL.

Table ES-1. Highest Priority Water Quality Condition (Eutrophication)

Beneficial Use Category	Highest Priority Water Quality Condition	Temporal Extent	Geographic Extent
Aquatic Life: Eutrophication	Eutrophication impacts (elevated algal biomass)	Dry	SMR Estuary [1], Warm Springs, Redhawk Channel [2]
	Nutrient loading to waterbodies with an adopted TMDL or listed as impaired	Dry	All Middle and Lower SMR Subwatershed subareas, except Fallbrook Creek and Sandia Creek[1]
		Wet	Rainbow Creek

1. MS4 discharges within the following subareas may reach the SMR Estuary during dry weather and contribute to the Eutrophication HPWQC in the Santa Margarita River Estuary: Upper Murrieta Creek and Tributaries, Warm Springs, Santa Gertrudis, Murrieta Creek and Long Canyon, Temecula Creek and Redhawk Channel, Upper Santa Margarita River, Lower Santa Margarita River, Rainbow Creek and De Luz Creek.
2. Other areas may be added as result of TMDL Alternative development during adaptive management process.

Chapter 3 of this document includes an assessment of potential sources within the watershed contributing to eutrophication and nutrient loading. The source assessment is based on a review of available data and information for potential sources that are likely to be present in the watershed. The main contributor to eutrophication was identified to be algal biomass. Excess algal biomass can be caused by nutrient loading of nitrogen and phosphorus. Such loading is primarily linked to land uses such as orchards, vineyards and nurseries, open scrublands and grasslands, and residential land uses. Additionally, irrigated agriculture was identified as a contributor of total nitrogen loading and roads as a contributor for total phosphorus loading. The mechanisms identified for these non-point source loads to reach a receiving water include stormwater runoff, irrigation return flow (excess irrigation water that reaches a receiving water), and subsurface flow associated with shallow groundwater pathways.

WATER QUALITY IMPROVEMENT GOALS, STRATEGIES, AND SCHEDULES

Chapter 4 defines the goals developed to measure progress, the strategies to be implemented to achieve the goals, and the schedules for implementation of strategies and goal achievement. Through the implementation of strategies and an iterative, adaptive management approach, it is anticipated that the numeric goals will be achieved and the water quality will be improved. The strategies were developed with multiple benefits in mind. They were designed to address the HPWQC, as well as other PWQCs identified in **Chapter 2**.

Within the Middle SMR Subwatershed, the Copermittees and the City of Menifee have the option of demonstrating compliance through one of six pathways. Each pathway includes interim goals, with at least one goal per Permit term, to demonstrate progress toward achieving the final goals. The final goals and timeframe for achieving the goals are based on the *proposed* allocations and schedule in the TMDL Alternative for the SMR Estuary. The Water Quality Improvement Plan goals and schedules may be revised through the adaptive management process, if necessary, to be consistent with the requirements for implementation of the TMDL Alternative for the SMR Estuary.

Within the Lower SMR Subwatershed, numeric goals and schedules were also developed for the Nutrient TMDL in Rainbow Creek. Compliance with the Rainbow Creek Nutrient TMDL final numeric goals can be met in one of five ways, similar to the approach for the eutrophication impacts HPWQC.

Given the different potential sources and jurisdictions in the Upper, Middle, and Lower SMR Subwatersheds, sets of strategies were developed for each jurisdiction in each subwatershed.

For the Middle SMR Subwatershed, the Copermittees and the City of Menifee developed jurisdictional, optional jurisdictional, and optional watershed scale strategies to address the HPWQC. The Copermittees and the City of Menifee also developed an adaptive management approach to implement and evaluate strategies. Each Copermittee will develop and implement a Jurisdictional Runoff Management Program (JRMP) that contains strategies to address the requirements in Provisions E.2 through E.7 of the Permit. As required by the Santa Ana Phase I MS4 Permit, Menifee's jurisdictional program is laid out in its LIP rather than a JRMP. Jurisdictional programs, strategies, and all minimum best management practices (BMPs) established per each Co-Permittee's JRMP will be implemented across all areas within the respective jurisdiction upon the Regional Water Board's acceptance of the Water Quality Improvement Plan.

Strategy implementation will also include enhanced jurisdictional strategies that are specific, locally appropriate, and focused in target areas. Program implementation will be evaluated on an annual basis, and overall progress toward achieving the final Water Quality Improvement Plan goals will be assessed at five year intervals in the Report of Waste Discharge as required for National Pollutant Discharge Elimination System (NDPES) permit renewals. If triggered, and depending on the procurement of funding and necessary approvals, enhanced jurisdictional strategies will be implemented.

In the Lower SMR Subwatershed, San Diego County has developed jurisdictional strategies to address known and suspected sources identified within their inventories, including persistently flowing outfalls and specific land use types (e.g., orchards, vineyards and nurseries, and residential land uses). Jurisdictional strategies target reductions in dry weather flow and address the types of

land use sources that are within the MS4 drainage area. Specific structural strategies such as nutrient-sensitive biofiltration, wetland channels, stream restoration, and channel improvements have also been identified.

Schedules for strategy implementation reflect the time necessary to fully fund, develop, initiate, and complete the chosen strategies. Strategies with relatively high benefit outcomes and low resource requirements are scheduled for earlier implementation. Strategies planned for later years may have implementation requirements that depend on the outcomes of earlier strategies, or might have significant funding needs. Strategies, including schedules for implementation, are included in **Table 4-6** through **Table 4-11** and in **Table 4-14**.

MONITORING AND ASSESSMENT PLAN (MAP)

Chapter 5 outlines the Monitoring and Assessment Plan (MAP) for the SMR watershed to support assessment of progress toward numeric goals and schedules, progress addressing eutrophication and nutrient loading, and each agency's overall efforts to implement the Water Quality Improvement Plan. The SMR watershed MAP is designed with the overall goal of answering the following monitoring questions, which correspond to the numeric goals presented in **Chapter 4**:

- How much has total nitrogen and total phosphorus loading been reduced in the SMR watershed?
- How much has non-storm water flow been reduced at Copermittee outfalls?
- How much has total nitrogen and total phosphorus loading been reduced at Copermittee outfalls?
- Are there sources of pollutants outside of Copermittee control that are causing exceedances of targets?

These questions will be answered through a multi-pronged monitoring approach that includes water quality monitoring in creeks and rivers, the SMR Estuary, and at major outfalls discharging to these waterbodies.

ITERATIVE APPROACH AND ADAPTIVE MANAGEMENT

Chapter 6 outlines the adaptive management process that will be used to evaluate and adapt the Water Quality Improvement Plan. The adaptive management process will be implemented using data collected as part of the MAP, to evaluate whether modifications to goals, schedules, and/or strategies are necessary. Triggers that may prompt program modification include persistent exceedances of water quality standards in receiving waters, new information (e.g., TMDL Alternative implementation requirements, new regulations, etc.), Regional Water Board recommendations, and input received during the public participation process.

1 Introduction

1.1 PURPOSE OF THE WATER QUALITY IMPROVEMENT PLAN

The purpose of this Water Quality Improvement Plan (WQIP) is to guide the development and implementation of jurisdictional runoff management programs of the Counties of Riverside and San Diego, the Riverside County Flood Control and Water Conservation District (RCFCWCD), and the Cities of Murrieta, Temecula, and Wildomar (hereafter referred to as the Copermittees), as well as the City of Menifee, towards achieving the outcome of improved water quality in MS4 (Municipal Separate Storm Sewer System) discharges and receiving waters within the Santa Margarita River (SMR) watershed management area (WMA).

1.2 REGULATORY BACKGROUND

On May 8, 2013, the California Regional Water Quality Control Board (RWQCB) - San Diego Region (Regional Water Board) adopted Order No. R9-2013-0001; National Pollutant Discharge Elimination System (NPDES) Permit No. CAS0109266, NPDES Permit and Waste Discharge Requirements (WDRs) for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds within the San Diego Region (Permit). The Permit was amended by Order No. R9-2015-0001 and Order No. R9-2015-0100 in 2015 to include all participating agencies (Copermittees) in the San Diego Region. The most recent amendment (Order No. R9-2015-0100), which enrolled the Riverside County Copermittees, became effective on January 7, 2016. The Permit covers portions of the counties of San Diego, Orange, and Riverside that reside within the Regional Water Board's jurisdiction.

The Permit has two primary goals[1]:

1) Bring a consistent set of permit requirements to all of the Copermittees within the San Diego Region; and

2) Provide permit requirements that will allow the Copermittees to focus their efforts and resources on achieving goals and desired outcomes toward the improvement of water quality rather than completing specific actions.

As such, the Permit incorporates a strategic planning component that includes short-term and long-term goal setting as well as a requirement to develop a comprehensive program to further the Clean Water Act's objective to protect, preserve, enhance, and restore the water quality and designated beneficial uses of the waters of the state.

The Permit requires two types of planning efforts and plans:

1) Water Quality Improvement Plans (WQIPs) - developed on a watershed basis, these plans identify the highest priority water quality condition(s) (HPWQC(s)) in a watershed as well as the goals, strategies, and schedules to improve discharge and receiving water quality.

2) Jurisdictional Runoff Management Plans (JRMPs)[2] – developed on a jurisdictional basis, describe how the individual Copermittees implement the Permit requirements,

[1] Permit, Attachment F, page F-16.

[2] Strategies for the City of Menifee are described in its equivalent plan referred to as Local Implementation Plan (LIP).

prohibit non-stormwater discharges to the MS4, and reduce pollutants in stormwater discharges from MS4s to the Maximum Extent Practicable (MEP). The JRMPs must also identify how the WQIP strategies will be implemented within each jurisdiction.

Permit Provisions B.1 through B.6 identify the technical requirements that must be addressed during the development and implementation of the WQIP.

- Provision B.1 – Watershed Management Areas - describes the WMAs and responsible agencies covered under the Permit.
- Provision B.2 – Priority Water Quality Conditions - provides the requirements for assessing and determining the priority water quality conditions for the watershed.
- Provision B.3 – Water Quality Improvement Goals, Strategies, and Schedules - contains requirements for developing the goals, strategies, and schedules to guide implementation.
- Provision B.4 – Water Quality Improvement Monitoring and Assessment Program - addresses the monitoring and assessment program that is required to support implementation and assess progress.
- Provision B.5 – Iterative Approach and Adaptive Management Process - describes the iterative approach and the adaptive management process that will be implemented over time to make improvements to the WQIP.
- Provision B.6 – WQIP Submittal, Updates, and Implementation - specifies the submittal and update requirements for the WQIP.

These provisions were adhered to during the development of this WQIP.

1.2.1 RCFCWCD and the City of Menifee

Unlike cities and counties, the RCFCWCD does not own or operate any sanitary sewer systems, public streets, roads, or highways. In 1945, the California State Legislature enacted Act 6642 creating the RCFCWCD. The Act empowered the RCFCWCD to manage flood risk and conserve stormwater for groundwater recharge. In coordination with the United States Army Corps of Engineers, the RCFCWCD developed and constructed a comprehensive system that provides for the regulation and control of flood waters through the use of reservoirs and flood channels. The RCFCWCD operates and maintains storm drains and other appurtenant drainage infrastructure within its service area. The RCFCWCD has no planning, zoning, development permitting, or other land use authority within its service area.

The City of Menifee is located primarily within the geographic jurisdiction of the Santa Ana RWQCB, but a small portion of the city, totaling less than 1.3 square miles, is within the SMR WMA, which is in the geographic jurisdiction of the San Diego RWQCB. Per the Regional Water Board Designation Letter dated October 26, 2015, the entire City of Menifee, including the portion within the SMR watershed, is regulated under the Santa Ana Region MS4 Permit (Order No. R8-2010-0033, as it may be amended or reissued) except for certain provisions specified in the Regional Water Board Designation Letter. One of these provisions is that the City of Menifee is required to participate in the development and implementation of the W QI P for the SMR WMA. Furthermore, the Regional Water Board Designation Letter states that, "The San Diego Water Board shall continue to regulate the City of Menifee under the San Diego Phase I MS4 Permit for the limited purpose of implementing any applicable TMDL."

1.3 PHYSICAL SETTING

The SMR WMA is a unique area because it is the least disturbed watershed along the Southern California coast, and the Santa Margarita River is the longest free flowing, undammed river in the region. The lower 27 miles of the SMR and its estuary are not channelized and support a large population of federally- or state-listed endangered species (County of San Diego, 2005). The SMR WMA encompasses a total area of approximately 741 square miles, spans the southern border of Riverside County and the northern border of San Diego County, and is bordered to the south by the San Luis Rey Watershed and to the west by the San Mateo Creek, Las Flores Creek, and Aliso Creek Watersheds. The watershed is comprised of the following waterbodies: Diamond Valley Lake, Lake Skinner, Vail Lake, Murrieta Creek, Temecula Creek, the SMR, and the SMR Estuary. The Middle SMR Subwatershed includes two major basins, drained by Murrieta and Temecula Creeks.

Murrieta Creek flows between two lengthy strands of the Elsinore fault zone on land that has been down dropped, relatively, by the faulting. Murrieta Creek flows southeasterly from the Wildomar area through the cities of Murrieta and Temecula to the confluence with Temecula Creek. Murrieta Creek and its tributaries drain approximately 222 square miles, with over 50 square miles tributary to Skinner Reservoir, in the northwest portion of the watershed. Temecula Creek has a drainage area of 366 square miles, with steep rugged topography in the Palomar and Thomas Mountain areas and rolling hills below. The upper 316 square miles of this basin is controlled by Vail Lake (completed in 1949).

At the Elsinore fault zone, located at the top of Temecula Gorge and near the City of Temecula, Temecula and Murrieta Creeks merge forming the Santa Margarita River. The Temecula Gorge and Santa Ana Mountains just south of the confluence of the Temecula and Murrieta Creeks serve as a natural barrier delineating the Middle and Lower SMR Subwatersheds. (Rancho California Water District, 2014) From this point, the river flows through the Temecula Gorge and then west into San Diego County for approximately thirty miles before ultimately draining to the SMR Estuary and into the Pacific Ocean.

1.4 SMR WMA SUBWATERSHED AREAS

For purposes of this analysis, the SMR WMA has been divided into three subwatersheds (Figure 1-1):

The Upper SMR Subwatershed;

The Middle SMR Subwatershed; and

The Lower SMR Subwatershed.

The Upper SMR Subwatershed includes all the area in the SMR WMA which drains to the three major manmade lakes: Diamond Valley Lake, Lake Skinner, and Vail Lake; and comprises approximately 385 square miles. Approximately 316 square miles of the subwatershed drain to Vail Lake, 51 square miles drain to Lake Skinner, and 18 square miles of undeveloped area drain to Diamond Valley Lake. Land uses for the subwatershed are shown in Figure 3-1. The Upper SMR Subwatershed includes the following entities/areas:

County of Riverside – 55% of the land area (213 square miles)

- Anza[3] – 12% of the County of Riverside land area (25 square miles)
- Aguanga[3] – 6% of the County of Riverside land area (14 square miles)
- Lake Riverside[3] – 3% of the County of Riverside land area (7 square miles)

Tribal, State and Federal lands – 37% of the land area (143 square miles)

County of San Diego – 8% of the land area (29 square miles)

RCFCWCD – <0.01% of the land area (0.013 square miles)

The Middle SMR Subwatershed is located inland along and east of the I-15 corridor and is approximately 201 square miles. The Middle SMR Subwatershed includes the following entities/areas:

County of Riverside – 53% of the land area (106 square miles)

City of Murrieta – 16% of the land area (33 square miles)

City of Temecula – 15% of the land area (30 square miles)

City of Wildomar – 8% of the land area (16 square miles)

Tribal, State and Federal lands – 6% of the land area (12 square miles)

City of Menifee – 1% of the land area (2 square miles – 815 acres)

RCFCWCD – 1% of the land area (2 square miles – 836 acres)

County of San Diego – <0.1% of the land area (0.13 square miles)

The Lower SMR Subwatershed spans the area downstream of the Temecula Gorge entrance to the Pacific Coast and is approximately 156 square miles. The Lower SMR Subwatershed includes the following entities/areas:

Tribal, State and Federal lands – 46% of the land area (71 square miles)

County of San Diego – 28% of the land area (43 square miles)

County of Riverside – 26% of the land area (40 square miles)

City of Temecula – 1% of the land area (1 square mile – 738 acres)

Vail Lake, Lake Skinner, and Diamond Valley Lake are operated to provide potable water supply. The 44,200 acre-feet Lake Skinner was formed by construction of a dam on Tucalota Creek. Vail Lake is a 49,370 acre-feet reservoir located at the confluence of Temecula Creek, Wilson Creek, and Kolb Creek. Diamond Valley Lake is Southern California's largest reservoir with a capacity of approximately 810,000 acre-feet (264 billion gallons). Diamond Valley Lake covers 4,500 surface acres and holds enough water to meet the area's emergency and drought needs for six months. Vail Lake, Lake Skinner, and Diamond Valley Lake provide important resources for municipal water supply for use by local water agencies. Vail Lake is owned by Rancho California

[3] Census Designated Area

Water District (RCWD); Diamond Valley Lake and Lake Skinner are owned by the Metropolitan Water District of Southern California.

Vail Lake and Skinner Lake capture the majority of incoming flows from Temecula Creek, Wilson Creek, Kolb Creek, and Tucalota Creek. These lakes are operated based on water supply and groundwater recharge considerations, and not for flood control purposes. Virtually all runoff received in these reservoirs is conserved for municipal, industrial, and agricultural use. Nonetheless, the storage capacity of each reservoir typically allows most storm events to be captured and stored. At these reservoirs, the majority of flows are contained and are only released into the downstream channels during higher magnitude storm events or when a series of back-to-back storms occurs. For example, storm flows have only been released from Vail Lake during two storm seasons since 1947. Lake Skinner has not released uncontrolled storm flows since 1975. Diamond Valley Lake releases flows to downstream drainage channel only in emergencies. Therefore, the Upper SMR Watershed is hydrologically disconnected from the Middle SMR Watershed in all but the very largest storms or storm series.

In most years, controlled releases from Vail Lake during the wet season (November – April) are infiltrated in the extensive Valle de los Caballos spreading basins. Although RCWD is required to meet in-stream flow requirements at the Temecula Gorge by releasing 4,000 acre-feet of water per year, this requirement is currently met by a separate discharge of untreated imported water directly into Murrieta Creek, and not by any releases from Vail Lake.

Beneficial Uses for the streams in the SMR WMA are shown in Appendix 2. However, the lakes also have important Beneficial Uses including:

- MUN: Municipal and Domestic Supply
- AGR: Agricultural Supply
- IND: Industrial Service Supply
- PROC: Industrial Process Supply
- GWR: Ground Water Recharge (potential Beneficial Use for Lake Skinner)
- REC-1: Contact Water Recreation (limited to fishing from shore or boat)
- REC-2: Non-contact Water Recreation
- WARM: Warm Freshwater Habitat
- WILD: Wildlife Habitat
- POW: Hydropower Generation (Diamond Valley Lake only)

The WQIP recognizes the importance of protecting the lakes from any adverse water quality impacts. The importance of these lakes is called out in the Basin Plan (Chapter 2: Reservoirs and Lakes):

> "The water resources with the greatest diversity of beneficial uses in the Region are the manmade water storage reservoirs and lakes. Located in nearly all of the Region's hydrologic units, these reservoirs and lakes intercept surface runoff and store imported water supplies.
>
> As such, the storage reservoirs serve as: (1) sources of supply for municipalities, agricultural areas, and industrial operations; (2) recreational bodies; and (3) habitats for fish and wildlife. In a few cases, such as reservoirs used primarily for drinking water, REC-1 uses can be restricted or prohibited by the entities that manage these waters. Many

of these reservoirs, however, are designated as potential for REC-1, reflecting federal Clean Water Act goals."

Population

The Upper SMR Subwatershed has very low population density compared to the Middle SMR Subwatershed (Figure 1-2). Recent estimates from the California Department of Finance 2017 show that there are 321,150 people living in the entire SMR WMA, whereas 2010 Census data shows approximately 15,400 people (5% of the total WMA population) live in the Upper SMR Subwatershed, which comprises approximately 52% of the total SMR WMA. Overall, the population density is low relative to the other subwatersheds. The census-designated areas of Anza, Lake Riverside, and Aguanga, and an area east of Lake Skinner contain most of the population. The small area of density shown in the southwestern corner of the WMA in San Diego County in Figure 1-2 is part of a larger census tract, and most of the population is actually in the San Luis Rey watershed. There is very little developed land in this area.

Infrastructure

Drainage facilities, roads, and receiving waters identified in the Basin Plan are shown in Figure 1-3. There is very limited drainage infrastructure present in the subwatershed. There are two facilities owned by the RCFCWCD: 1) Anza Creek Channel is a 3,500-foot long 30-foot wide X 7-foot deep trapezoidal concrete drainage channel adjacent to and on the south side of Highway 371 in the Anza area; 2) Sage Road Bridge over Wilson Creek is an approximately 750-foot long bridge and a 1.25 acre vegetated mitigation area. Figure 1-3 also shows 115 culverts owned by the County of Riverside that are primarily associated with County roads. No major outfalls have been identified within this portion of the WMA within either Riverside or San Diego County.

Roads

The County of Riverside owns and maintains Primary, Secondary, and lesser roads in the subwatershed as shown in Figure 1-3. Most roads lack curb and gutter, and storm runoff from these roads is managed by infiltration along the road shoulders, by conveying flows under roads via culverts, in some cases surface drainage in natural channels flows over and across roads. Storm runoff may also flow along roadside ditches for short distances. The County of San Diego maintains one single road in this portion of the WMA. The road cuts across the south eastern portion of the WMA through a sparsely populated area for about 6 miles. The county maintains approximately 35 culverts along this road.

Tribal, State, and Federal Lands

The Upper SMR Subwatershed contains large areas of land that are outside the jurisdiction of the counties of Riverside and San Diego, including the Cahuilla, Pechanga, and Ramona Reservations, National Forest and Bureau of Land Management Lands, and the San Felipe Valley Wildlife Area managed by the California Department of Fish and Wildlife (Figure 1-2). These areas comprise approximately 37% of the Upper SMR Subwatershed.

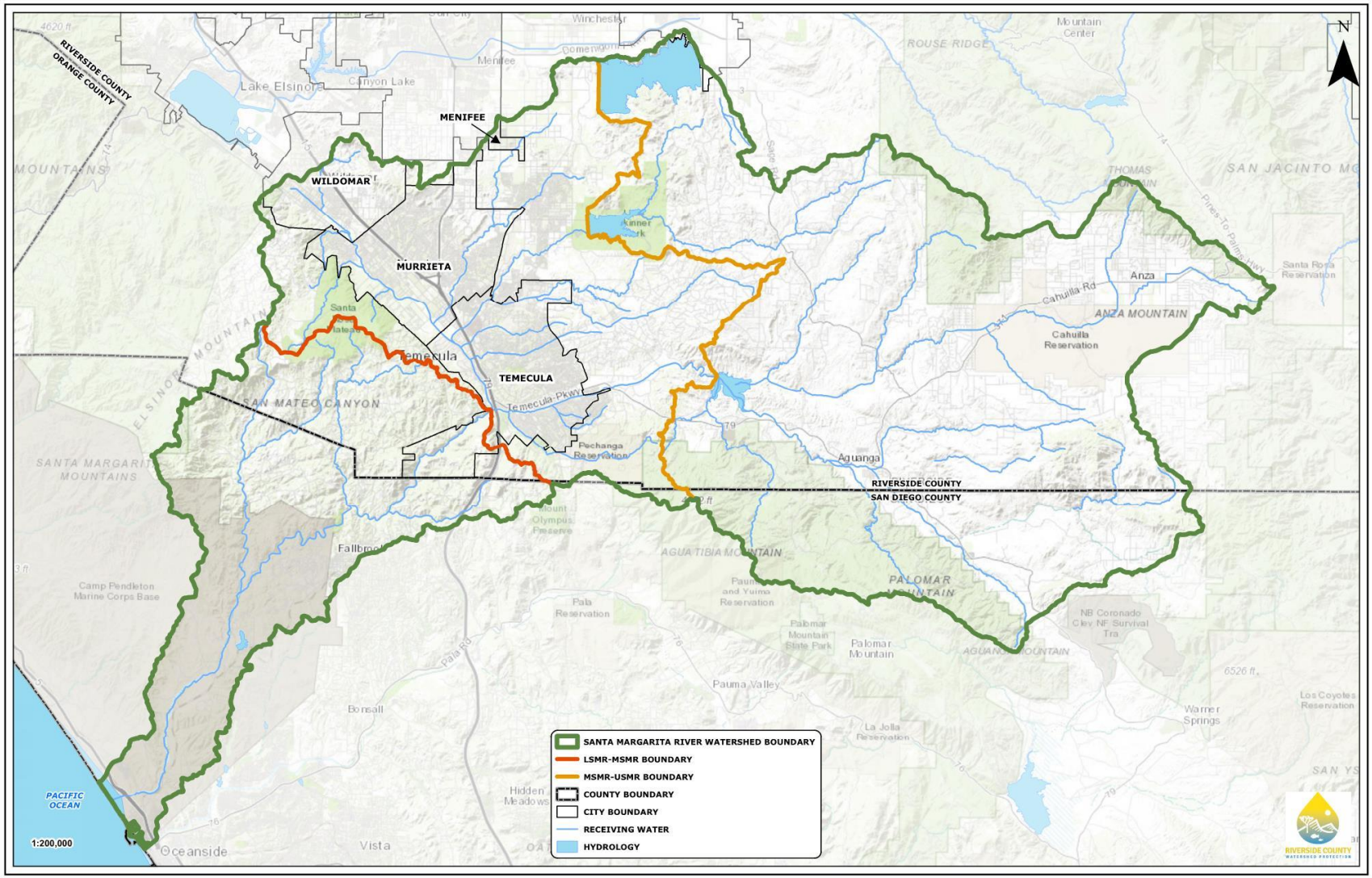

Figure 1-1. Santa Margarita River Watershed Management Area

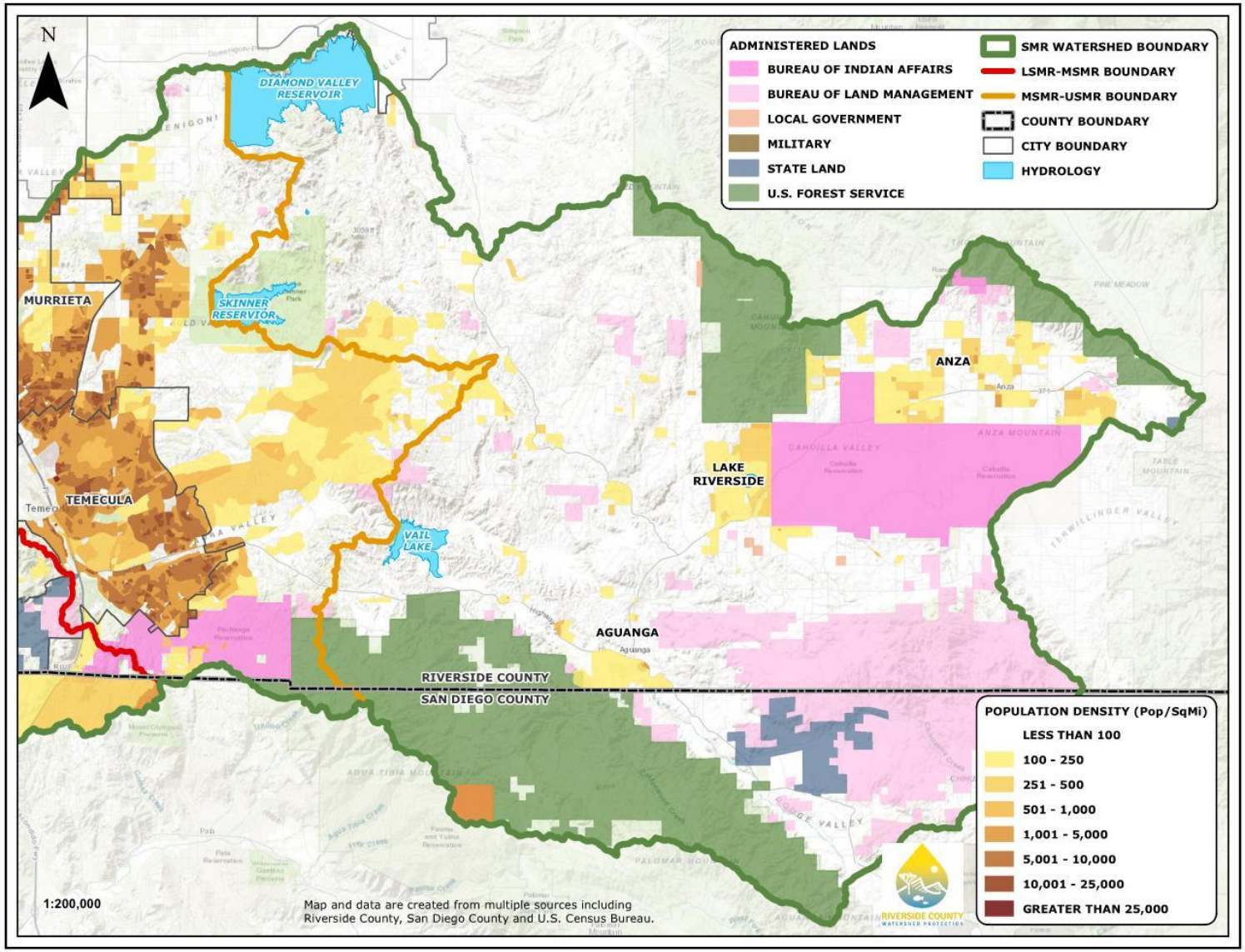

Figure 1-2. Population Density in the Upper SMR Subwatershed

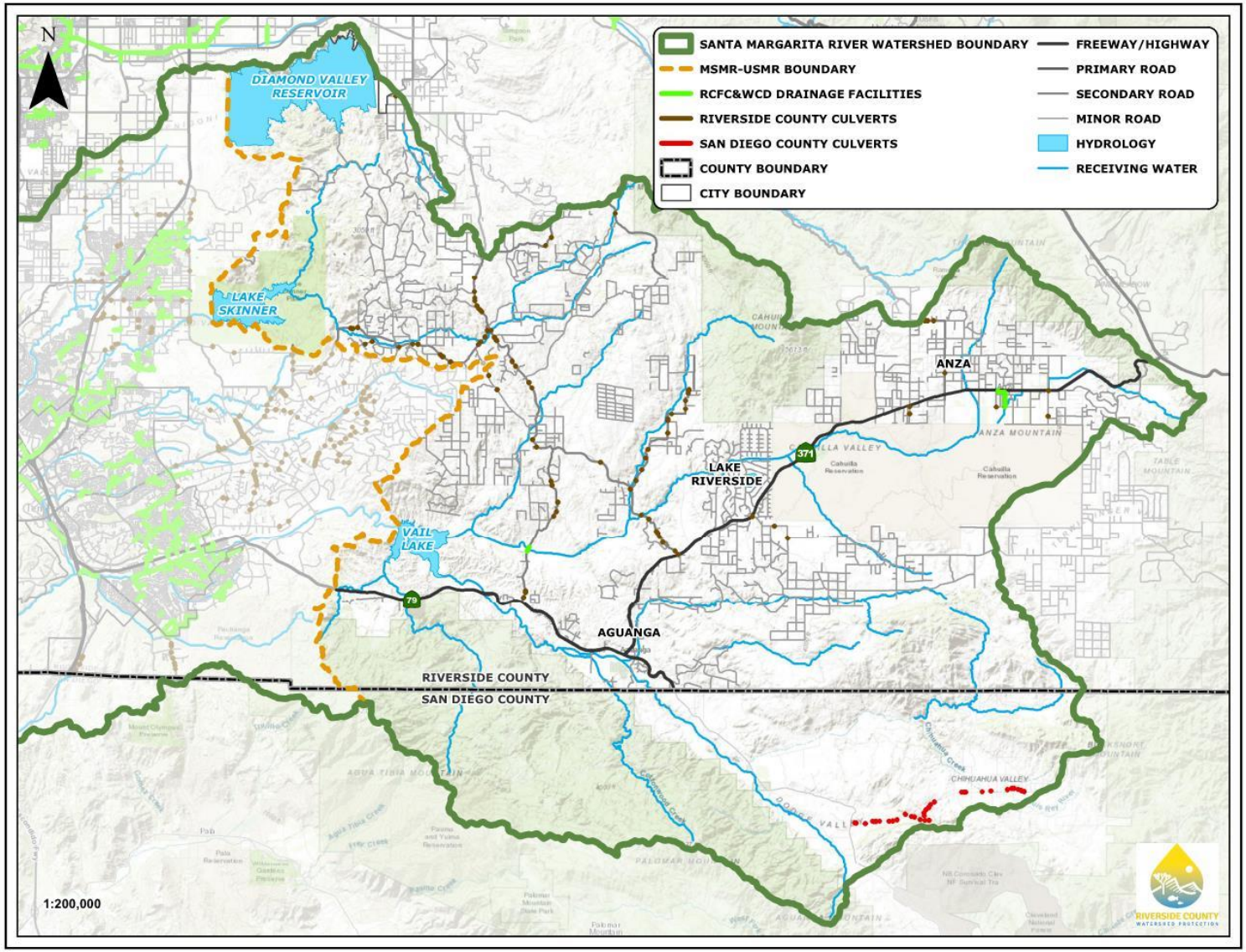

Figure 1-3. Infrastructure in the Upper SMR Subwatershed

1.5 WATER QUALITY IMPROVEMENT PLAN DEVELOPMENT AND IMPLEMENTATION PROCESS

The WQIP has been developed in three phases, according to the process described within the Permit (Provision F.1).

Phase 1: Priority water quality conditions, the high priority water quality conditions, potential sources, and potential water quality improvement strategies were identified (Provision B.2).

Phase 2: Numeric goals for the HPWQC and strategies that the Copermittees and the City of Menifee will implement to achieve the numeric goals were developed (Provision B.3).

Phase 3: A monitoring and assessment program was designed to provide feedback to program managers on progress towards goals (Provision B.4).

An adaptive management process will be utilized during implementation to assess progress towards goals and adjust the implementation process as needed (Provision B.5). The process for implementation of the WQIP is outlined in **Figure 1-2**.

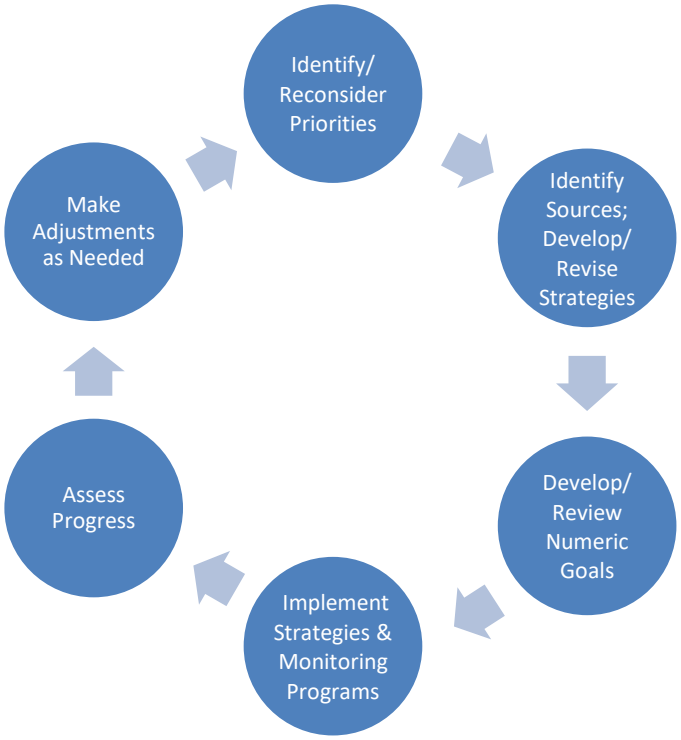

Figure 1-2. Water Quality Improvement Plan Implementation Process

1.5.1 Document Overview

The WQIP is organized into seven chapters. **Chapters 2 - 6** address specific Permit requirements for Plan development (**Table 1-1**). **Chapter 7** contains a glossary of terms and **Chapter 8** contains a list of references cited within the document.

Table 1-1. Structure of the Water Quality Improvement Plan and Associated Permit Requirements

Chapter Content	Permit Requirements Addressed (Provision)
Chapter 1. Introduction	
Chapter 2. Priority Water Quality Conditions	
Water quality priorities identified after evaluating receiving water conditions and impacts from MS4 discharges and potential water quality improvement strategies.	B.2.a-c. Priority Water Quality Conditions
Chapter 3. Identification of MS4 Sources of Pollutants and/or Stressors	
An analysis to identify and prioritize known and suspected sources of stormwater and non-stormwater pollutants associated with MS4 discharges that may cause or contribute to eutrophication or nutrient loading within the watershed.	B.2.d. Identification of MS4 Sources of Pollutants and/or Stressors B.2.e. Identification of Potential Water Quality Improvement Strategies
Chapter 4. Water Quality Improvement Goals and Schedules	
Watershed interim and final goals, along with strategies and schedules developed to achieve the goals.	B.3 Water Quality Improvement Goals, Strategies and Schedules
Chapter 5. Monitoring and Assessment Program	
Integrated Monitoring and Assessment Program developed based on the requirements of the Permit and Plan process.	B.4. Monitoring and Assessment Program
	D. Monitoring and Assessment Program Requirements
Chapter 6. Iterative Approach and Adaptive Management	
Elaboration on the adaptive management processes, including the frequencies of adaptation required by the Permit (annual versus once per Permit term), triggers, and resulting actions.	B.5 Iterative Approach and Adaptive Management
Chapter 7. Glossary of Terms	
Chapter 8. References	

In addition, as part of the WQIP's development, the Copermittees and the City of Menifee created a "crosswalk" to identify which Permit provisions are addressed in specific document sections (**Appendix 1A**). This crosswalk is intended to ease the review process and is based on the Permit checklist used by the Regional Water Board to evaluate the WQIP. The crosswalk includes Permit requirements, comments from the Regional Water Board based on their review of the draft documents, and responses by agencies to comments based on revisions to the WQIP.

1.5.2 Public Participation Process

The Copermittees and the City of Menifee implemented a public participation process as part of Plan development in accordance with Permit Provision F. The process included data solicitation, the formation and participation of a Consultation Committee, presentations at public meetings and other outreach to the community, and participation in the Santa Margarita River Nutrient Initiative Group (SMRNIG), to provide opportunities for public input on the WQIP. Drafts of the priority water quality conditions, numeric goals, water quality improvement strategies, and schedules were submitted to the Regional Water Board as required and were subsequently posted for public

review. Feedback and comments received during Plan development were considered in the process and helped to shape the WQIP.

1.5.2.1 Data Solicitation

On April 22, 2016, the Copermittees issued a public request for data to a distribution list of 83 interested parties, and posted the data solicitation on the RCFCWCD's website, allowing 30 days for submittal of information. The data solicitation closed on May 23, 2016. The notice requested any available quantitative or qualitative data related to water quality within the watershed. Although widely distributed and targeting relevant stakeholders, as well as the general public, no data was received in response to the data solicitation. As a follow-up, Copermittees and the City of Menifee requested and received water quality data from the SMRNIG which was incorporated into the analysis and assisted in prioritization of water quality conditions.

1.5.2.2 Consultation Committee

The Copermittees and the City of Menifee formed a Consultation Committee to receive recommendations during the development of the WQIP (Provision F.1.a.(1)(b)). The Permit includes requirements for the Consultation Committee to review and provide recommendations at key points during the WQIP development process. Feedback from the Committee is vital to the development of the WQIP. The Consultation Committee consisted of representatives from the Regional Water Board, the environmental community, the development community, community organizations, neighborhood groups, and businesses all sharing a commitment to improve water quality. The Consultation Committee included the following individuals:

Required Members

Erica Ryan (San Diego Regional Water Quality Control Board)

Terri Biancardi (Environmental Community)

Dr. Mark Grey, Clint Lorimore (*alternate*) (Development Community)

At Large Members

Ben Drake (Temecula Winegrowers Association)

Andy Domenigoni (Riverside County Farm Bureau)

Kyle Cook (Camp Pendleton Marine Base)

Pablo Bryant (Santa Margarita Ecological Reserve)

Laurie Correa (Western Riverside County Regional Conservation Authority)

Rick Neugebauer (Temecula/Elsinore/Anza/Murrieta Resource Conservation District (TEAM-RCD))

The Copermittees and the City of Menifee hosted three Consultation Committee meetings during development of the WQIP. The meetings were all open to the public, were held at varied times and locations, and publicly noticed to provide ample time and opportunity for the public to participate. Dates and content of the Consultation Committee meetings are summarized in **Table 1-2**. A summary of comments received and their consideration within Plan development are included in the Public Review Process discussion in **Section 1.5.2.5**.

Table 1-2. Summary of Consultation Committee Meetings

Consultation Committee Meeting Date/Location	Key Content of the Meeting
September 7, 2016 Rancho California Water District	• Overview of the Planning Process • Preliminary Prioritization Methodology • Results and Initial Priority Water Quality Conditions • Potential Water Quality Improvement Strategies
May 17, 2017 City of Wildomar	• Revisions to the Prioritization Process • Priority Water Quality Conditions • Proposed goal and schedules • Overview of strategies and schedules • Watershed Management Area Analysis
October 17, 2017 City of Temecula	• Watershed Management Area Analysis Updates • Monitoring and Assessment Program • Adaptive Management

1.5.2.3 Additional Public Participation

In August 2017, the issue of poor attendance at public meetings convened to support Water Quality Improvement Plan development in the San Juan WMA was discussed with RWCQB staff. Arising from this discussion was agreement to implement an alternate approach based on presentations at scheduled council meetings. This approach was accepted, contingent upon informational materials being clearly made available to all individuals attending the meeting and the presentations, including a request for further public engagement. Based on this acceptance, presentations on the SMR WQIP were made at the following council meetings:

October 24, 2017 – City Council Presentation, City of Temecula

November 1, 2017 – City Council Presentation, City of Menifee

November 7, 2017 – City Council Presentation, City of Murrieta

November 8, 2017 – City Council Presentation, City of Wildomar

The same presentation was also provided to the following County Supervisors:

October 18, 2017 – Supervisor Washington briefing, Riverside County Administration Center

October 30, 2017 – Supervisor Jeffries briefing, Riverside County Administration Center

In addition to the presentations, the Copermittees participated in the following public meetings and events to solicit input on the WQIP:

June 1, 2016 – Upper Santa Margarita River Watershed Integrated Regional Water Management Region Stakeholder Meeting

July 12, 2016 – Riverside County Board of Supervisors Meeting

August 9, 2016 – City Manager's Roundtable Meeting

September 7, 2016 – Upper Santa Margarita River Watershed Integrated Regional Water Management Region Stakeholder Meeting

January 19, 2017 – Western Riverside Council of Governments (WRCOG) Technical Advisory Committee

January 30, 2017 – Meeting with City Managers and Public Works Directors

April 22, 2017 – RCFCWCD booth at the Earth Day Celebration

June 7, 2017 – Upper Santa Margarita River Watershed Integrated Regional Water Management Region Stakeholder Meeting.

1.5.2.4 Santa Margarita River Nutrient Initiative Group (SMRNIG)

The Copermittees also regularly participate in the SMRNIG which includes cities and counties, utility districts, Caltrans, scientists, tribes, non-governmental organizations (NGOs), United States Geological Survey (USGS), Camp Pendleton, Farm Bureau, and RWQCB staff that periodically meet to focus on nutrient-related issues in the SMR Estuary. While the SMRNIG did not participate directly in WQIP development, they have conducted extensive modeling efforts in support of a Total Maximum Daily Load (TMDL) Alternative for the SMR Estuary for nutrients, and their work has provided valuable insight and scientific information used in the development of this Plan. With respect to the SMR Copermittees, this WQIP will be a key implementation mechanism for the TMDL Alternative. The TMDL Alternative is expected to be activated through the issuance of an Investigative Order by the Regional Water Board. For simplicity, hereinafter this WQIP will use the term "TMDL Alternative" to refer to this action, pending finalization of the implementation approach to be conducted by the Regional Water Board. Further discussion of the TMDL Alternative process and how it dovetails with the WQIP is provided in **Chapters 2, 3,** and **4**.

1.5.2.5 Public Review Process

In addition to public outreach conducted and input received during development of the WQIP, **Chapters 2** and **3** underwent formal public review processes upon submittal to the Regional Water Board.

1.5.2.5.1 Chapter 2 – Priority Water Quality Conditions and Potential Strategies

Following the first Consultation Committee meeting, draft work products of **Chapter 2** were distributed to the Consultation Committee for review and feedback in September 2016. Draft work products distributed included:

- Summary table of the Clean Water Act Section 303(d) List of Water Quality Limited Segments (303(d) listings) in the watershed,
- Summary table of the datasets used in the evaluation of water quality conditions,
- Maps of the monitoring locations within the watershed,
- Flowchart describing the draft prioritization process,
- Summary tables showing the results of the ranking process (including all evaluations and scoring), and

- Table of potential strategies to address the priority and highest priority water quality conditions identified for the watershed.

In September 2016, the Copermittees and the City of Menifee received two sets of comments from members of the Consultation Committee. To keep the Consultation Committee informed of progress and direction, Copermittees and the City of Menifee provided drafts of the Executive Summary and section related to Highest Priority Water Quality Conditions with updated results for review and additional comments on November 23, 2016. Several sets of comments were received from Consultation Committee members, including one set of written comments from the Regional Water Board received on December 8, 2016.

The initial complete draft of **Chapter 2** (Priority Water Quality Conditions) considered and addressed all comments received, as appropriate, and was submitted to the Regional Water Board on January 5, 2017 and subsequently released for public comment. The public comment period ended on February 20, 2017. Comment letters were received from one member of the public on January 22, 2017 and from the Regional Water Board on March 30, 2017. All comments received were considered in revisions to **Chapter 2**. The primary focus of the comments was related to the process to identify priority water quality conditions (PWQCs) and the HPWQC(s) for the watershed and source information (i.e., municipal parks and landfills).

All comments received during development of **Chapter 2** are included in the crosswalk provided in **Appendix 1A** and **Appendix 1B** and have been considered and addressed as appropriate.

In response to comments received from the Consultation Committee and from the public, the following changes were made to the analyses and findings presented in **Chapter 2**:

- Watershed delineations were revised based on hydrology only, not on political boundaries;
- PWQCs and the HPWQC were identified by hydrologic subareas and subwatersheds and Copermittees and the City of Menifee were assigned responsibility based on their land areas within the hydrologic subareas;
- The prioritization process was revised to consider current TMDLs, TMDLs under development, and 303(d) listings more explicitly and earlier in the process;
- Included assessment of California Rapid Assessment Method (CRAM) index scores and evidence of erosion in the analysis;
- Available loading information was considered specific to various sources;
- The prioritization process was revised and includes a detailed description of how sensitive or highly valued received waters were considered and the results;
- Perennial/non-perennial criteria were removed from the revised prioritization process and the assessments no longer exclude areas based on flow;
- The HPWQC selection process was revised to address all requirements under Permit Provision B.2;
- Source information was updated to ensure that consistent, accurate information was included for all Copermittees and the City of Menifee;

- Language was added to source discussion to clarify the extent to which Copermittees and the City of Menifee have jurisdiction over agriculture;
- IC/ID information was updated to include five years of IC/ID data and related sources;
- Potential strategies tables were updated to better reflect the relationships between the strategies and the benefits to the PWQCs and HPWQC;
- Text and figures were modified for clarity and simplicity to better reflect the information considered within the prioritization process;
- The public participation process was updated to include additional outreach through public meetings;
- Clarification was added to describe how the City of Menifee and RCFCWCD were included in the assessment and prioritization process.

Based on comments received on the draft of **Chapter 2**, subsequent discussions with Regional Water Board and stakeholders, and a second Consultation Committee meeting held on May 17, 2017, the Copermittees and the City of Menifee submitted a revised draft of **Chapter 2** and an initial draft of **Chapter 3** to the Regional Water Board on July 7, 2017. The combined document was subsequently posted for public review by the Regional Water Board, with comments due by August 10, 2017. There were no further comments received from the public. Four sets of comments were received from Consultation Committee members, however, only comments from the Regional Water Board, received on October 11, 2017, are relevant to **Chapter 2**. Based on these comments, further revisions were made to **Chapter 2**. A summary of the key changes is provided below:

- Additional studies were considered in the evaluation of priorities and sources;
- Facilities, areas, and activities for which RCFCWCD is responsible were described in greater detail and a figure was added;
- Clarification was provided related to the geographic extent of the PWQCs and HPWQC with respect to the connectivity of MS4 discharges to receiving waters;
- Technical work related to the TMDL Alternative for eutrophication in the SMR Estuary was more fully incorporated into the evaluation of priorities and sources;
- Potential nutrient contributions from agriculture were better characterized for the watershed as a whole and for discharges that could be conveyed through the Copermittees' MS4s;
- Clarification was added related to regulation of discharges from agriculture, noting that discharges from agriculture that enter the Copermittee's MS4 is under their control;
- Source information, previously included in an appendix, was moved into **Chapter 2** and additional source information was added (subsequently updated to **Chapter 3**); and

- Potential strategies were updated to better relate to the PWQCs and HPWQC and to provide more detail.

1.5.2.5.2 Chapter 3 – Goals, Strategies, and Schedules[4]

In addition to the second Consultation Committee meeting, each Copermittee and the City of Menifee met with Regional Water Board staff during May 2017 to discuss their jurisdictional strategies. Following these meetings, an initial draft of **Chapter 3** (Goals, Strategies, and Schedules) was distributed to the Consultation Committee for review and feedback in June 2017. Comments received from the Consultation Committee by June 15, 2017 on **Chapter 3** are included in **Appendix 1B**. A combined document including a revised **Chapter 2** and the initial public draft of **Chapter 3** incorporated these comments and was submitted to the Regional Water Board on July 7, 2017. The draft was subsequently posted for public review, with comments due by August 10, 2017. There were no further comments received from the public. Four sets of comments were received from Consultation Committee members, including one set of written comments from the Regional Water Board received on October 11, 2017. Based on these comments, revisions have been made to **Chapter 3**. A summary of the key changes to **Chapter 3** in response to comments is provided below:

- Definitions were added for specific terms where needed (e.g., controllable);
- Rainbow Creek Nutrient TMDL compliance analysis and approach was revised;
- The "menu" approach for strategies was abandoned and tables of selected strategies were included in the document;
- Strategies were updated to ensure that each Copermittee addressed Permit Provisions E.2 – E.7;
- Strategies have been modified to include coordination with water districts;
- Strategies updated to include more specificity with respect to which PWQCs/HPWQC, sources, and conditions (i.e., dry/wet/both weather conditions) are addressed;
- Strategies were updated to include frequency as applicable; and
- Optional strategies were updated to include a better description of resources and triggers.

[4] In consideration of further comments, Chapter 3 – Goals, Strategies, and Schedules, was subsequently re-numbered to Chapter 4 with the addition of a chapter discussing sources.

2 Priority Water Quality Conditions

The first phase of the WQIP development identified the PWQCs associated with MS4 discharges that will be addressed by the WQIP. PWQCs are "pollutants, stressors and/or receiving water conditions that are highest threat to receiving water quality or that most adversely affect the quality of receiving waters."[5] To identify the PWQCs, the Copermittees and the City of Menifee used a prioritization process that identified the pollutants, stressors, and conditions that could impact each of the beneficial uses present in the watershed, assessed whether those pollutants, stressors, and conditions were present at levels that could be of concern for the beneficial uses, and assessed the potential contribution from MS4s to the identified conditions. The prioritization process utilized available physical, chemical, and biological data, considered known impacts to beneficial uses, and incorporated local knowledge and information about watercourse function, environmental values, community goals, and habitat preservation to determine the PWQCs and HPWQC. **Chapter 2** provides an overview of this prioritization process, the assessment results for each step in the process, and the resulting PWQCs and HPWQC identified as a result of the analysis.

2.1 PROCESS TO PRIORITIZE WATER QUALITY CONDITIONS

The developed prioritization process follows the order outlined in Permit Provisions B.2.a (Assessment of Receiving Water Conditions), B.2.b (Assessment of Impacts from MS4 Discharges), and B.2.c (Identification of Priority Water Quality Conditions). Available data were compiled and prepared for analysis by grouping the data into assessment areas, identifying the beneficial uses in the assessment areas, determining the physical, chemical and biological indicators that could impact the beneficial uses, and determining the analysis process and thresholds to use to assess potential impacts on beneficial uses. After the data were compiled and prepared for analysis, a four step process was used to identify the PWQCs. An overview of the prioritization approach is illustrated in **Figure 2-1** and detailed in **Figure 2-2**. **Table 2-1** provides an overview of how the prioritization process relates to the Permit requirements and the section that provides the assessment process and results for each prioritization step.

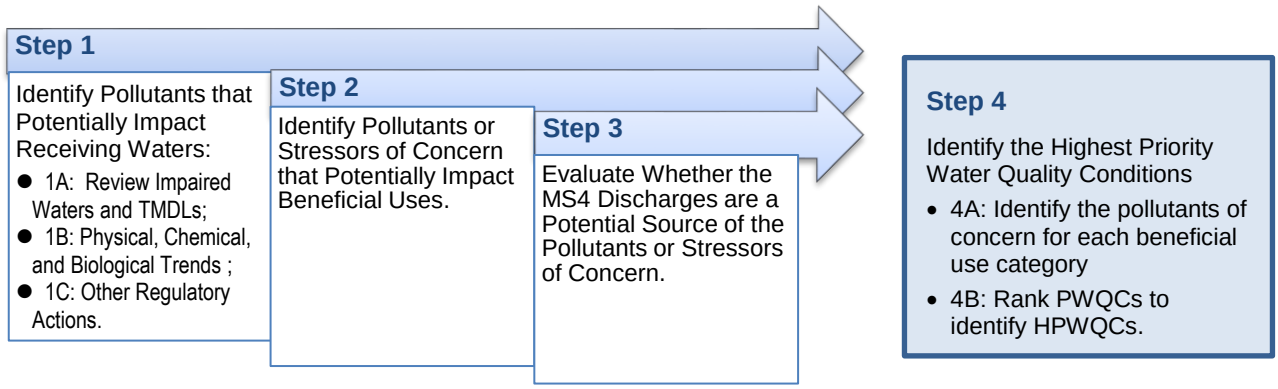

Figure 2-1. Prioritization Process

[5] Provision B.2.c.(1).

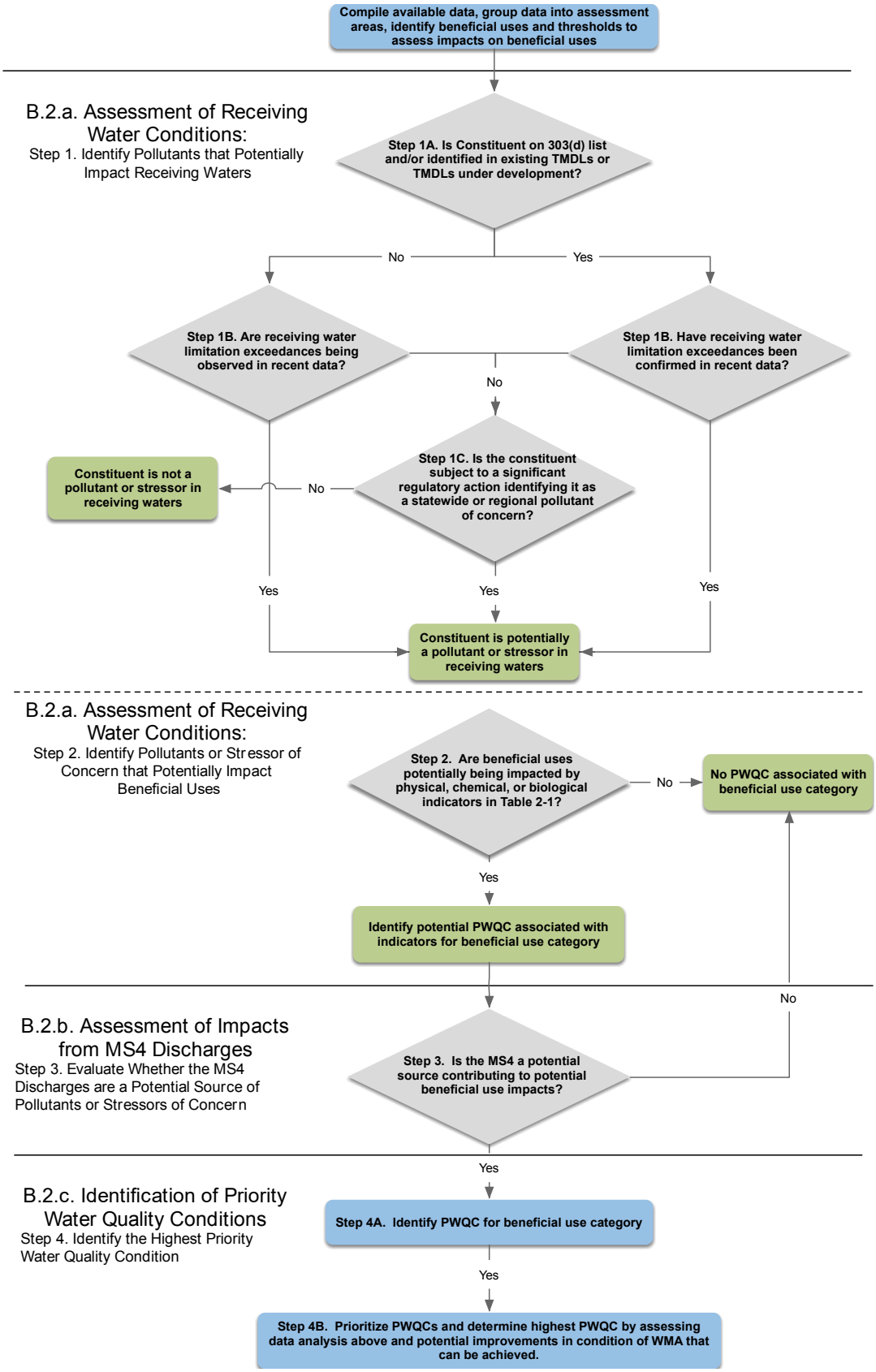

Figure 2-2. Prioritization Process for the SMR WMA

Table 2-1. Prioritization Process Overview and Associated Permit Requirements

Prioritization Step	Permit Requirements Addressed (Provision)
2.3 - B.2.a. ASSESSMENT OF RECEIVING WATER CONDITIONS	
2.3.1 - Step 1. Identify Pollutants and Stressors of Potential Concern in Receiving Waters	
2.3.1.1 – Step 1A. Impaired Receiving Waters and Total Maximum Daily Loads	B.2.a(1) Receiving waters listed as impaired on the Clean Water Act Section 303(d) List of Water Quality Limited Segments (303(d) List)
2.3.1.2 – Step 1A. Impaired Receiving Waters and Total Maximum Daily Loads	B.2.a(2) TMDLs adopted and under development by the Regional Water Board
2.3.1.3 – Step 1B. Evaluation of Receiving Water Limitation Exceedances and Comparison to Historical Conditions	B.2.a(4) Receiving water limitations of Permit Provision A.2 B.2.a(5) Known historical versus current physical, chemical, and biological water quality conditions B.2.a(6) Available, relevant, and appropriately collected and analyzed chemical receiving water monitoring data
2.3.1.4 – Step 1C. Identify Significant Regulatory Actions	N/A
2.3.2 - Step 2. Identify PWQCs Potentially Impacting Beneficial Uses	B.2.a(3) Sensitive or highly valued receiving waters[6] B.2.a(6) Available, relevant, and appropriately collected and analyzed physical, chemical, and biological receiving water monitoring data B.2.a(7) Available evidence of erosional impacts in receiving waters due to accelerated flows (i.e., hydromodification) B.2.a(8) Available evidence of adverse impacts to the chemical, physical, and biological integrity of receiving waters;
2.4 - B.2.b. ASSESSMENT OF IMPACTS FROM MS4 DISCHARGES	
2.4 – Step 3. Assessment of Potential MS4 Discharge Impacts	B.2.b(1) The discharge prohibitions of Provision A.1 and effluent limitations of Provision A.3 B.2.b(2) Available monitoring data from the Copermittees' MS4 outfalls B.2.b(3) Locations of each Copermittees' MS4 outfalls that discharge to receiving waters B.2.b(4) Locations of MS4 outfalls that are known to persistently discharge non-stormwater to receiving waters likely causing or contributing to impacts on receiving water beneficial uses B.2.b(5) Locations of MS4 outfalls that are known to discharge pollutants in stormwater causing or contributing to impacts on receiving water beneficial uses

[6] Defined in Order No. R9-2013-0001 as estuaries designated under the National Estuary Program under Clean Water Act Section 320, marine protected areas, wetlands defined by the State or U.S. Fish and Wildlife Service's National Wetlands Inventory as wetlands, waters having the Preservation of Biological Habitats of Special Significance (BIOL) beneficial use designation, and receiving waters identified as Areas of Biological Significance, or areas recognized as sensitive or highly valued by the Copermittees.

Prioritization Step	Permit Requirements Addressed (Provision)
2.5 and 2.6 - B.2.c. IDENTIFICATION OF PRIORITY WATER QUALITY CONDITIONS	
2.5. – Step 4A. Priority Water Quality Conditions	B.2.c(1) The Copermittees must use the information gathered for Provisions B.2.a and B.2.b to develop a list of priority water quality conditions as pollutants, stressors and/or receiving water conditions that are the highest threat to receiving water quality or that most adversely affect the quality of receiving waters. The list must include the following information for each priority water quality condition: • The beneficial use(s) associated with the priority water quality condition; • The geographic extent of the priority water quality condition within the Watershed Management Area, if known; • The temporal extent of the priority water quality condition (e.g., dry weather and/or wet weather); • The Copermittees with MS4 discharges that may cause or contribute to the priority water quality condition; and • An assessment of the adequacy of and data gaps in the monitoring data to characterize the conditions causing or contributing to the priority water quality condition, including a consideration of spatial and temporal variation.
2.6 – Step 4B. Highest Priority Water Quality Conditions	B.2.c(2) The Copermittees must identify the highest priority water quality conditions to be addressed by the Water Quality Improvement Plan, and provide a rationale for selecting a subset of the water quality conditions identified pursuant to Provision B.2.c.(1) as the highest priorities. B.2.a(9) The potential improvements in the overall condition of the watershed management area that can be achieved. B.2.b(6) The potential improvements in the quality of discharges from the MS4s that can be achieved.

2.2 AVAILABLE, RELEVANT AND APPROPRIATELY COLLECTED AND ANALYZED DATA RECEIVED

The Copermittees and the City of Menifee identified the available data and information for receiving water conditions, MS4 discharges, and sources of pollutants within the SMR WMA. Data were obtained from Copermittees, publicly available datasets, and through a public request for data (as described in **Section 1.5.2.1)**.

Sources of raw data available for the assessment are listed in **Table 2-2**. The datasets obtained were from the following sources:

- RCFCWCD MS4 NPDES permit monitoring data, which included data from the Southern California Stormwater Coalition Monitoring (SMC).
- County of San Diego MS4 NPDES permit monitoring data.
- Santa Margarita River Nutrient Initiative Group (SMRNIG) dataset from the water quality database developed for the *Hydrological and Biological Support to the Lower Santa Margarita Watershed Monitoring Program* final report (Stetson, 2010).
- California Environmental Data Exchange Network (CEDEN), which was a combined dataset from the United States Environmental Protection Agency (USEPA), Southern California Bight Program, SMC and Surface Water Ambient Monitoring Program (SWAMP) extracted from the CEDEN website.

- California Storm Water Multiple Applications and Report Tracking System (SMARTS) and California Integrated Water Quality System (CIWQS) Project databases were also reviewed to identify industrial and Publicly Owned Treatment Works (POTW) data. No relevant data and information were found in these databases.

The types of data and information that were obtained from these datasets generally included field measurements, field observations, photographs, site/field reconnaissance findings and mapping, water quality chemistry, bioassessment, toxicity, algal biomass and CRAM information. Where multiple datasets contained data from the same monitoring program (e.g. SMC), duplicates were removed from the compiled dataset.

Table 2-2. SMR WMA Receiving Water Data Sources- Raw Datasets

Data Source	Program	Period of Record	# of Locations	Data Type					
				Chemistry	Field Data	Observations/ Photographs	Biological	Toxicity	Physical Habitat
RCFCWCD	MS4 Permit	1993 – 2015	41	X	X	X	X	X	-
	SMC	2009 – 2015	41	X	X	X	X	X	X
CEDEN	SMC	2009 – 2015	41	X	X	X	X	X	-
	SWAMP	2003 – 2013	15	X	X	X	X	-	-
	So. Cal Bight Program	2003 – 2008	6	X	X	X	-	-	-
SMRNIG (Stetson)	State Water Board	1951 – 1988	9	X	X	-	-	-	-
	USEPA	1949 – 2001	32	X	X	-	X	-	-
	Law Crandall	1948 – 2000	6	X	X	-	-	-	-
	Mission Resource Conservation District	1995 – 1999	2	X	X	-	-	-	-
	RCFCWCD	1993 – 2007	15	X	X	-	-	X	-
	Rancho California Water District	1997 – 2007	5	X	X	-	-	-	-
	Regional Water Board	1998	8	X	-	-	-	-	-
	Stetson 2004 and 2009	2003 – 2009	35	X	X	-	X	-	-
	SWAMP	2005 - 2011	7	X	X	-	-	-	-
	Unknown	1963 – 1999	8	X	X	-	-	-	-
	USGS	1966 – 1982	3	X	X	-	-	-	-
	Water Master	1971 – 2002	33	X	X	-	-	-	-
	USEPA	2001	1	X	X	X	X	-	-
San Diego County	MS4 Permit	2008 - 2015	22	X	X	-	X	X	X

Note: Available data are indicated in the table by a "X.". Dashes indicate data were not available in the dataset for the given data type.

In addition to these programs, multiple special studies have been performed for areas within the SMR WMA. These studies provided additional information related to sources of nutrients in the watershed, contributions from other sources such as federal, state, and tribal lands, the effects of hydromodification on receiving waters, sediment toxicity, sources of iron and manganese in the watershed, the presence of trash in the watershed, and TMDL-related information. The special studies used in the prioritization process are shown in **Table 2-3**. Other studies used for evaluating sources are discussed in **Appendix 3A**.

Table 2-3. Other Types of Data Used for PWQC Identification [1]

Special Study Title	Type of Data	Notes
Eutrophication and Nutrient Cycling in Santa Margarita River Estuary: A Summary of Baseline Studies for Monitoring Order R9-2006-0076 (Estuary Data Report)	Algal biomass and percent cover, dissolved oxygen, total nitrogen and total phosphorus concentrations and fluxes between water and sediment.	---
Status of Eutrophication over a Two Year Period (2015-2016) in Lower Santa Margarita River, San Diego, California (SMRNIG Phase I Data Report)	Benthic algal abundance, benthic organic carbon, dissolved oxygen, pH, total nitrogen and total phosphorus concentrations, stream velocity, depth, discharge, channel substrate and riparian canopy cover.	Two year study in three portions of river.
Santa Margarita River Watershed Phase II-Sediment and Nutrient Calibration Memorandum	Results of Watershed Loading Model calibration for nitrogen and phosphorus.	---
Calibration of Linked Hydrodynamic and Water Quality Model for Santa Margarita Lagoon	Results of estuary model calibration for algae, dissolved oxygen, nitrogen and phosphorus.	---
Application of watershed loading and estuary water quality models to inform nutrient management in the Santa Margarita River Watershed.	Results of using the watershed loading model and estuary model to inform major science objectives for the SMRNIG, including understanding the major pathways that supply nutrients to the SMR Estuary, estimate the range of allowable loads to the SMR Estuary, evaluate potential numeric targets, identify preliminary scenarios for evaluating nutrient management, and estimate sources of nutrients to SMR Estuary.	---
Hydromodification Monitoring Project	Channel and bank conditions (gradient, particle size, channel width), location of discharge points, habitat integrity (individual CRAM attribute scores and selected parameters from SWAMP stream physical habitat characterization), quantification of bank eroded areas, and vertical and lateral susceptibility ratings.	Three monitoring locations.

Special Study Title	Type of Data	Notes
Sediment Toxicity Special Study, Santa Margarita Region, 2013-2014 Final Report	Analytical results for particle size, general chemistry, trace metals, organochlorine pesticides, and synthetic pyrethroids. Acute and chronic solid phase toxicity bioassay results, rapid stream bioassessment results (including IBI scores for four reaches).	---
Transitional Monitoring and Assessment Program Report for the Santa Margarita River Watershed Management Area (2014 - 2015)	Dry and wet weather receiving water trends.	One monitoring location

1. Pesticides Subcommittee Annual Report and Effectiveness Assessment 2014-2015 contains qualitative updates regarding short-term and long-term pesticide management efforts and concerns that are not immediately relevant to the assessment of receiving water conditions.

2.2.1 Assessment Areas

All available data were compiled and reviewed to conduct this assessment. Based on the data review, virtually no water quality data were identified to support the evaluation of the Upper SMR subwatershed, which is comprised of a total of 15 subareas. Where available, data for the Upper SMR Subwatershed are included in the tables in Sections 2 and 3.

As described in Section 1.3, the Upper SMR subwatershed has much lower population density and limited infrastructure relative to the Middle SMR subwatershed, and is hydrologically disconnected from the Middle and Lower SMR subwatersheds in all but very large storm events or storm series. Due to the lack of water quality data, very few documented water quality concerns, the absence of impaired beneficial uses in the lakes, and the hydrologic disconnection from the downstream subwatersheds created by the lakes, the Upper SMR subwatershed could not be fully evaluated using the process described in Sections 2.3 – 2.6 and Section 3. In particular, although there are 303(d) listings for Temecula Creek (Step 1A), the data used to support the listings were collected downstream from Vail Lake, and there are no data documenting exceedances within this subwatershed; so Step 1B of the process could not be completed. There were also no available data regarding erosional or other adverse impacts to receiving waters, and Step 2 could not be completed. In addition, data were not available from the Upper SMR Subwatershed to characterize discharges or potential impacts from developed areas, so Step 3 could not be completed.

Therefore, although the Upper SMR Subwatershed was characterized and evaluated, there were insufficient recent data to assign PWQCs and/or HPWQCs. However, a new Receiving Water Monitoring Site has been identified upstream of Vail Lake and monitoring will be conducted as specified in Section 5. As part of the WQIP adaptive management process, further evaluation of this subwatershed area will be conducted in the future as more data become available and in consideration of any new receiving water conditions of concern, and this WQIP will be updated accordingly. Although PWQCs and HPWQCs were not identified for the Upper SMR Subwatershed in this evaluation, the strategies identified in Section 4 will be implemented as applicable in the Upper SMR Subwatershed and as described in the JRMPs to ensure any potential water quality impacts are avoided.

The three subwatersheds of the SMR WMA are comprised of the 28 hydrologic subareas listed in Table 2-4 and shown in Figure 2-3. This delineation was based on a combination of watershed hydrologic subareas and the 2010 Clean Water Act Section 303(d)/305(b) Integrated Report (**Figure 2-3** and **Table 2-4**).

Table 2-4. Subareas in the SMR Subwatersheds

Upper SMR Subwatershed	Middle SMR Subwatershed	Lower SMR Subwatershed
Chihuahua Creek	Upper Murrieta Creek and Tributaries	Upper Santa Margarita River
Rattlesnake Creek-Temecula Creek	Warm Springs	Lower Santa Margarita River
Tule Creek	Murrieta and Long Canyon Creeks	Rainbow Creek
Long Canyon	Santa Gertrudis Creek	Sandia Creek

Cottonwood Creek-Temecula Creek	Temecula Creek and Redhawk Channel	De Luz Creek
Upper Cahuilla Creek	Pechanga Creek	Fallbrook Creek
Lower Cahuilla Creek		Santa Margarita River Estuary
Upper Wilson Creek		
Lower Wilson Creek		
Arroyo Seco Creek		
Rawson Canyon		
Upper Tucalota Creek		
Temecula Creek		
Warm Springs Creek		
Lower Tucalota Creek		

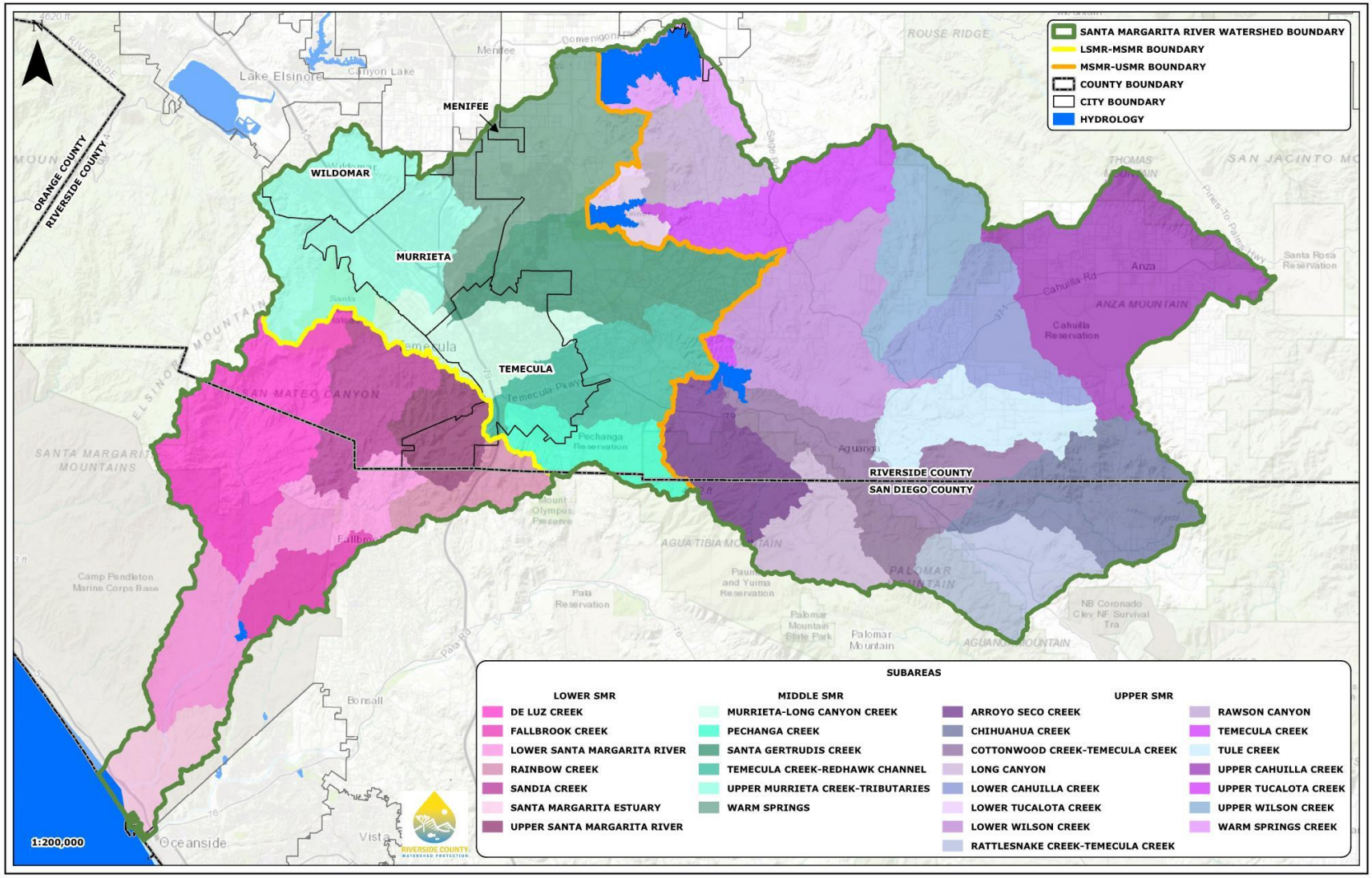

Figure 2-3. Priority Condition Assessment Subareas

2.2.2 Beneficial Uses and Thresholds to Assess Data

Beneficial uses for the SMR WMA are designated in the Water Quality Control Plan for the San Diego Basin (Basin Plan) (California Regional Water Quality Control Board, 1994 as amended in 2016). Per the Basin Plan, "Beneficial uses are defined as the uses of water necessary for the survival or well being of man, plants and wildlife." The designated beneficial uses for the SMR WMA are summarized in **Appendix 2**. Beneficial uses for Diamond Valley Lake, Lake Skinner, and Vail Lake are also described in Section 1.3, above. Per the Basin Plan:

"Existing beneficial uses were originally determined as part of a use survey of water resources in the Region described in Chapter 1, History of Basin Planning in the San Diego Region. Beneficial use designations have also been determined using additional information gathered since 1975. Beneficial uses are designated as "potential" for a variety of reasons, including:

- Plans are proposed to put the water to a future use;
- Potential exists to put the water to a future use;
- The public desires to put the water to future use;
- The water is potentially suitable for municipal or domestic water supply under the terms of the Sources of Drinking Water Policy (State Board Resolution No. 88-63); or
- The Regional Board has designated a beneficial use as a regional water quality goal."

Designated beneficial uses can only be modified through a use attainability analysis that meets the requirements of Title 40 of the Code of Federal Regulations (CFR) 131.10(g).

The WQIP is designed to support protection of the thirteen designated beneficial uses in the SMR WMA. Many of these beneficial uses have overlapping or related pollutants, stressors, and conditions that could be pollutants of concern. To streamline the analysis and aid in identifying PWQCs, the thirteen designated beneficial uses were grouped into five beneficial use categories (shown in **Table 2-5**). The groupings provide an organized framework for the large amount of data that is included in the analysis and focus the analysis on beneficial use impacts. The beneficial use categories do not represent Basin Plan designated beneficial uses. The assessments conducted in Steps 1 through 3 are all organized around these five beneficial use categories.

Based on the review of the available data summarized above, physical, chemical and biological indicators were identified that could be used to assess impacts to the beneficial use categories in the Subwatersheds. For each of these indicators, thresholds developed to protect beneficial uses were identified. Water quality objectives (WQOs) were used as the threshold where available, but WQOs do not exist for all identified chemical, physical, and biological indicators. For indicators without WQOs, thresholds were identified from available literature and guidance. The WQOs used for the assessment are included in **Appendix 2**. Other identified thresholds are discussed in **Section 2.3.2** in the summary of the assessment process for the indicator.

The beneficial use category, associated beneficial uses, and associated physical, chemical and biological indicators used to assess the potential impact on the beneficial uses are shown in **Table 2-5**. The assessments conducted to develop PWQCs are based on these beneficial use categories and indicators. Per the Basin Plan, "Designated beneficial uses are generally, but not always, present throughout the entire reach of a particular hydrologic unit, area, subarea, or water body.

Designated beneficial uses may not be present throughout the year." However, the Regional Water Board has noted that there are no seasonal variations identified in the designated surface waters (which includes the unlisted tributaries to these surface waters) in the Basin Plan tables. As a result, the assessments were conducted for all receiving water conditions, even though surface waters may not be present year-round.

Table 2-5. Beneficial Uses and Associated Physical, Chemical, and Biological Indicators Within the Santa Margarita River WMA

Beneficial Use Category [4]	Beneficial Uses	Physical, Chemical, and Biological Indicators
Aquatic Life	WARM COLD WILD RARE BIOL (limited) SPWN (limited)	Algal biomass Benthic community indices (IBI/CSCI) Dissolved Oxygen Total Nitrogen Total Phosphorus Ammonia Pesticides [1] Metals [2] Toxicity Sediment – visual observations [5] Physical habitat scores (CRAM) Evidence of erosion and hydromodification Trash
Recreation	REC-1 REC-2	Trash Fecal Coliform *E. coli*
Water Supply	MUN GWR	Nitrate Title 22 Constituents[3]
Agricultural Supply	AGR	Total Dissolved Solids Chloride Boron
Industry	IND PROC	pH Total Dissolved Solids

1. Pesticides include: Organophosphorus, Organochlorine, and Pyrethroid pesticides.
2. Metals include: Copper, Nickel, Zinc, and Selenium.
3. A full list of the California Code of Regulations Title 22 (Title 22) Constituents is included in **Appendix 2**.
4. Beneficial use categories were developed to group related designated beneficial uses from the Basin Plan for ease of assessment in the Water Quality Improvement Plan. Beneficial use categories are not designated in the Basin Plan.
5. Visual observations provided by Consultation Committee.

2.3 ASSESSMENT OF RECEIVING WATER CONDITIONS

The assessment of receiving water conditions consisted of two steps. Step 1 identified all constituents that could potentially impact beneficial uses. The identification was completed by summarizing constituents on the 303(d) list and identified in TMDLs or TMDLs under development that are causing impairments (Step 1A), comparing chemical data to WQOs to identify other pollutants with the potential to impair waterbodies (Step 1B), assessing known historic conditions and identifying if conditions are of potential concern based on more recent data by evaluating trends (Step 1B), and reviewing regulatory actions to determine if any other constituents have been identified as a priority by Regional or State Water Boards (Step 1C).

Step 2 identifies potential beneficial use impacts through a comparison of physical and biological data to identified thresholds.

2.3.1 Step 1. Identify Pollutants and Stressors of Potential Concern in Receiving Waters

2.3.1.1 Step 1A. Impaired Receiving Waters - 303(d) Listings (Permit Provision B.2.a(1))

In this step, the Copermittees identified constituent/water body combinations that are on the 303(d) list that could be considered pollutants or stressors of potential concern in receiving waters.

The Clean Water Act Section 303(d)/305(b) Integrated Report (Integrated Report) identifies the condition of the region's surface waters as well as the water quality limited segments that are identified as "impaired" or "threatened" (the 303(d) list). In California, water bodies are assessed and listed consistent with the State Water Board's Listing Policy. (California State Water Resources Control Board, 2004)

The receiving waters in the SMR WMA listed as impaired in the 2010 Integrated Report are summarized in **Table 2-6**. The 2010 Integrated Report is currently being updated. A proposed 2014/2016 list of impaired waters was approved by the State Water Board on October 3, 2017, but has not yet been approved by USEPA. Because the proposed listings are not yet effective, they have not been included within **Table 2-6**. However, the Step 1B assessment includes a review of the data used for the development of the 2014/2016 list to identify additional constituents that may be contributing to impairments based on data collected since the 2010 303(d) list and the State Water Board approved list was considered in the identification of PWQCs.

Table 2-6. 2010 303 (d) Listings for the SMR WMA

	Water Body [3]												
	Upper Santa Margarita River Subwatershed	Middle Santa Margarita River Subwatershed						Lower Santa Margarita River Subwatershed					
Pollutant/ Stressor	Temecula Creek [2]	Warm Springs	Long Canyon Creek [1]	Murrieta Creek [1]	Santa Gertrudis Creek	Temecula Creek [2]	Redhawk Channel [2]	Santa Margarita River Upper	Santa Margarita River Lower	Rainbow Creek [4]	De Luz Creek	Sandia Creek	Santa Margarita River Estuary [5]
Aluminum										•		•	
Chlorpyrifos	•	•	•	•	•	•	•		•				
Copper	•			•	•	•	•						
Diazinon							•						
Escherichia coli (*E. coli*)	•	•			•	•	•						
Enterococcus								•	•				
Eutrophic													X X
Fecal Coliform	•	•	•		•	•	•		•				
Fecal Indicator Bact	•					•		•					
Iron		•	•	•	•		•	•		•	•	•	
Manganese		•	•	•	•		•	•			•		
Nitrogen				•			•	•		X	•		
Phosphorus	•	•		•	•	•	•	•	•	X			
Selenium												•	
Silver												•	
Sulfates										•	•	•	
Total Dissolved Solids	•					•	•			•		•	
Total Nitrogen as N		•							•				
Toxicity	•			•		•		•					

1. Both reaches are within the Murrieta and Long Canyon Creeks subarea.
2. Both reaches are within the Temecula Creek and Redhawk Channel subarea. Listed extent of Temecula Creek lies within the Temecula Creek-Redhawk Channel, Cottonwood Creek-Temecula Creek, and Rattlesnake Creek-Temecula Creek subareas.
3. There are no 303(d) listed waterbodies in the Pechanga Creek subarea in the Middle SMR Subwatershed; Fallbrook Creek subarea in the Middle SMR Subwatershed; or in the Chihuahua Creek, Tule Creek, Long Canyon, Upper Cahuilla Creek, Lower Cahuilla Creek, Upper Wilson Creek, Lower Wilson Creek, Arroyo Seco Creek, Rawson Canyon, Upper Tucalota Creek, Temecula Creek, Warm Springs Creek or Lower Tucalota Creek subareas in the Upper SMR Subwatershed. There are no 303(d) listings for Vail Lake, Lake Skinner, or Diamond Valley Lake.
4. X – Currently being addressed by a TMDL.
5. XX – Currently being addressed by development of a TMDL Alternative project.

2.3.1.2 Step 1A. TMDLs

In this step, the Copermittees identified TMDLs that have been adopted or are under development.

2.3.1.2.1 Adopted TMDLs

The only adopted TMDL in the SMR WMA is the Rainbow Creek Nutrient TMDL (Basin Plan Amendment: Resolution No. R9-2005-0036), which became effective in 2006 (San Diego RWQCB, 2006). The TMDL includes targets and allocations to address nitrogen and phosphorus 303(d) listings in Rainbow Creek. In 2013, the TMDL was incorporated into Attachment E.3 of the Permit. The County of San Diego is the only Copermittee subject to this TMDL.

2.3.1.2.2 SMR Estuary TMDL Alternative

In 2011, a diverse group of stakeholders (cities and counties, utility districts, Caltrans, scientists, tribes, environmental groups, USGS, Camp Pendleton, Farm Bureau, Regional Water Board staff) formed the SMRNIG with the goal of addressing eutrophic, nitrogen and/or phosphorus 303(d) listings in the SMR WMA. The multi-year process will address the 303(d) listings in four reaches: SMR Estuary, Lower Santa Margarita River to confluence with De Luz Creek, Upper Santa Margarita River, and the Tributaries to the Santa Margarita River (hereafter called the Upper SMR Subwatershed[7]). The Regional Water Board is currently planning to formalize the regulatory requirements for the TMDL Alternative for the SMR Estuary by the end of 2018. The work that has been completed to date is summarized below. The listings in the remaining portions of the watershed will be addressed as funding is available.

The SMRNIG received two Proposition 84 grants to conduct studies and analyses to support the development of a TMDL Alternative for the watershed.

1. The first grant covered data analysis in the SMR Estuary to identify potential targets as well as monitoring in the SMR below the confluence with De Luz Creek.
2. The second grant covered the data analysis for the river monitoring conducted under the first grant as well as monitoring of the remainder of the SMR and tributaries.

The results of the monitoring and data analysis are summarized in two reports:

1. *Eutrophication and Nutrient Cycling in Santa Margarita River Estuary: A Summary of Baseline Studies for Monitoring Order R9-2006-0076* (Estuary Data Report)*;* and
2. *Status of Eutrophication over a Two Year Period (2015-2016) in Lower Santa Margarita River, San Diego, California* (SMRNIG Phase I Data Report).

The major findings of the reports were that the SMR Estuary is "exhibiting symptoms of eutrophication, as documented by high biomass and cover of macroalgae and episodes of low dissolved oxygen." Additionally, high dry weather concentrations of nutrients in the SMR Estuary indicate the presence of anthropogenic sources of nutrients. Findings from the SMRNIG Phase I Data Report identified significant variations in concentrations depending on the season for all parameters measured. The majority of the nitrogen and phosphorus observed results were below Basin Plan WQOs. The monitoring showed some periods of low DO in the summer. Higher algal biomass was observed in 2015 as compared to 2016 when concentrations were similar to reference conditions. The results of the studies identified that eutrophication is a concern in the SMR Estuary

[7] For the purpose of this TMDL Program the "Upper SMR Subwatershed" refers to both the Upper and Middle subwatershed areas as defined under the WQIP.

and nutrient loading from the watershed is contributing to the eutrophication in the Estuary. Results are less clear in the Lower SMR and eutrophication was not identified in the river as part of the SMRNIG Phase I Data Report.

As part of the development of the TMDL Alternative for the SMR Estuary, the SMRNIG partner, Marine Base Camp Pendleton, sponsored Space and Naval Warfare Systems Command (SPAWAR) to develop an estuary model using monitoring data for total nitrogen, total phosphorus, algal biomass, and dissolved oxygen collected in 2008 and 2009 in the SMR Estuary. The Estuary model predicts the dissolved oxygen and algal biomass concentrations resulting from total nitrogen and total phosphorus loading to the SMR Estuary. Several model scenarios were run to assess the changes in dissolved oxygen and algal biomass concentrations predicted to result from reducing loadings of total nitrogen and total phosphorus to the SMR Estuary. The results of the model scenarios are summarized in the Model Application Report (Sutula, et al., 2016).

In addition to the Estuary model, a watershed loading model was developed by Tetra Tech on behalf of the Regional Water Board for the SMR Watershed. The purpose of this model was to predict the loadings from the watershed into the SMR Estuary and estimate the contributions from various land based sources (e.g. agricultural, open space, Caltrans, federal lands, and MS4s). The watershed loading model was only calibrated at the base of the watershed at the point of entry into the SMR Estuary. As a result, the loading estimates for areas upstream of the SMR Estuary are preliminary and will likely be refined as future phases are completed. The results of the watershed loading model are also presented in the Model Application Report.

The relevant findings for the WQIP development from the Model Application Report were as follows:

- Eutrophication is a dry weather concern in the SMR Estuary. Eutrophication symptoms are present during dry weather, and exhibit their peak during summer dry weather. Uncertainties exist regarding the impact of wet weather discharges on groundwater concentrations that could ultimately result in baseflows during dry weather.
- As configured in the Estuary model, major external sources of total nitrogen (TN) to the SMR Estuary during dry weather consist of surface water and local groundwater inputs, while major total phosphorus (TP) sources include surface water and upstream aquifer discharge, though many uncertainties exist in the estimates.
- Dissolved oxygen and macroalgal biomass and cover have demonstrated linkages to beneficial uses, have a predictive relationship with nutrient loading to the SMR Estuary, and have practical and generally cost-effective methods for measurement and interpretation of data. These two indicators seem to be well suited for further consideration as numeric targets for the SMR Estuary. Use of TN and TP targets is not recommended because ambient TN and TP concentrations do not have a strong linkage to beneficial use impairments.
- The watershed loading model provides a quantitative basis for summarizing the nutrient loads and sources for the SMR watershed, for the purpose of supporting nutrient management discussions. While tools for modeling watershed loading can be improved, the basic requirements for quantitative analysis are met.

While the Rainbow Creek Nutrient TMDL used a numeric interpretation of the narrative Basin Plan WQOs to derive TN and TP targets and associated allocations for various sources, the TMDL Alternative for the SMR Estuary is focused on reducing nutrient loading to the SMR Estuary to

prevent low dissolved oxygen and benthic community impacts that result from excess algal biomass, based on the findings in the Model Application Report. As a result, the TMDL Alternative for the SMR Estuary will likely have targets based on some combination of DO, algal biomass and benthic community scores rather than TN and TP concentrations. Then, necessary TN and TP load reductions to meet those targets in the SMR Estuary (based on the Estuary model scenarios) will be used to develop load and wasteload allocations based on the watershed loading model.

To facilitate this process, several technical memoranda have been prepared by the SMRNIG and provided to the Regional Water Board for consideration in the TMDL Alternative development. These technical memoranda, combined with the Model Application Report, were used to inform the selection of the PWQCs and to develop goals and strategies for the WQIP. Because the TMDL Alternative for the SMR Estuary is still under development, the information provided in the WQIP is subject to revision once the TMDL Alternative for the SMR Estuary is approved. Additionally, if future phases of the project are funded, relevant findings will be incorporated into the WQIP as part of the adaptive management process.

2.3.1.3 Step 1B. Evaluation of Receiving Water Limitation Exceedances and Comparison to Historical Conditions (Provisions B.2.a.(4) and B.2.A.(5))

To assess the receiving water quality conditions, Step 1B of the prioritization process included two types of analyses: 1) evaluation of exceedances of receiving water limitations and a comparison of the results to the 303(d) listings, TMDLs, and known historic conditions; and 2) historic data review and a trend analysis to compare current conditions to known historic conditions. The data used for the two assessments is described in the following section.

2.3.1.3.1 Data Used in the Assessment

The available raw data included samples from 1950 to 2015. All historic data was included in a qualitative review for an assessment of historic conditions. However, upon review of the full dataset, it became clear that data prior to 1998 was not collected with established Quality Assurance Project Plans (QAPPs) and, therefore, lacked sufficient data quality to be used in assessing the receiving waters (e.g., inconsistent methods, issues with reporting limits; discussed further in **Section 2.5.2**). Therefore, the time period from 1998 to 2015 was selected to perform the data evaluation and assess trends. For the evaluation of exceedances of receiving water limitations, data from 2005 to 2015 was selected to represent the current conditions because monitoring data during that time period reflects requirements from the two most recent MS4 NPDES permit cycles. Locations of the monitoring sites used for the assessment are shown in **Figure 2-4**.

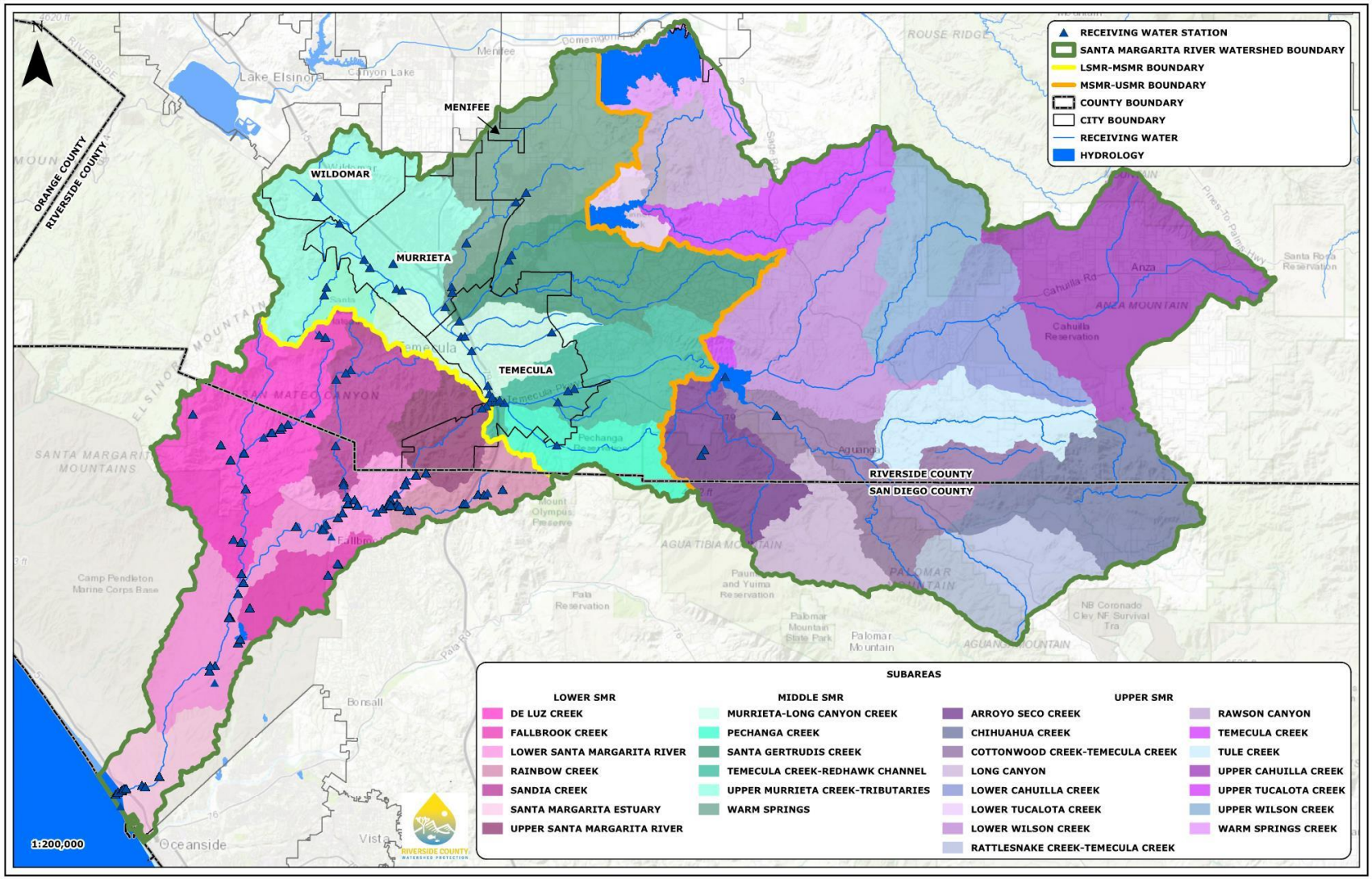

Figure 2-4. Historic Receiving Water Monitoring Stations Used in Assessment

2.3.1.3.2 Evaluation of Receiving Water Limitation Exceedances

The evaluation of receiving water limitation exceedances was conducted by comparing all constituents to applicable WQOs for the designated beneficial uses in the subarea. WQOs contained in the Basin Plan, California Toxics Rule (CTR), and the National Toxics Rule (NTR) identified as receiving water limitations in Permit Provisions A.2 and B.2 were compiled for the evaluation and are included in **Appendix 2**. The following approach was used to select the WQOs used for the exceedance evaluation. Where conflicting objectives were identified, the most conservative objective was chosen.

- For dry weather samples, the lowest applicable acute, chronic, or human health objective from either the CTR/NTR or the Basin Plan was used for the evaluation.
- For wet weather samples, the lowest acute objective between the CTR/NTR and the Basin Plan was selected. If there were no acute objectives, the CTR/NTR or Basin Plan WQOs with the shortest averaging period was selected.
- Reach-specific objectives apply for total dissolved solids (TDS), sulfate, chloride, and dissolved oxygen and were applied appropriately for the reach where the sample was collected.
- For WQOs that are calculated using pH, temperature or hardness, the pH, temperature and/or hardness of the sample was used to calculate the objective if available. If not available, the median value for all wet and/or dry samples was used to calculate the value of the objective.

For this evaluation, exceedances were defined as a subarea that has not met an applicable WQO in at least two samples and more than 10% of all samples in the subarea. The ≥10% threshold was used as it is an allowable exceedance frequency for objectives for biostimulatory substances, dissolved oxygen, and all constituents in Tables 3-2 in the Basin Plan and it approximates the thresholds used for evaluation in the State Water Board's Listing Policy[8] (California State Water Resources Control Board, 2004). **Figure 2-5** summarizes the constituents with current exceedances during dry and wet weather conditions. Constituents on the 303(d) list for the subarea are bolded and underlined in the figure.

In some cases, the exceedance analysis demonstrated that WQOs are no longer being exceeded for some constituents on the 303(d) list. While there were insufficient data to delist the constituents in most cases, the lack of recent exceedances, combined with a stable or decreasing trend analysis, was determined to be sufficient evidence that these constituents were likely no longer a pollutant of concern in receiving waters (e.g., chlorpyrifos).

[8] The Listing Policy uses a binomial distribution approach based on the number of samples that has a hypothesis that the actual exceedance proportion is between 10 and 25% for conventional pollutants and between 3 and 18% for toxicants. Ten percent was selected as a threshold for streamlined analysis that was on the lower end for conventional pollutants and in the range of the thresholds for toxic pollutants.

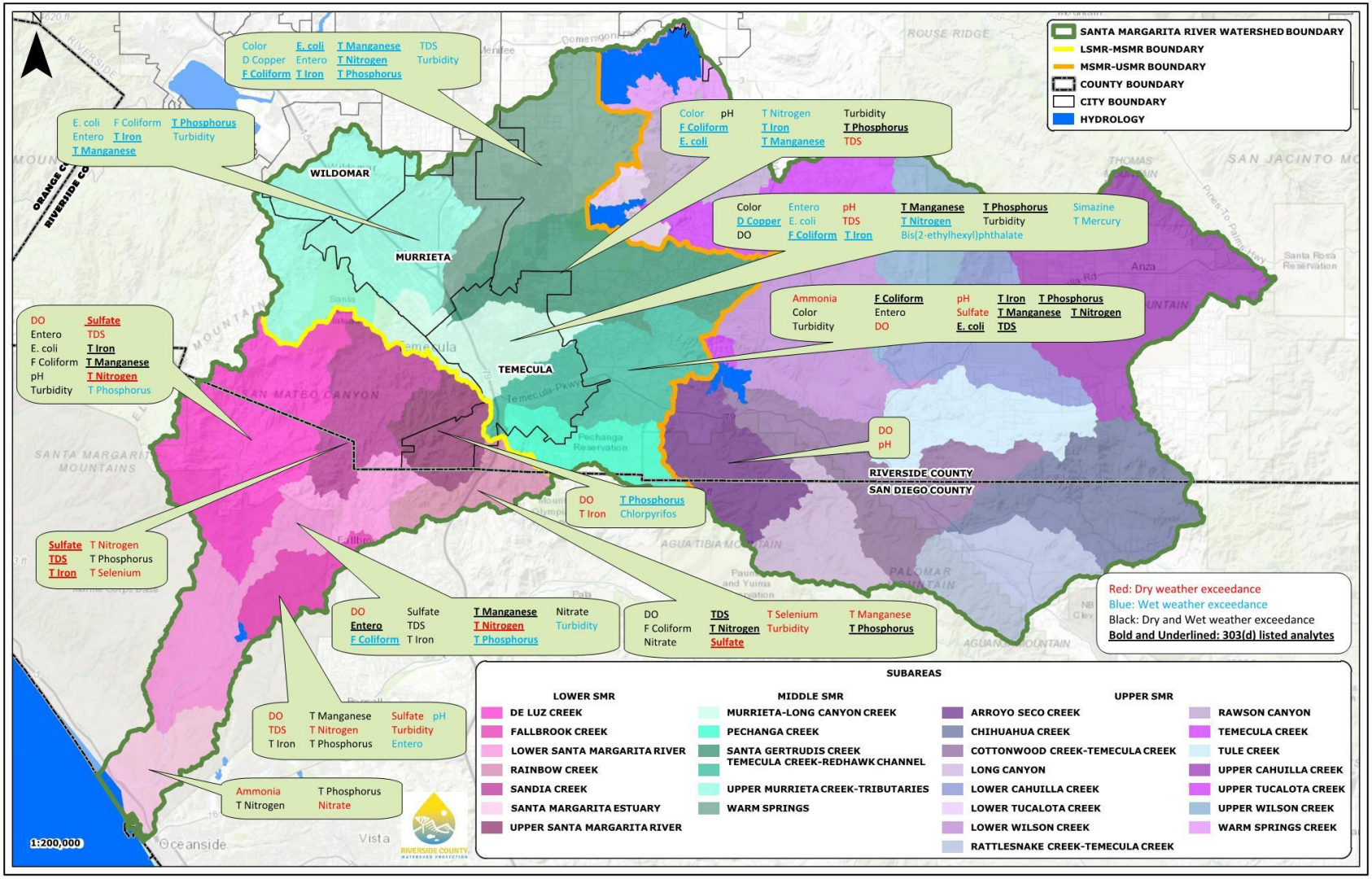

Figure 2-5. Water Quality Objective and Threshold Exceedances Identified in Receiving Waters (Recent Data: 2005 – 2015)

2.3.1.3.3 Comparison to Historical Conditions

Comparison of current data to known historic conditions was evaluated through a trends analysis.

For the Middle SMR Subwatershed, a trend analysis was conducted using data from 1998-2015, grouped by subarea, to assess whether the water quality indicator conditions were improving, declining, or stable. The trend analyses were conducted using the Mann-Kendall (M-K) test (Helsel, Hirsch, 2002). The M-K test is a simple but robust statistical method to find trends in datasets. The M-K test cannot assess trends for datasets with three or fewer samples.

The statistic of the M-K test (S) is computed by evaluating differences between all possible pairs of measurements in the dataset. An S value greater than zero indicates that the majority of later measurements are larger than the earlier ones, suggesting an upward trend over time. Similarly, a negative S value implies that earlier measurements are larger and the trend over time is decreasing. The decision for how the water quality of the receiving water is changing (or not) was made according to the rules shown in **Table 2-7** (Aziz, 2003):

Table 2-7. Trend Estimation Based on M-K Test Statistic (S) and Critical S Value ($S_{crit95\%}$)

Rule	Condition	Trend
1	$S > 0$ and $S > S_{crit\ 95\%}$	Declining
2	$S > 0$ and $S_{crit\ 90\%} < S < S_{crit\ 95\%}$	Probably Declining
3	$0 < S < S_{crit\ 90\%}$	No trend
4	$S \leq 0$, $\lvert S \rvert < S_{crit\ 90\%}$, and COV ≥ 1	No trend
5	$S \leq 0$, $\lvert S \rvert < S_{crit\ 90\%}$, and COV < 1	Stable
6	$S < 0$ and $S_{crit\ 90\%} < \lvert S \rvert < S_{crit\ 95\%}$	Probably Improving
7	$S < 0$ and $\lvert S \rvert > S_{crit\ 90\%}$	Improving

COV: Coefficient of variation

DO is the only exception to the stated rules, given that an increasing DO concentration results in an improving condition, and decreasing DO values are linked to a declining condition.

For the Lower SMR Subwatershed, due to readily available trends analysis from the recent SMR WMA Transitional Monitoring and Assessment (TMAR) Report (County of San Diego, 2016), the statistical analysis was not needed for the Lower SMR. The TMAR Report presented an analysis of receiving water trends using the historical dataset for the SMR-MLS-2 Long Term Monitoring Station (LTMS).

The trend analyses are presented in **Table 2-8** for wet weather and **Table 2-9** for dry weather. The detailed statistical results for the trend analysis for exceedances in the Middle SMR Subwatershed are included in **Appendix 2**.

Table 2-8. Trend Analysis of Current versus Historical Water Quality Conditions in Wet Weather

Subarea	Murrieta and Long Canyon Creeks	Santa Gertrudis Creek	Temecula Creek and Redhawk Channel	Upper Murrieta Creek and Tributaries	Warm Springs	Santa Margarita River Upper	Santa Margarita River Lower	Rainbow Creek	Sandia Creek
Nitrogen	→	→	↗	—	→	—	—	—	—
Phosphorus	↑	→	↑	—	↗	NT	↑	—	↑
Unionized Ammonia/Ammonia	—	—	—	—	—	NT	↑	↑	↑
Dissolved Oxygen	—	—	—	—	—	—	—	—	—
Metals	↘	—	—	—	→	—	—	—	—
Fecal Coliform	NT	NT	↑	—	↗	—	—	—	—
E. Coli	NT	NT	↗	↑	NT	—	—	—	—
Title 22	↑	↑	↑	—	↑	—	—	—	—
Total Dissolved Solids	—	—	↘	—	—	—	—	—	—
pH	—	—	—	—	—	—	—	—	—
Color	→	NT	→	—	→	—	—	—	—
Enterococcus	NT	—	NT	—	—	—	—	—	—
Turbidity	↑	↑	↑	—	↑	—	↑	↑	↑
Dissolved Organic Carbon	—	—	—	—	—	—	↑	↑	↑
Surfactants (MBAS)	—	—	—	—	—	—	↓	↓	↓
Biochemical Oxygen Demand	—	—	—	—	—	—	↑	↑	↑
Total Cadmium	—	—	—	—	—	—	↑	↑	↑
Dissolved Selenium	—	—	—	—	—	—	↓	↓	↓
Dissolved Antimony	—	—	—	—	—	—	—	—	—
Conductivity	—	—	—	—	—	—	↓	↓	↓

↗ probably improving ↑ improving ↘ probably declining ↓ declining → stable NT no trend — no exceedance/no data

Reaches not included did not have any trends data available

Table 2-9. Trend Analysis of Current versus Historical Water Quality Conditions in Dry Weather

Subarea	Murrieta and Long Canyon Creeks	Santa Gertrudis Creek	Temecula Creek and Redhawk Channel	Arroyo Seco Creek	Santa Margarita River Upper	Santa Margarita River Lower	Rainbow Creek	Sandia Creek
Nitrogen	—	—	↗	—	—	—	↓	—
Phosphorus	—	—	↑	—	—	↑	↑	↑
Unionized Ammonia/Ammonia	—	—	NT	—	NT	—	—	—
Dissolved Oxygen	→	—	→	NT	—	—	—	—
Metals	—	—	—	—	—	—	—	—
Fecal Coliform	—	—	↑	—	—	—	—	—
E. Coli	—	—	↑	—	—	—	—	—
Title 22	NT	—	NT	—	—	—	—	—
Total Dissolved Solids	→	NT	↓	—	—	—	—	—
pH	→	NT	NT	—	—	—	—	—
Color	NT	—	NT	—	—	—	—	—
Enterococcus	—	—	NT	—	—	—	—	—
Turbidity	NT	→	↑	—	—	—	—	—
Dissolved Organic Carbon	—	—	—	—	—	—	—	—
Surfactants (MBAS)	—	—	—	—	—	—	—	—
Biochemical Oxygen Demand	—	—	—	—	—	↑	↑	↑
Total Cadmium	—	—	—	—	—	—	—	—
Dissolved Selenium	—	—	—	—	—	—	—	—
Dissolved Antimony	—	—	—	—	—	↑	↑	↑
Conductivity	—	—	—	—	—	—	—	—

↗ probably improving ↑ improving ↘ probably declining ↓ declining → stable NT no trend — no exceedance/no data
Reaches not included did not have any trends data available

Where sufficient data were available for the assessment and trends could be developed, the trend analysis demonstrates that most conditions in the Middle SMR Subwatershed appear to either show no trend or are trending towards improvement. The exceptions include some subareas where conditions are declining for TDS. For the Lower SMR Subwatershed, most trends were toward improvement with some declining trends for nitrogen, dissolved selenium, conductivity and surfactants.

2.3.1.4 Step 1C. Identify Significant Regulatory Actions

In Step 1C, Copermittees identified constituents that are subject to significant regulatory action (other than 303(d) listings and TMDLs, which are addressed in Step 1A). Constituents subject to significant regulatory actions were evaluated to determine if any other constituents have been identified as a priority by Regional or State Water Boards.

The Statewide Trash Amendments (California State Water Resources Control Board, 2015) constitute a significant regulatory action affecting all Copermittees with land use jurisdiction over designated priority land uses pursuant to the amendments. This includes all subareas in the Middle SMR Subwatershed, and the Fallbrook Creek subarea in the Lower SMR Subwatershed. The Upper SMR Subwatershed has not been evaluated regarding priority land uses pursuant to the amendments.

No other existing or proposed significant regulatory actions were identified.

2.3.1.5 Step 1 Results

Based on the Step 1A assessment of 303(d) listings and TMDLs, eutrophication, nitrogen, phosphorus, pesticides (chlorpyrifos and diazinon), metals (copper), toxicity, bacteria (*E. coli*, *Enterococcus*, fecal coliform), some Title 22 constituents (iron and manganese), Total Dissolved Solids, and sulfate were identified as pollutants and stressors of potential concern in receiving waters.

The Step 1B exceedance and trend analyses confirmed most of the Step 1A analysis and identified a few additional constituents in limited locations. The analysis also demonstrated that chlorpyrifos in the Middle SMR Subwatershed was no longer exceeding and should likely be delisted once sufficient samples are collected.

Step 1C resulted in the addition of trash for subareas with priority land uses to the list of pollutants and stressors of potential concern.

Table 2-10. Summary of Step 1 Results: Pollutants and Stressors of Potential Concern

Beneficial Use Category	Pollutants of Potential Concern in Receiving Waters
Aquatic Life	Eutrophication, nitrogen, phosphorus, chlorpyrifos, simazine, copper, selenium, toxicity, turbidity, trash
Recreation	Bacteria, trash
Water Supply	Nitrate, iron, manganese, Total Dissolved Solids, sulfate
Agricultural Supply	Total Dissolved Solids
Industrial Supply	Total Dissolved Solids, pH

2.3.2 Step 2. Identify PWQCs Potentially Impacting Beneficial Uses (Provisions B.2.a.(3), B.2.a.(6), B.2.a.(7), B.2.a.(8))

Based on the constituents identified in Step 1 as pollutants and stressors of potential concern in the receiving waters, Step 2 was completed to evaluate the potential impacts on beneficial uses from physical, chemical, and biological indicators and develop potential PWQCs. The evaluation consisted of the following:

- Assessing locations of known beneficial use impacts and sensitive receiving waters in the watershed.
- Evaluating biological and physical indicators using identified assessment thresholds (chemical factors were assessed in Step 1).
- Incorporating the results from Step 1 for the chemical indicators to identify potential PWQCs by beneficial use category.

2.3.2.1 Location of Known Beneficial Use Impacts and Sensitive Receiving Waters

For each subarea, a series of questions related to the beneficial use categories were used to evaluate where beneficial uses may be impacted as a result of the physical, chemical, and biological indicators identified in **Table 2-12**. The questions included the following:

Aquatic Life: Are sensitive areas present that could be impacted?

Recreation: Are there areas of known contact recreation and are flow conditions supportive of contact recreation (REC-1)?

Municipal Supply: Are there any known municipal supply diversions?

Agricultural Supply: Are there any known agricultural supply diversions?

Industrial Supply: Are there any known industrial diversions?

Table 2-11 and the text below provides a summary of this analysis, which was conducted in order to elevate water bodies recognized as sensitive or highly valued to potential priority areas. Sensitive receiving waters in the Middle SMR Subwatershed include streams with the Preservation of Biological Habitats of Special Significance (BIOL) designated beneficial use and bodies of water recognized as wetlands by the State or U.S. Fish and Wildlife Service's National Wetland Inventory (NWI) (www.fws.gov/wetlands/). The Upper and Lower SMR Subwatersheds do not include any BIOL designated waterbodies but do include NWI recognized waterbodies. Sensitive water bodies in the Middle and Lower SMR Subwatersheds are identified in **Figure 2-6**.

Known locations of contact recreation beneficial uses were identified in the Murrieta Creek and Long Canyon subarea and all subareas of the Lower SMR Subwatershed. Flow conditions to support contact recreation were identified in the Warm Springs, Murrieta Creek and Long Canyon, Santa Gertrudis Creek subareas and all subareas of the Lower SMR Subwatershed.

Known municipal diversions were identified in the Lower SMR subarea. Known agricultural diversions were identified in Sandia Creek and the De Luz Creek subareas. No known industrial diversions were identified in any subarea. Active diversions in the watershed are included in **Appendix 2**.

Table 2-11. Beneficial Use Associated Questions

Subwatershed	Subarea	Aquatic Life: Sensitive Areas Potentially Impacted?	REC: Location of Known Recreation?	REC: Flow Conditions Supportive of Recreation?	MUN: Location of Known Municipal Supply Diversion?	AGR: Location of Known Agricultural Supply Diversion?	IND: Location of Known Industrial Diversion?
Upper SMR	Arroyo Seco Creek	No	No	No	No	No	No
Middle SMR	Upper Murrieta Creek and Tributaries	No	No	No	No	No	No
	Warm Springs	No	No	**Yes**	No	No	No
	Murrieta and Long Canyon Creek	**Yes**	**Yes**	**Yes**	No	No	No
	Santa Gertrudis Creek	**Yes**	No	**Yes**	No	No	No
	Temecula Creek and Redhawk Channel	**Yes**	No	No	No	No	No
Lower SMR	Upper Santa Margarita River	No	**Yes**	**Yes**	No	No	No
	Lower Santa Margarita River	**Yes**	**Yes**	**Yes**	**Yes**	No	No
	Rainbow Creek	No	**Yes**	**Yes**	No	No	No
	Fallbrook Creek	No	**Yes**	**Yes**	No	No	No
	De Luz Creek	No	**Yes**	**Yes**	No	**Yes**	No
	Sandia Creek	No	**Yes**	**Yes**	No	**Yes**	No
	Santa Margarita River Estuary	No	**Yes**	**Yes**	No	No	No

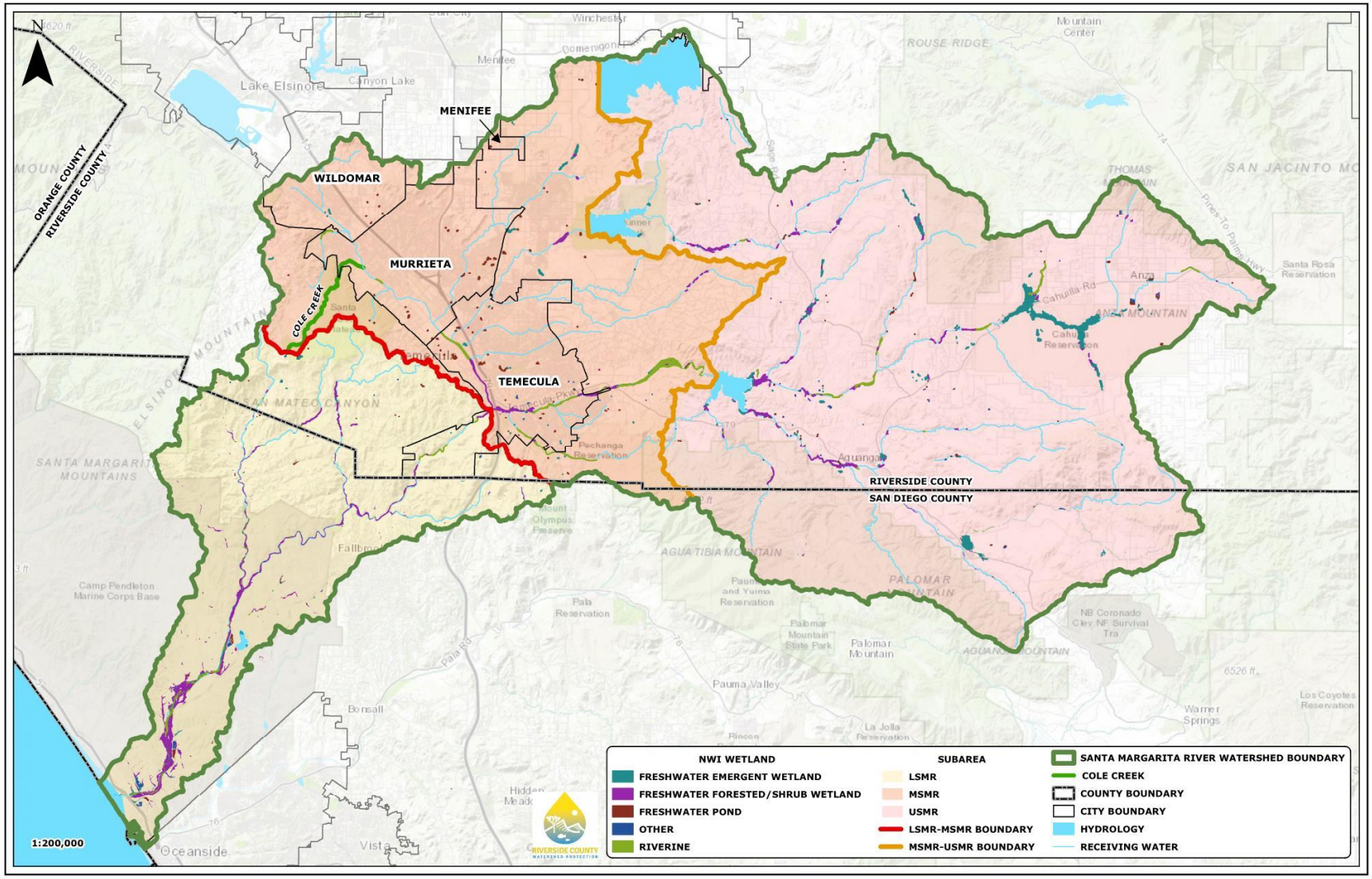

Figure 2-6. SMR Sensitive Waters – Wetlands Designated by the NWI and Cole Creek (with BIOL Beneficial Use)

2.3.2.2 Step 2A. Biological and Physical Indicator Assessment

As discussed in **Section 2.2.2**, the beneficial uses in the SMR WMA were grouped into a number of beneficial use categories. In addition to the chemical data assessed in Step 1, some beneficial use categories are potentially impacted by physical and biological indicators. The physical and biological indicators assessed are summarized in **Table 2-12**. Only the aquatic life and recreation beneficial use categories had associated physical and biological indicators that were evaluated in this step.

Table 2-12. Beneficial Uses and Associated Physical and Biological Indicators Within the Santa Margarita River WMA

Beneficial Use Category	Beneficial Uses	Physical, Chemical, and Biological Indicators
Aquatic Life	WARM COLD WILD RARE BIOL (limited) SPWN (limited)	Algal biomass Benthic community indices Physical habitat scores (CRAM) Evidence of erosion and hydromodification Trash
Recreation	REC-1 REC-2	Trash

2.3.2.2.1 Algal Biomass Assessment

No WQOs or established thresholds are available for algal biomass. In the early 2000s, the State Water Board began a process for establishing a biostimulatory policy. As part of that process, they developed an initial assessment of potential thresholds that included benthic algal biomass. (Tetra Tech, 2006) The metrics presented in **Table 2-13** were developed for freshwater streams and are indicative of three beneficial use risk categories. Category I is considered presumptively unimpaired (use is supported), Category II is considered potentially impaired, and Category III is considered presumptively impaired (use is not supported or is highly threatened). While the science being used to develop the State Water Board's biostimulatory policy is still evolving, the thresholds developed as part of this initial effort have been used in TMDL development in Southern California and represent the best available information for determining thresholds for algal biomass at this time.

Table 2-13. Benthic Algal Biomass Thresholds for SMR WMA Beneficial Uses (Tetra Tech, 2006)

Beneficial Use Risk Category [2]	Benthic Algal Biomass In Streams (mg chl-a/m^2)		
	Beneficial Use[1]		
	COLD	WARM	SPWN
I/II	100	150	100
II/III (maximum)	150	200	150

1. Although the 2006 TetraTech Report included additional beneficial uses, only the beneficial uses presented are applicable to reaches in the Santa Margarita River Watershed.
2. Thresholds shown are the break point between the two beneficial use risk categories.

The benthic algal biomass chlorophyll-a concentrations observed within the SMR watershed were compared to a threshold of 150 milligram per cubic meter (mg/m^2). This threshold was selected as it represents an unimpaired condition for the WARM beneficial use, which applies to all waters in the WMA, and is the maximum threshold for the COLD beneficial use under the cited framework. It is also consistent with the numeric targets for TMDLs for similar watersheds with both WARM and COLD beneficial uses (Malibu Creek and Ventura River). Chlorophyll-a data for SMR WMA are shown in **Table 2-14**. In the Middle SMR Subwatershed, data from 2005 to 2015 were obtained from the SMC dataset and the annual reports. In the Lower SMR Subwatershed, data from 2008 to 2015 were obtained from the SMC and SWAMP datasets. Results exceeding 150 mg/m^2 were considered indicative of eutrophic conditions.

Table 2-14. Chlorophyll-a Concentrations Observed Within the SMR WMA During Dry Weather

Subwatershed	Subareas	Reach Name	Chlorophyll-a (mg/m^2)
Upper SMR	Arroyo Seco Creek	Arroyo Seco Creek	9
Middle SMR	Upper Murrieta Creek and Tributaries	Slaughterhouse Canyon	48
		Cole Canyon	122
	Warm Springs	Warm Springs Creek	43
		French Valley	**179**
	Santa Gertrudis Creek	Tucalota Creek	85
	Murrieta and Long Canyon Creek	Murrieta Creek	49
	Temecula Creek and Redhawk Channel	Redhawk Channel	**2300**
		Temecula Creek	85
Lower SMR	Upper Santa Margarita River	Santa Margarita River	125
	Lower Santa Margarita River	Santa Margarita River	23
	Rainbow Creek	Rainbow Creek	-
	Fallbrook Creek	Fallbrook Creek	-
	De Luz Creek	Adobe Creek	111
	Sandia Creek	Sandia Canyon Creek	72
		Sandia Canyon	4

BOLDED values exceed the identified threshold of 150 mg/m2 and were considered indicative of eutrophic conditions
A dash means no data available

Elevated algal biomass concentrations were only observed in two subareas, indicating potential eutrophication conditions.

2.3.2.2.2 Benthic Macroinvertebrate Assessment

Benthic macroinvertebrate community condition is assessed using the California Stream Condition Index (CSCI) and the Benthic Macro-Invertebrate (BMI) index of biotic integrity (IBI). The BMI IBI is a multi-metric index developed specific to Southern California and is used to evaluate the conditions of the benthic macro-invertebrate community structure (Ode, et al., 2005). This metric has been calculated at various monitoring locations in the watershed based on bioassessment data.

The BMI IBI score is calculated based on several metrics including taxa richness, EPT[9] taxa, percent intolerant individuals, percent tolerant taxa, and percent collector filterers and collector gatherers. In addition, the CSCI is used throughout the state in a similar fashion and may be available for some or all sites. Because water quality objectives are not currently available for IBI and CSCI results, thresholds were developed for the assessment based on literature values as shown in **Table 2-15**.

Table 2-15. Thresholds Associated with Benthic Macro-Invertebrate Index of Biotic Integrity and California Stream Conditions Index Scores

Threshold	IBI Score[1]	CSCI Score[1]
Very High	56 – 70	≥ 0.92
Good	41 – 55	0.79 – 0.91
Moderate	27 – 40	0.63 – 0.78
Low	14 – 26	0 – 0.63
Very Low	0 - 13	

1. Weston, 2015.

Subareas were considered to be potentially impacted if CSCI < 0.78 or IBI < 40 (i.e., very low, low, or moderate thresholds). In cases where both CSCI and IBI data were available, the CSCI data were used in the assessment as this index represents the latest science and assessment methodology for benthic macroinvertebrate community conditions. The CSCI and IBI scores for subareas with available benthic macroinvertebrate data are presented in **Table 2-16**. Reaches within subareas with potentially impacted biological condition are identified using an "X". Biological data were included in the SMC and MS4 Permit compliance monitoring datasets. Data ranged from 2005 to 2015.

[9] Relative abundance of taxa within the groups, Trichoptera, Ephemeroptera, and Plecoptera.

Table 2-16: CSCI and IBI Scores Observed Within the SMR WMA During Dry Weather

Subwatershed	Subarea	Reach Name	CSCI	IBI
Upper SMR	Arroyo Seco Creek	Arroyo Seco Creek	**-**	**-**
Middle SMR	Upper Murrieta Creek and Tributaries	Slaughterhouse Canyon	0.87	-
		Cole Canyon	**0.61**	-
	Warm Springs	Warm Springs Creek	0.82	-
		French Valley	**0.49**	-
	Santa Gertrudis Creek	Tucalota Creek	0.79	-
	Murrieta and Long Canyon Creek	Murrieta Creek	**0.55**	**30.26**
	Temecula Creek and Redhawk Channel	Redhawk Channel	**0.641**	-
		Temecula Creek	**0.78**	**27.39**
Lower SMR	Upper Santa Margarita River	Santa Margarita River	0.98	-
	Lower Santa Margarita River	Santa Margarita River	0.87	**22.7**
	Rainbow Creek	Rainbow Creek	1.04	**35.4**
	Fallbrook Creek	Fallbrook Creek	-	**-**
	De Luz Creek	Adobe Creek	0.93	65.5
	Sandia Creek	Sandia Canyon Creek	1.05	-

BOLDED values exceed the identified threshold of CSCI<0.79 or IBI<40 and are indicative of a potentially impacted biological condition.
A dash means no data available.

Four subareas had lowered benthic community scores based on the CSCI. Two subareas in the Lower SMR subwatershed had lowered IBI scores, but the CSCI scores were similar to reference. As the CSCI scores are based on the most recent science and are representative of a broader reference data set, the CSCI scores were used to determine the subareas with lowered scores. The lower scores are indicative of potential aquatic life beneficial use impacts, but need to be considered along with other information (such as algal biomass concentrations and physical habitat scores) to identify potential causes of the impacts.

2.3.2.2.3 Toxicity Data Assessment

Receiving water monitoring for toxicity is conducted as required by the Permit during wet and dry weather conditions. Toxicity results are evaluated using the Test of Significant Toxicity (TST) as outlined in the NPDES Test of Significant Toxicity Implementation Document. Results are considered to be either "pass" or "fail" depending on whether the response observed is significantly different than the control. (USEPA, 2010) In subareas where TST results are not available, the chronic toxic unit calculation (i.e., TUc) is used. When the TUc is above 1.0, the sample is considered to be exceeding the threshold; the larger the toxic unit, the greater the toxicity. The 1.0

TUc threshold was selected based on its use in NPDES permits as a trigger for additional investigation of the causes of toxicity.

Results of chronic toxicity analyses for receiving waters within the SMR WMA are presented in **Table 2-17** and **Table 2-18** for dry and wet weather conditions, respectively, based on data collected from 2005 - 2015.

Table 2-17. Chronic Toxicity Test Results Number of Samples Collected by Category in the SMR WMA During Dry Weather

Subarea	Reach Name	TUc Count			TST Count	
		TUc<1	TUc=1	TUc>1	TST Pass	TST Fail
Upper Murrieta Creek and Tributaries	Slaughterhouse Canyon Cole Canyon	-	-	-	-	-
Warm Springs	Warm Springs Creek French Valley	-	-	-	-	-
Santa Gertrudis Creek	Tucalota Creek	-	-	-	-	-
Murrieta and Long Canyon Creek	Murrieta Creek	-	28	-	-	-
Temecula Creek and Redhawk Channel	Redhawk Channel	-	13	**2**	-	-
	Temecula Creek	-	23	**3**	-	-
Arroyo Seco Creek	Arroyo Seco Creek	-	-	-	-	-
Upper Santa Margarita River	Santa Margarita River	-	13	-	-	-
Lower Santa Margarita River	Santa Margarita River	-	2	-	17	-
Rainbow Creek	Rainbow Creek	-	-	-	-	-
Fallbrook Creek	Fallbrook Creek	-	-	-	-	-
De Luz Creek	Adobe Creek	-	27	**3**	-	-
Sandia Creek	Sandia Canyon Creek	-	11	-	-	-

TUc and TST Test are two different ways of measuring toxicity. When TUc is greater than 1.0 or TST is Fail **(bolded)** the sample is considered to be exceeding thresholds.

Table 2-18. Chronic Toxicity Test Results Number of Samples Collected by Category in the SMR WMA During Wet Weather

Subarea	Reach Name	TUc Count			TST Count	
		TUc<1	TUc=1	TUc>1	TST Pass	TST Fail
Upper Murrieta Creek and Tributaries	Cole Canyon	1	6	**1**	-	-
Warm Springs	Warm Springs Creek French Valley	**-**	**-**	**-**	**-**	**-**
Santa Gertrudis Creek	Tucalota Creek	**-**	**-**	**-**	**-**	**-**
Murrieta and Long Canyon Creek	Murrieta Creek	-	20	**2**	-	-
Temecula Creek and Redhawk Channel	Temecula Creek	-	22	-	-	-
Arroyo Seco Creek	Arroyo Seco Creek	**-**	**-**	**-**	**-**	**-**
Upper Santa Margarita River	Santa Margarita River	**-**	**-**	**-**	**-**	**-**
Lower Santa Margarita River	Santa Margarita River	-	-	-	16	**1**
Rainbow Creek	Rainbow Creek	**-**	**-**	**-**	**-**	**-**
Fallbrook Creek	Fallbrook Creek	**-**	**-**	**-**	**-**	**-**
De Luz Creek	Adobe Creek	-	22	**3**	-	-
Sandia Creek	Sandia Canyon Creek	-	5	-	-	-

TUc and TST Test are two different ways of measuring toxicity. When TUc is greater than 1.0 or TST is Fail **(bolded)** the sample is considered to be exceeding thresholds.
A dash means no data available

The majority of the toxicity samples collected during both dry and wet weather were not toxic. On occasion, toxicity was observed in three subareas during dry weather and four subareas during wet weather. The presence of toxicity indicates potential impacts to aquatic life beneficial uses, but the associated water quality data needs to be evaluated to determine the cause of the toxicity. Toxicity in the SMR WMA has been previously correlated with pyrethroid pesticides. However, neither toxicity nor pyrethroid pesticides are currently persistent in the mass loading station monitoring data. Furthermore, the organophosphate pesticides, chlorpyrifos and diazinon, that have been shown to cause toxicity in other areas of Southern California are no longer regularly detected in the SMR WMA receiving waters.

2.3.2.2.4 Physical Habitat –Erosional Impacts Data Assessment (Provision B.2.a.(7))

The physical habitat conditions of the subareas (**Table 2-20**) were assessed using the California Rapid Assessment Method (CRAM) index. Additionally, information from studies and the public were used to identify potential areas of hydromodification, erosion and sedimentation. CRAM provides an overall summary score for the physical habitat of the monitoring location. (www.cramwetlands.org) CRAM scores range from 25 – 100 and can be divided to reflect physical habitat quality as shown in **Table 2-19**. The CRAM scores account for channel substrate and evidence of erosion within the assessment methodology.

Four attributes of riverine stream evaluation:

1. buffer and landscape context (i.e., stream corridor continuity, stream buffers)
2. hydrology (i.e., water source, channel stability, hydrologic connectivity),
3. physical structure (i.e., structural patch richness, topographic complexity), and
4. biotic structure (i.e., plant community composition, horizontal interspersion, and vertical biotic structure).

Table 2-19. Habitat Quality Indicated by CRAM Score

Habitat Quality	CRAM Score
High	> 75
Moderate	50 - 75
Low	< 50

In the Middle SMR Subwatershed, the CRAM scores were obtained from the SMC dataset and the hydromodification project monitoring report (from 2005 to 2015). In the Lower SMR Subwatershed, the CRAM scores were obtained from the SMC and SWAMP datasets (from 2008 to 2015). Results of the physical habitat assessment are presented in **Table 2-20**, respectively. For the purposes of the assessment, CRAM scores below 50 alone (i.e., a low habitat quality) and CRAM scores between 50 and 75 (i.e., a moderate habitat quality), combined with evidence of hydromodification, were considered indicative of potential impacts to aquatic life.

Table 2-20. CRAM Scores Observed Within the SMR WMA During Dry Weather

Subwatershed	Subarea	Reach Name	CRAM Score	Evidence of Hydromodification
Upper SMR	Arroyo Seco Creek	Arroyo Seco Creek	-	-
Lower SMR	Upper Murrieta Creek and Tributaries	Slaughterhouse Canyon	67	-
	Warm Springs	Warm Springs Creek	**63**	✓
		French Valley	70	-
	Santa Gertrudis Creek	Tucalota Creek	78	-
	Murrieta and Long Canyon Creek [1]	Long Canyon	**-**	✓
		Murrieta Creek	74	-
	Temecula Creek and Redhawk Channel	Temecula Creek	73	-
	Upper Santa Margarita River	Santa Margarita River	84	-
	Lower Santa Margarita River	Santa Margarita River I	84	-
	Rainbow Creek	Rainbow Creek	73.4	-
	Fallbrook Creek	Fallbrook Creek	-	-
	De Luz Creek	Adobe Creek	74	-
	Sandia Creek	Sandia Canyon Creek	86	-
		Sandia Canyon Creek	80	-

CRAM scores below 50 are automatically considered indicative of potential impacts to aquatic life. A CRAM score between 50 and 75 with other evidence of hydromodification was also considered to be potentially impacting (**bolded**).

A dash means no data available

1. CRAM index scores from Murrieta Creek and evidence of hydromodification on Long Canyon Creek. The WMAA analysis found that the hydromodification exemption could be applied to Murrieta Creek, indicating hydromodification is not a concern in that reach of the subarea.

In addition to the CRAM index scores, stream conditions and potential areas of erosion and observed hydromodification were considered in the assessment. The Consultation Committee provided comments with areas recommended for investigation for potential erosion/hydromodification concerns in the Middle SMR Subwatershed. These areas, along with the characteristics of the channels are shown in **Figure 2-7**. Similar information is not available for the Lower SMR Subwatershed and no areas for investigation were identified in the Lower SMR Subwatershed.

Evidence of erosion/hydromodification was assessed by reviewing available reports and information provided during the data request. Two key documents were identified that discussed physical habitat conditions, potential hydromodification, and erosion/sedimentation impacts. The Hydromodification Monitoring Project documented hydromodification surveys at two streams within the Cities of Temecula and Murrieta in the Middle SMR Subwatershed; however, this report contained no hydromodification surveys for sites in the Upper or Lower SMR Subwatersheds. Parameters observed and measured in this report included channel dimensions, hydrological and geomorphic conditions, presence and condition of vegetation and habitat, location of discharge points, habitat integrity, dimensions of existing channel bed or bank erosion and known or suspected causes of existing downstream erosion or habitat impact. Two areas were

identified as having evidence of erosion/hydromodification based on this report, Long Canyon Creek in the Murrieta Creek and Long Canyon subarea, and Warm Springs Creek in the Warm Springs subarea.

The Bioassessment of Perennial Streams in Southern California: A Report on the First Five Years of the Stormwater Monitoring Coalition's Regional Stream Survey was also reviewed for evidence of erosion/hydromodification in the SMR WMA. This report was conducted at a regional level, evaluating watersheds at a hydrologic scale larger than the SMR WMA that ranged from Ventura to San Diego. This report utilized data from the SMC dataset and contained summary statistics for physical habitat variables relating to biomass, instream habitat, riparian characteristics and stream substrates. No mention of erosion processes was included and, therefore, no additional areas of concern were identified based on this report.

In addition to the reviewed reports and data, the analysis conducted to evaluate the potential for a hydromodification exemption for Murrieta Creek, Temecula Creek, and the Upper and Lower Santa Margarita River as part of the Watershed Management Area Analysis (**Appendix 4B**) was also considered. The analysis determined that the hydromodification exemption could be applied to Murrieta Creek and the Upper and Lower Santa Margarita River reaches. As a result, evidence of hydromodification/erosion was not identified for these areas. The potential for erosion was identified in the lower portion of Temecula Creek in the analysis.

The results of the assessment show that the CRAM scores were generally good throughout the SMR WMA, although there were a few areas in the Middle SMR Subwatershed where there is evidence of erosion/hydromodification and some other subareas of potential concern identified by the Consultation Committee and in the WMAA analysis (**Figure 2-7**).

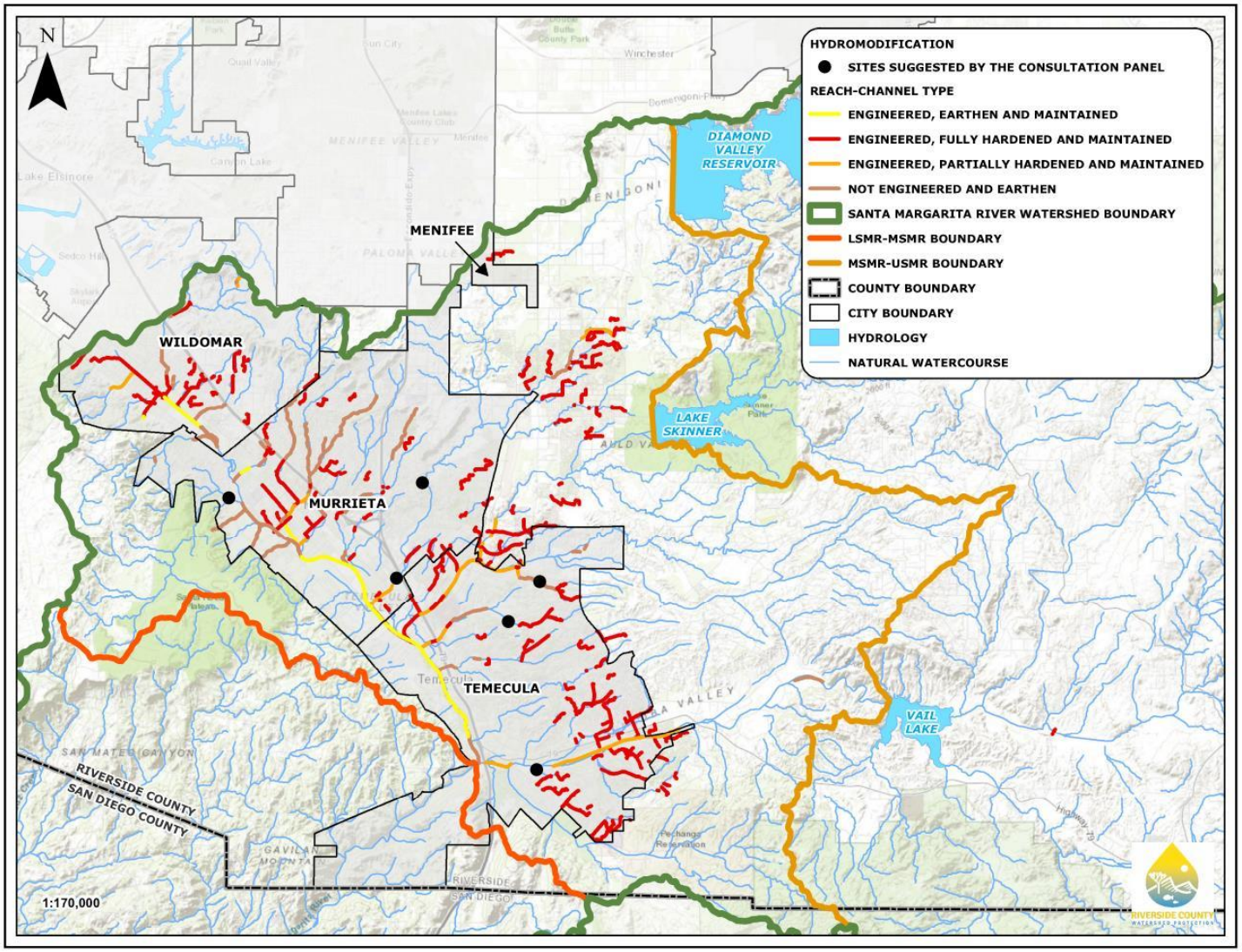

Figure 2-7. Middle SMR Subwatershed Channel Characteristics and Areas Identified by Consultation Committee for Investigation

2.3.2.2.5 Trash Data Assessment

The Statewide Trash Amendments identify specific priority land uses for trash for which the amendments are applicable, based on the potential to impact aquatic life and recreational beneficial uses in receiving waters. While the Middle SMR Subwatershed and Fallbrook Creek are the only areas that have been identified with priority land uses, additional data available from special studies were assessed to determine if any additional subareas should be added. The Upper SMR Subwatershed has not been evaluated for potential priority land use areas pursuant to the trash amendments. Results from trash assessments conducted within the Middle SMR Subwatershed and Lower SMR Subwatershed are summarized in **Table 2-21** and **Table 2-22**, respectively.

Table 2-21. Trash Conditions Within the Upper and Middle SMR Subwatershed Subareas

Subwatershed	Subarea	Dry Weather		Wet Weather	
		Rating	Score	Rating	Score
Upper SMR	Arroyo Seco Creek	N/A	N/A	N/A	N/A
Middle SMR	Upper Murrieta Tributaries	Optimal	111	Optimal	119
	Warm Springs	Suboptimal	85	Suboptimal	88
	Murrieta Creek and Long Canyon Creek	Suboptimal	86	Suboptimal	90
	Santa Gertrudis Creek	Optimal	107	Optimal	103
	Temecula Creek and Redhawk Channel	Suboptimal	80	Suboptimal	81

[1] Results from Trash and Litter Investigation Special Study.
[2] Assessment conducted in accordance with Rapid Trash Assessment (RTA) protocols to develop scores. Scores were assigned to the categories of optimal and suboptimal in accordance with the RTA category descriptions.
[3] N/A – no data for assessment

Table 2-22. Dry Weather MS4 Outfall Field Screening Trash Assessments Within the Lower SMR Subwatershed (Source: 2015-2016 TMAR)

Copermittee	Hydrologic Subarea	Trash Present (# of sites)			
		None	Low (<50 pieces)	Medium (50 to 400 pieces)	High (>400 pieces)
County of San Diego	902.13	1	5	2	2
	902.23	1	8	1	0
	Total	2	13	3	2

Based on the data presented above showing minimal trash in the measured areas, no additional subareas were identified for consideration of impacts due to trash.

2.3.3 Identification of Potential PWQCs in Receiving Waters Based on Step 1 and Step 2 Data Assessments

Potential PWQCs were identified by integrating the Step 1 assessments with the Step 2 assessments of locations of known beneficial use locations and an evaluation of physical and biological indicators for each beneficial use category. The potential PWQCs and associated chemical, physical, and biological indicators for each beneficial use category are summarized in **Table 2-23**.

Table 2-23. Potential PWQCs by Beneficial Use Category

Potential PWQCs	Physical, Chemical, and Biological Indicators	Beneficial Use Category
Eutrophication	Algal biomass Benthic community indices Dissolved Oxygen	
Nutrient Loading to TMDL Waterbodies	Total Nitrogen Total Phosphorus	
Toxicity		
	Ammonia Pesticides [1] Metals [2] Toxicity	Aquatic Life
Physical Habitat		
	Sediment Physical habitat scores (CRAM) Evidence of erosion and hydromodification	
Nuisance	Trash	Aquatic Life and Recreation
Indicator Bacteria	Fecal Coliform *E. coli*	Recreation
Constituents of concern for drinking water supplies	Nitrate Title 22 Constituents[3]	Water Supply
Constituents of concern for agricultural supply	Total Dissolved Solids Chloride Boron	Agricultural Supply
Constituents of concern for industrial supply	pH Total Dissolved Solids	Industry

This section summarizes the results of the analysis from the previous sections of the indicators shown in **Table 2-23** to determine the subareas with each potential PWQC based on the receiving water analysis. In Step 3, the potential contributions from MS4 discharges will be compared to the potential PWQCs identified from the receiving water analysis to determine the PWQCs for the WQIP. Each column in the following set of tables represents a type of analysis that was conducted by geographic reach. By reviewing the data in this way, this section 2B will result in a complete list of Potential PWQCs (**Table 2-30**).

2.3.3.1 Aquatic Life-Eutrophication PWQC

Eutrophication is caused by excessive growth of algal biomass. Elevated biomass levels cause changes in water column and sediment chemistry that can cause fish kills and impact benthic communities. As shown in **Figure 2-8**, eutrophication can be assessed by measuring macroalgae and phytoplankton and the associated changes in DO and pH in the water column. Additionally, eutrophication symptoms can result from excess TN and TP loading. While TN and TP may not cause eutrophication in all areas of the watershed, even when above assessment thresholds, the elevated nutrient concentrations can contribute to downstream eutrophication impacts. Therefore, all of these indicators were evaluated in the assessment of the potential PWQC of eutrophication.

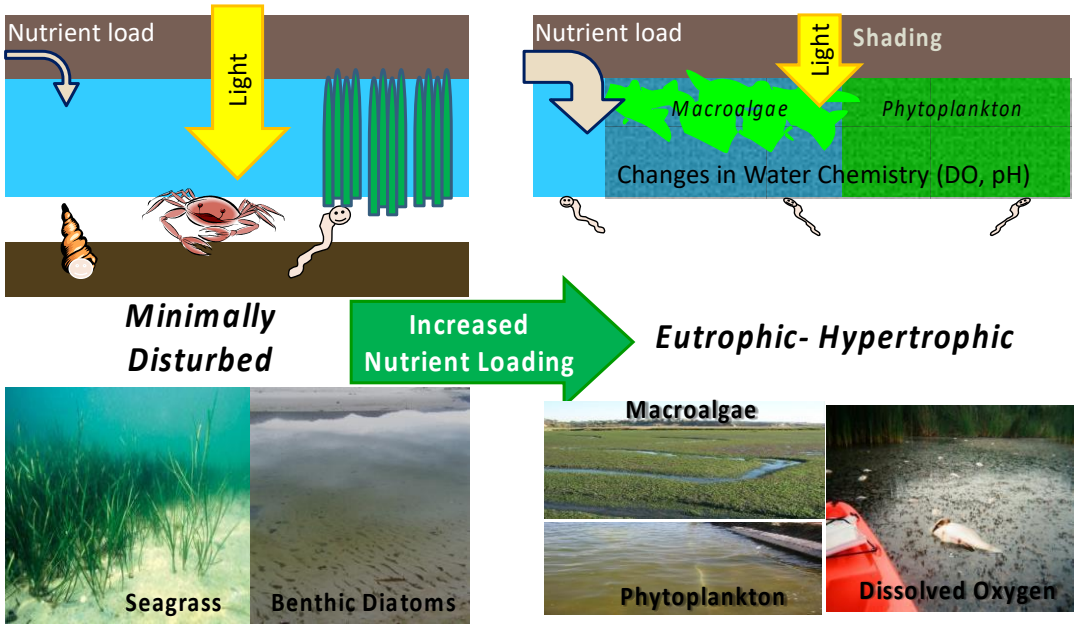

Figure 2-8. Conceptual Model of Eutrophication in Mediterranean Estuaries (from Model Application Report)

While all of the metrics discussed above are indicative of eutrophication, elevated levels of nutrients or other indicators may or may not have an impact on aquatic life beneficial uses, due to physical factors or other waterbody conditions (Sutula, et al., 2016). Benthic macroinvertebrate community condition can be used to assess whether the elevated algal biomass is impacting aquatic life beneficial uses. As a result, the benthic community condition data were also used in the eutrophication assessment. The results of the assessment are summarized in **Table 2-24**.

Table 2-24. Summary of Eutrophication PWQC Assessment Results

Subwatershed	Subarea	303(d) Listings for Associated Chemical Indicators	TMDL	Nitrogen Above Assessment Threshold	Phosphorus Above Assessment Threshold	Algal Biomass Above Threshold	Benthic Below Threshold	Dissolved Oxygen
Upper SMR	Arroyo Seco Creek	No	No [1]	No	No	No	N/A	**D**
Middle SMR	Upper Murrieta Creek and Tributaries	No	No [1]	No	**W**	No	No	No
	Warm Springs	**Yes**	No [1]	**W**	**W**	**D**	**D**	No
	Murrieta and Long Canyon Creek	**Yes**	No [1]	**W**	**D, W**	No	**D**	**D,W**
	Santa Gertrudis Creek	**Yes**	No [1]	**W**	**D, W**	No	No	No
	Temecula Creek and Redhawk Channel	**Yes**	No [1]	**D, W**	**D, W**	**D**	**D**	**D**
Lower SMR	Upper Santa Margarita River	**Yes**	No [1]	No	**W**	No	No	**D**
	Lower Santa Margarita River	**Yes**	No [1]	**D**	**W**	No	No	**D**
	Rainbow Creek	**Yes**	**Yes [2]**	**D, W**	**D, W**	N/A	No	**D, W**
	Fallbrook Creek	No	No	**D**	**D, W**	N/A	N/A	**D**
	De Luz Creek	**Yes**	No [1]	**D**	**W**	No	N/A	**D**
	Sandia Creek	No	No [1]	**D**	**D, W**	No	No	No
	Santa Margarita River Estuary	**Yes**	No [1]	**D, W**	**D, W**	N/A	N/A	No

N/A: no data for assessment; Threshold exceedance: D for dry weather; W for wet weather.

1. TMDL Alternative (under development) for the SMR Estuary identifies dry weather nutrient loading from the subarea to be potentially contributing to eutrophication concerns in the SMR Estuary.
2. Effective TMDL with dry and wet weather allocations for MS4s.

Results of the analysis show that many subareas are above the assessment threshold for nitrogen and phosphorus and have the potential to contribute nutrient loading to eutrophic conditions in the SMR Estuary. All subareas that have elevated nitrogen or phosphorus concentrations and are considered as part of a TMDL or TMDL Alternative have a potential PWQC of nutrient loading to a TMDL waterbody. Additionally, Warm Springs and Temecula Creek and Redhawk Channel have elevated algal biomass levels and lowered benthic community condition results, indicating the potential for localized eutrophication concerns and are, therefore, assigned a potential PWQC of eutrophication along with SMR Estuary which is listed for eutrophication. Murrieta and Long Canyon Creek subarea had benthic community measurements below thresholds, but did not have associated elevated algal biomass above thresholds so were not assigned a potential eutrophication PWQC. Santa Gertrudis Creek subarea benthic community scores were around the threshold, but the algal biomass levels were not above thresholds and, therefore, the subarea was not assigned a potential eutrophication PWQC.

2.3.3.2 Aquatic Life-Toxicity PWQC

Toxicity can be assessed in the water column and in sediment, each of which can affect the aquatic life. Toxicity is directly measured through toxicity testing, but the potential for toxicity can also be assessed through the examination of constituents that have the potential to cause toxicity to water quality objectives. The assessment of toxicity considered both the results of toxicity tests and evaluation of constituents most likely to cause toxicity. Toxicity in the Santa Margarita River WMA has been previously correlated with pyrethroid pesticides. Organophosphate pesticides, ammonia and metals are other constituents that have the potential to cause or contribute to receiving water toxicity.

The assessment of chemical, physical and biological indicators associated with toxicity are summarized in **Table 2-25**. The assessment included the Step 2 evaluation of toxicity samples and results from the exceedance analyses of pesticides, metals, and ammonia conducted in Step 1B.

Table 2-25. Summary of Toxicity PWQC Assessment Results

Subwatershed	Subarea	303(d) Listings	TMDL	Toxicity Above Assessment Threshold	Pesticides Above Assessment Threshold	Metals Above Assessment Threshold	Ammonia Above Assessment Threshold
Upper SMR	Arroyo Seco Creek	No	No	N/A	No	No	No
Middle SMR	Upper Murrieta Creek and Tributaries	No	No	No	No	No	No
	Warm Springs	**Yes[6]**	No	N/A	No	**W[2]**	No
	Murrieta and Long Canyon Creek	**Yes[6]**	No	**W**	**W[1]**	**W[2]**	No
	Santa Gertrudis Creek	**Yes[5]**	No	N/A	No	No	No
	Temecula Creek and Redhawk Channel	**Yes**	No	**D, W**	No	No	**D**
Lower SMR	Upper Santa Margarita River	**Yes[7]**	No	No	W[3]	No	No
	Lower Santa Margarita River	No	No	No	N/A	No	No
	Rainbow Creek	No	No	N/A	N/A	No	No
	Fallbrook Creek	No	No	No	N/A	No	No
	De Luz Creek	No	No	N/A	N/A	No	No
	Sandia Creek	No	No	No	N/A	**D[4]**	No
	Santa Margarita River Estuary	No	No	N/A	N/A	No	**D**

N/A: no data for assessment; Threshold exceedance: D for dry weather; W for wet weather.

1. Simazine is the only pesticide with exceedances in this subarea.
2. Copper is the only metal with exceedances in this subarea.
3. Chlorpyrifos is the only pesticide with exceedances in this subarea.
4. Selenium is the only metal with exceedance in this subarea.
5. Listings for chlorpyrifos and copper were not confirmed during the Step 1B exceedance analysis.
6. Listing for chlorpyrifos was not confirmed during the Step 1B exceedance analysis.

7. Listing for toxicity was not confirmed by the Step 2 toxicity data assessment.

Results of the analysis show that observed toxicity is limited to a few subareas and the organophosphate pesticides, that may have historically contributed to toxicity, are no longer exceeding in receiving waters.

Constituents potentially contributing to toxicity, including diazinon and copper, exceeded thresholds in a few subareas. Additionally, although 303(d) listings for constituents potentially contributing to toxicity (e.g. copper and chlorpyrifos) exist in most subwatersheds, most of these listings were not confirmed in the Step 1B exceedance analysis and the pesticide trends indicate improving conditions. The Murrieta and Long Canyon Creek and Temecula Creek and Redhawk Channel subareas were assigned potential PWQCs of observed toxicity due to observed toxicity in the subareas and continuing exceedances of WQOs for constituents that could potentially contribute to toxicity. Warm Springs, Sandia Creek and SMR Estuary had some constituents that were above objectives, but no associated toxicity so were not assigned this potential PWQCs.

2.3.3.3 Aquatic Life-Physical Habitat PWQC

Physical habitat is important for protection of aquatic life. Erosion of stream channels, increased sediment deposition, and modified channels can alter conditions necessary to support spawning and macroinvertebrate communities. Several factors can be used to evaluate physical habitat including channel substrate, evidence of erosion, and the creek rapid assessment methods.

Table 2-26. Summary of Physical Habitat PWQC Assessment Results

Subwatershed	Subarea	303(d) Listing	TMDL	CRAM Index Score below threshold	Benthic Below Threshold	Evidence of Hydromodification[1]
Upper SMR	Arroyo Seco Creek	No	No	N/A	N/A	No
Middle SMR	Upper Murrieta Creek and Tributaries	No	No	No[2]	No	(4)
	Warm Springs	No	No	No[2]	**D**	**Yes**
	Murrieta and Long Canyon Creek[3]	No	No	No[2]	**D**	**Yes**
	Santa Gertrudis Creek	No	No	No	No	No
	Temecula Creek and Redhawk Channel	No	No	No[2]	**D**	(4)
Lower SMR	Upper Santa Margarita River	No	No	No	No	N/A
	Lower Santa Margarita River	No	No	No	No	N/A
	Rainbow Creek	No	No	No[2]	No	N/A
	Fallbrook Creek	No	No	N/A	N/A	N/A
	De Luz Creek	No	No	No[2]	N/A	N/A
	Sandia Creek	No	No	No	No	N/A
	Santa Margarita River Estuary	No	No	N/A	N/A	N/A

N/A: no data for assessment; Threshold exceedance: D for dry weather; W for wet weather.

1. As reported in the Hydromodification Monitoring Project Report.
2. As described above, the CRAM threshold is <50. However, for scores between 50 and 75, physical habitat impacts were considered a PWQC if there was also evidence of hydromodification. These reaches had CRAM scores between 50 and 75.
3. CRAM index scores from Murrieta Creek and evidence of hydromodification on Long Canyon Creek. The WMAA analysis found that the hydromodification exemption could be applied to Murrieta Creek, indicating hydromodification is not a concern in that reach of the subarea.
4. Areas are under investigation for erosion/sediment impacts at the sites identified by the Consultation Committee and in Temecula Creek based on the results of the WMAA.

Warm Springs and Murrieta and Long Canyon Creek were identified as subareas having potential PWQCs for lowered physical habitat scores (CRAM) or evidence of hydromodification/erosional impacts. Subareas with sites under investigation based on input from the Consultation Committee and the WMAA may be included as a PWQC in the future if the investigations confirm evidence of hydromodification/erosional impacts. The Temecula Creek and Redhawk Channel subarea was not assigned this PWQC at this time because the elevated algal biomass values are likely contributing to the lowered benthic community scores, but may be added after further investigation of potential erosion impacts in the reach as follow up to the WMAA and Consultation Committee input.

2.3.3.4 Recreation-Indicator Bacteria PWQC

Recreation beneficial uses are impacted by the presence of pathogens that have the potential to cause illness. Indicator bacteria, such as *E. coli*, fecal coliform, and *Enterococcus* are used to assess the potential risk of illness. No other physical or biological indicators were identified as

indicators for the recreation beneficial use category. The assessment for recreation utilizes indicator bacteria results from the Step 1 analysis as summarized in **Table 2-27**.

Table 2-27. Summary of Recreational Beneficial Use Impact Assessment

Subwatershed	Subarea	303(d) Listings	TMDL	Fecal Coliform Above Threshold	*E. coli* Above Threshold	Location of Known Recreation	Flow Condition Supportive of Recreation
Upper SMR	Arroyo Seco Creek	No	No	No	No	No	No
Middle SMR	Upper Murrieta Creek and Tributaries	No	No	**W**	**W**	No	No
	Warm Springs	**Yes**	No	**W**	**W**	No	**Yes**
	Murrieta and Long Canyon Creek	**Yes**	No	**W**	**W**	**Yes**	**Yes**
	Santa Gertrudis Creek	**Yes**	No	**W**	**W**	No	**Yes**
	Temecula Creek and Redhawk Channel	**Yes**	No	**D,W**	**D,W**	No	No
Lower SMR	Upper Santa Margarita River	No	No	No	No	**Yes**	**Yes**
	Lower Santa Margarita River	**Yes**	No	**W**	No	**Yes**	**Yes**
	Rainbow Creek	No	No	No	No	**Yes**	**Yes**
	Fallbrook Creek	No	No	No	No	**Yes**	**Yes**
	De Luz Creek	No	No	**D,W**	**D,W**	**Yes**	**Yes**
	Sandia Creek	No	No	No	No	**Yes**	**Yes**
	Santa Margarita River Estuary	No	No	No	No	**Yes**	**Yes**

Threshold exceedance: D for dry weather; W for wet weather.

All subareas with fecal coliform or E. coli values above thresholds were assigned to this potential PWQC.

2.3.3.5 Municipal Supply-Constituents of Potential Concern for Municipal Supply PWQC

The municipal supply beneficial use can be impacted by elevated concentrations of constituents that have the potential to impact the health of people drinking the water. The constituents that could impact the municipal supply beneficial use are those that have identified objectives for the protection of human health as outlined in Title 22. A list of these constituents is included in **Appendix 2**. No physical or biological indicators were identified for consideration for the municipal supply beneficial use category. The assessment of chemical indicators associated with municipal supply are summarized in **Table 2-28** based on the analysis conducted in Step 1.

Table 2-28. Summary of Municipal Supply Beneficial Use Impact Assessment

Subwatershed	Subarea	303(d) Listings	TMDL	Nitrate Above Threshold	Title 22 Above Threshold	Location of Known Municipal Supply Diversion
Upper SMR	Arroyo Seco Creek	No	No	No	No	No
Middle SMR	Upper Murrieta Creek and Tributaries	No	No	No	W[1,2]	No
	Warm Springs	Yes[1,2]	No	No	W[1,2,4,5]	No
	Murrieta and Long Canyon Creek	Yes[1,2]	No	No	D,W[1,2,4,5]	No
	Santa Gertrudis Creek	Yes[1,2]	No	No	D,W[1,2,4,5]	No
	Temecula Creek and Redhawk Channel	Yes[1,2,4]	No	No	D,W[1,2,3,4,5]	No
Lower SMR	Upper Santa Margarita River	No	No	No	D[1]	No
	Lower Santa Margarita River	No	No	D,W	D,W[1,2,3,4]	Yes
	Rainbow Creek	Yes[1,3,4]	No	D,W	D,W[2,3,4]	No
	Fallbrook Creek	No	No	No	D,W[1,2,3,4]	No
	De Luz Creek	Yes[1,2,3]	No	No	D,W[1,2,3,4]	No
	Sandia Creek	Yes[1,3,4]	No	No	D,W[1,3,4]	No
	Santa Margarita River Estuary	(6)	(6)	(6)	(6)	(6)

N/A: no data for assessment; Threshold exceedance: D for dry weather; W for wet weather.

1. Iron
2. Manganese
3. Sulfate
4. TDS
5. Color
6. Municipal drinking water beneficial use does not apply to the Santa Margarita River Estuary so the analysis was not conducted for this subarea.

All subareas with nitrate or Title 22 constituents values above thresholds were assigned to this potential PWQC.

Agricultural and Industrial Supply

Potential impacts to agricultural and industrial supply were evaluated through assessments of the potential PWQCs: constituents of potential concern for agricultural and industrial supply.

Agricultural and industrial supply beneficial uses are potentially impacted by constituents, that at elevated concentrations, can impact the viability of agriculture or impact industrial processes. TDS, chloride and boron are constituents that could adversely impact agriculture and TDS and pH could potentially impact industrial uses. No physical or biological indicators were identified for consideration for these beneficial use categories. The assessment of chemical indicators associated with agricultural and industrial supply are summarized in **Table 2-29** based on the analysis conducted in Step 1.

Table 2-29. Summary of Agricultural and Industrial Supply Beneficial Use Impact Assessment

Subwatershed	Subarea	303(d) Listings	TMDL	TDS Above Threshold	Chloride Above Threshold	Boron Above Threshold	pH Above Threshold	AGR: Location of Known Agricultural Supply Diversion?	IND: Location of Known Industrial Diversion?
Upper SMR	Arroyo Seco Creek	No	No	No	No	N/A	D	No	No
Middle SMR	Upper Murrieta Creek and Tributaries	No	No	No	N/A	N/A	No	No	No
	Warm Springs	No	No	W	No	N/A	No	No	No
	Murrieta and Long Canyon Creek	Yes	No	D	No	No	D	No	No
	Santa Gertrudis Creek	No	No	D	No	N/A	D,W	No	No
	Temecula Creek and Redhawk Channel	Yes	No	D, W	No	No	D	No	No
Lower SMR	Upper Santa Margarita River	No	No	No	No	No	No	No	No
	Lower Santa Margarita River	No	No	D, W	No	No	No	No	No
	Rainbow Creek	Yes	No	D, W	No	No	No	No	No
	Fallbrook Creek	No	No	D	No	No	W	No	No
	De Luz Creek	No	No	D	No	No	D,W	Yes	No
	Sandia Creek	Yes	No	D	No	No	W	Yes	No
	Santa Margarita River Estuary	No	No	No	No	No	No	No	No

N/A: no data for assessment; Threshold exceedance: D for dry weather; W for wet weather.

All subareas with TDS, chloride, boron, and pH values above thresholds were assigned to this potential PWQC.

Table 2-30 summarizes the potential PWQCs identified from the receiving water analysis.

Table 2-30. Summary of Step 2-Potential PWQCs

Beneficial Use Category	Potential PWQCs	Physical, Chemical, and Biological Indicators	Upper SMR Subwatershed	Middle SMR Subwatershed					Lower SMR Subwatershed						
			Arroyo Seco Creek	Upper Murrieta Creek and Tributaries	Warm Springs	Murrieta and Long Canyon Creek	Santa Gertrudis Creek	Temecula Creek and Redhawk Channel	Upper Santa Margarita River	Lower Santa Margarita River	Rainbow Creek	Fallbrook Creek	De Luz Creek	Sandia Creek	Santa Margarita River Estuary
Aquatic Life	Eutrophication	Algal biomass	-	-	X	-	-	X	-	-	-	-	-	-	X[1]
		Benthic community indices	-	-	X	X	-	X	-	-	-	-	-	-	-
		Dissolved Oxygen	X	-	-	X	-	X	X	X	X	X	X	-	X[1]
	Nutrient Loading to TMDL waterbodies	Total Nitrogen	-	-	X	X	X	X	-	X	X	X	X	X	X
		Total Phosphorus	-	X	X	X	X	X	X	X	X	X	X	X	X
	Toxicity	Ammonia	-	-	-	-	-	X	-	-	-	-	-	-	X
		Pesticides	-	-	-	X	-	-	X	-	-	-	-	-	-
		Metals	-	-	X	X	-	-	-	-	X	-	-	X	-
		Toxicity	-	-	-	X	-	X	-	-	-	-	-	-	-
	Physical Habitat	Sediment	-	-	-	-	-	-	-	-	-	-	-	-	-
		Physical habitat index scores (CRAM)	-	-	-	-	-	-	-	-	-	-	-	-	-
		Evidence of erosion and hydromodification	-	-	X	X[2]	-	-	-	-	-	-	-	-	-

Beneficial Use Category	Potential PWQCs	Physical, Chemical, and Biological Indicators	Upper SMR Subwatershed	Middle SMR Subwatershed					Lower SMR Subwatershed						
			Arroyo Seco Creek	Upper Murrieta Creek and Tributaries	Warm Springs	Murrieta and Long Canyon Creek	Santa Gertrudis Creek	Temecula Creek and Redhawk Channel	Upper Santa Margarita River	Lower Santa Margarita River	Rainbow Creek	Fallbrook Creek	De Luz Creek	Sandia Creek	Santa Margarita River Estuary
Recreation	Nuisance	Trash	-	X	X	X	X	X	-	-	-	X	-	-	-
			-												
	Indicator Bacteria Concentrations	Fecal Coliform	-	X	X	X	X	X	-	X	X	-	X	-	-
		E. coli	-	X	X	X	X	X	-	-	-	-	X	-	-
Water Supply	Constituents of potential concern for drinking water supplies	Nitrate	-	-	-	-	-	-	-	X	X	-	-	-	-
		Title 22 Constituents	-	X	X	X	X	X	X	X	X	X	X	X	-
Agricultural Supply	Constituents of potential concern for agricultural supply	Total Dissolved Solids	-	-	X	X	X	X	-	X	X	X	X	X	-
		Chloride	-	-	-	-	-	-	-	-	-	-	-	-	-
		Boron	-	-	-	-	-	-	-	-	-	-	-	-	-
Industry	Constituents of potential concern for industrial supply	pH	X	-	-	X	X	X	-	-	-	-	X	-	-
		Total Dissolved Solids	-	-	X	X	X	X	-	X	X	X	X	X	-

Note: Potential PWQCs are indicated by an "X" in the table.

1. Identified as potential PWQC based on TMDL Alternative studies.
2. Evidence of hydromodification on Long Canyon Creek only. The WMAA analysis found that the hydromodification exemption could be applied to Murrieta Creek, indicating hydromodification is not a concern in that reach of the subarea.

2.4 STEP 3. ASSESSMENT OF POTENTIAL IMPACTS FROM MS4 DISCHARGES

The assessment of receiving water conditions in Steps 1 and 2 identified potential PWQCs of concern in receiving waters within the SMR WMA. Step 3 assesses if discharges from MS4s could cause or contribute to the potential PWQCs. The assessment was conducted by identifying the locations where MS4 discharges occur. Then, representative chemical monitoring data and persistent flow data were reviewed to determine which constituents the MS4 discharges may be contributing to receiving waters to create the list of PWQCs.

2.4.1 Locations of MS4 Discharges (Provision B.2.b.(3))

As a first step, the locations of each Copermittee's MS4 outfalls, as defined in the Regional Permit, that discharge to receiving waters were identified to assess where MS4 discharges were most likely to contribute to receiving water conditions identified in Step 2. For most of the subareas, MS4 contributions are a possibility where there are MS4 outfalls and jurisdictional area within or upstream of the subarea (see **Figure 3-4**).

2.4.2 Identification of Potential PWQCs Which MS4 Discharges May be Contributing (Provisions B.2.b.(1), B.2.b.(2), B.2.b.(4) and B.2.b.(5))

Monitoring data from Copermittee's MS4 outfalls was compared to established thresholds to determine whether or not MS4s s are contributing pollutants. All relevant and appropriate data for both stormwater and non-stormwater discharges were considered. MS4 outfall monitoring locations are shown in **Figure 2-10**. The outfall monitoring stations shown in Figure 2-10 represent the best available information on the locations ofMS4 outfalls that discharge pollutants and are considered representative of all MS4 outfalls that discharge to receiving waters. Locations of outfalls with persistent non-stormwater flow are shown in **Figure 2-11**. All of the Upper SMR Subwatershed, and the Pechanga Creek and Sandia Creek subareas do not have storm drain outfall monitoring data and are primarily comprised of open space and federal lands. Due to the lack of data and the minimal amount of urban land use in these subareas, MS4 discharges were not identified as contributing to potential PWQCs in these subareas. As a result, no PWQCs are assigned for these subareas, but modifications will be considered during the adaptive management process if data are collected that identify MS4 contributions to potential PWQCs in these areas.

As discussed further in **Section 2.5.2**, the assessment of potential impacts of the MS4 discharges on the receiving waters is based on limited MS4 outfall data. While the available data generally support characterization of the discharges from the MS4s, the limited spatial extent of data from the MS4 outfalls means the assessment of the potential impacts from storm drain outfalls for a whole subarea is based on data from a single outfall and the results may not be fully representative of conditions across the whole subarea. The assessment of MS4 discharge impacts on receiving waters will improve over time as this data gap is addressed by future outfall monitoring and non-stormwater field screening.

Although limitations on the amount of MS4 outfall discharge data exist, the available data were considered representative for the purposes of the analysis. At least one MS4 outfall monitoring location was available in each subarea within the Middle and Lower SMR Subwatersheds, with the exception of the Pechanga Creek, Sandia Creek, and SMR Estuary subareas, which have a minimal amount of urban land use and are primarily comprised of open space and federal lands. Therefore,

the analysis assumes that all MS4 outfalls within a subarea have the potential to discharge any pollutants that are observed in the representative outfall(s) for that subarea.

The procedure for assessing the contribution of MS4 discharges to the potential PWQCs identified in Step 2 is shown in **Figure 2-9**. The potential for non-storm water discharges to cause or contribute to impacts on beneficial uses was assessed in the same method as storm water discharges and all outfalls identified as persistent in Figure 2-11 are assumed to potentially contribute pollutants to receiving waters under dry weather conditions. Based on the Step 3 assessment, the subareas with identified MS4 discharges potentially contributing to PWQCs are shown in **Figure 2-9. Table 2-31** summarizes the results of the MS4 discharge assessment for each of the potential PWQCs identified in Step 2. If the indicator of the impact was not available for the MS4 outfall data, the potential PWQC was noted as "N/A" in the table. If the MS4 outfall data demonstrated exceedances, the potential PWQC is identified with an "X" in the table. If the MS4 outfall data did not demonstrate exceedances of an indicator, a footnote is referenced in the table to explain the assessment.

Impacts are summarized by wet and dry weather conditions and organized according to beneficial use category. Further investigation of the contribution of discharges from MS4 outfalls to the PWQCs will be conducted as part of the Monitoring and Assessment Program and may result in refinement of the PWQCs or the geographic extent of these conditions.

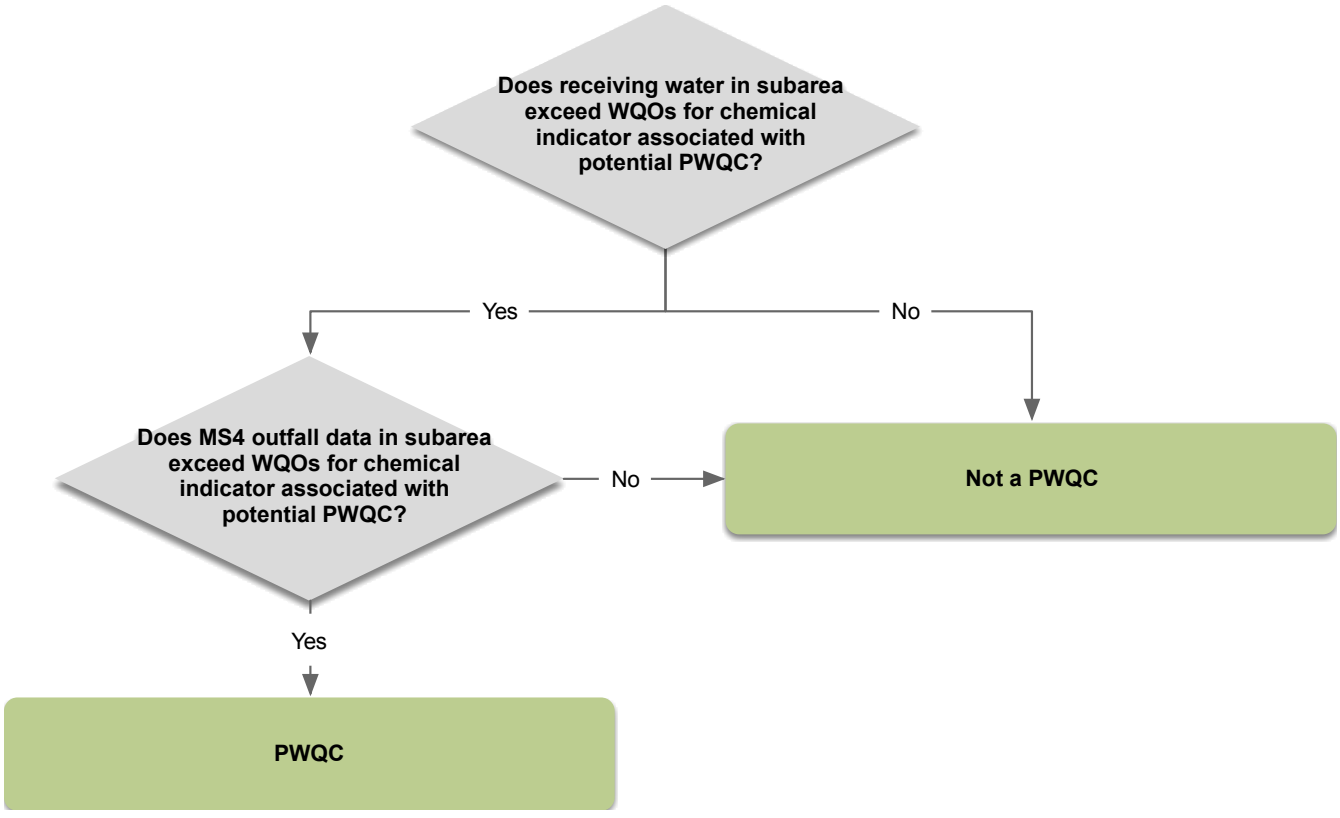

Figure 2-9. Procedure for Assessing Potential Impact of MS4 Discharges to Potential PWQCs in a Subarea

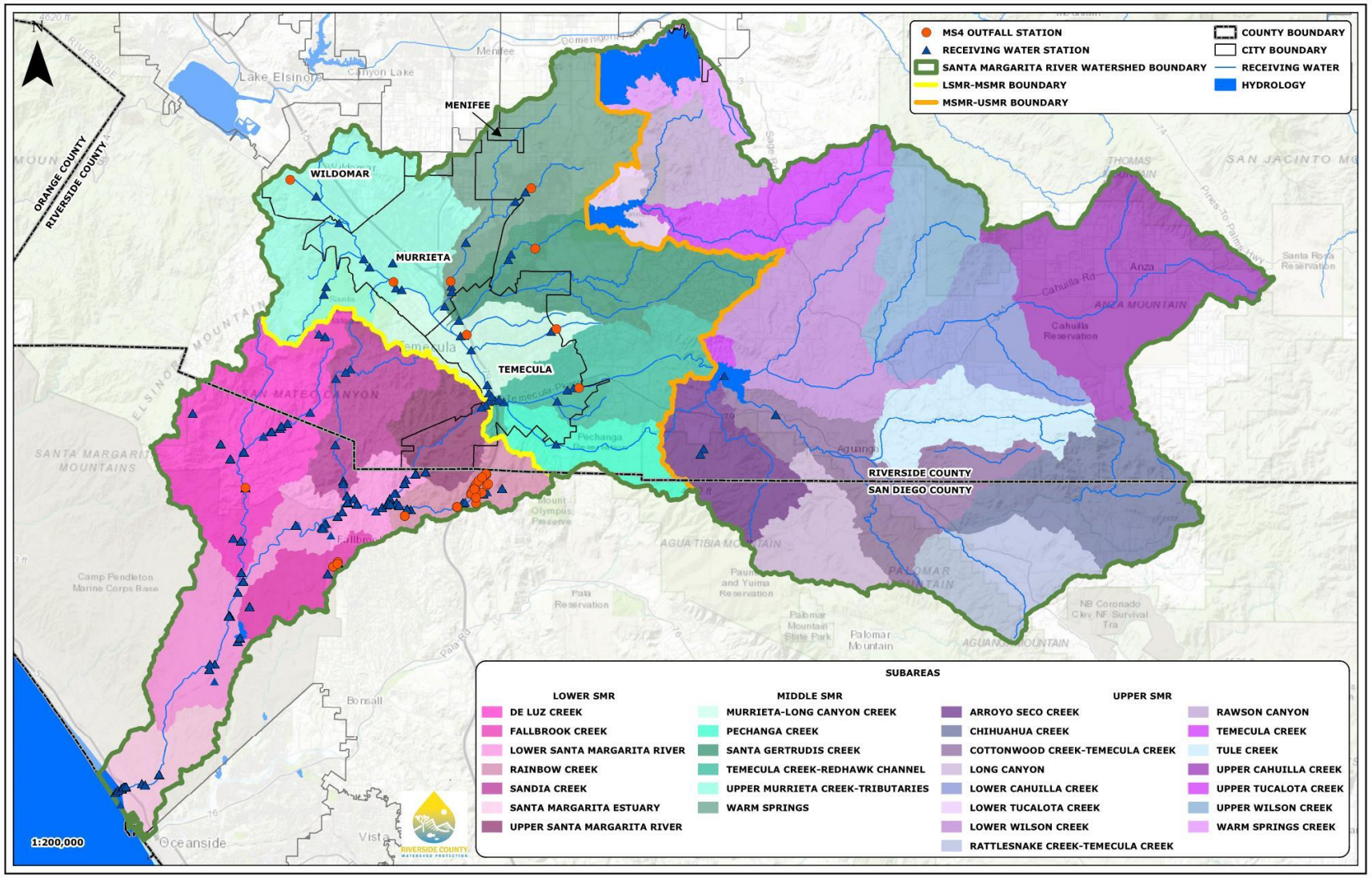

Figure 2-10. SMR WMA Receiving Water and Outfall Monitoring Stations (with Available Data)

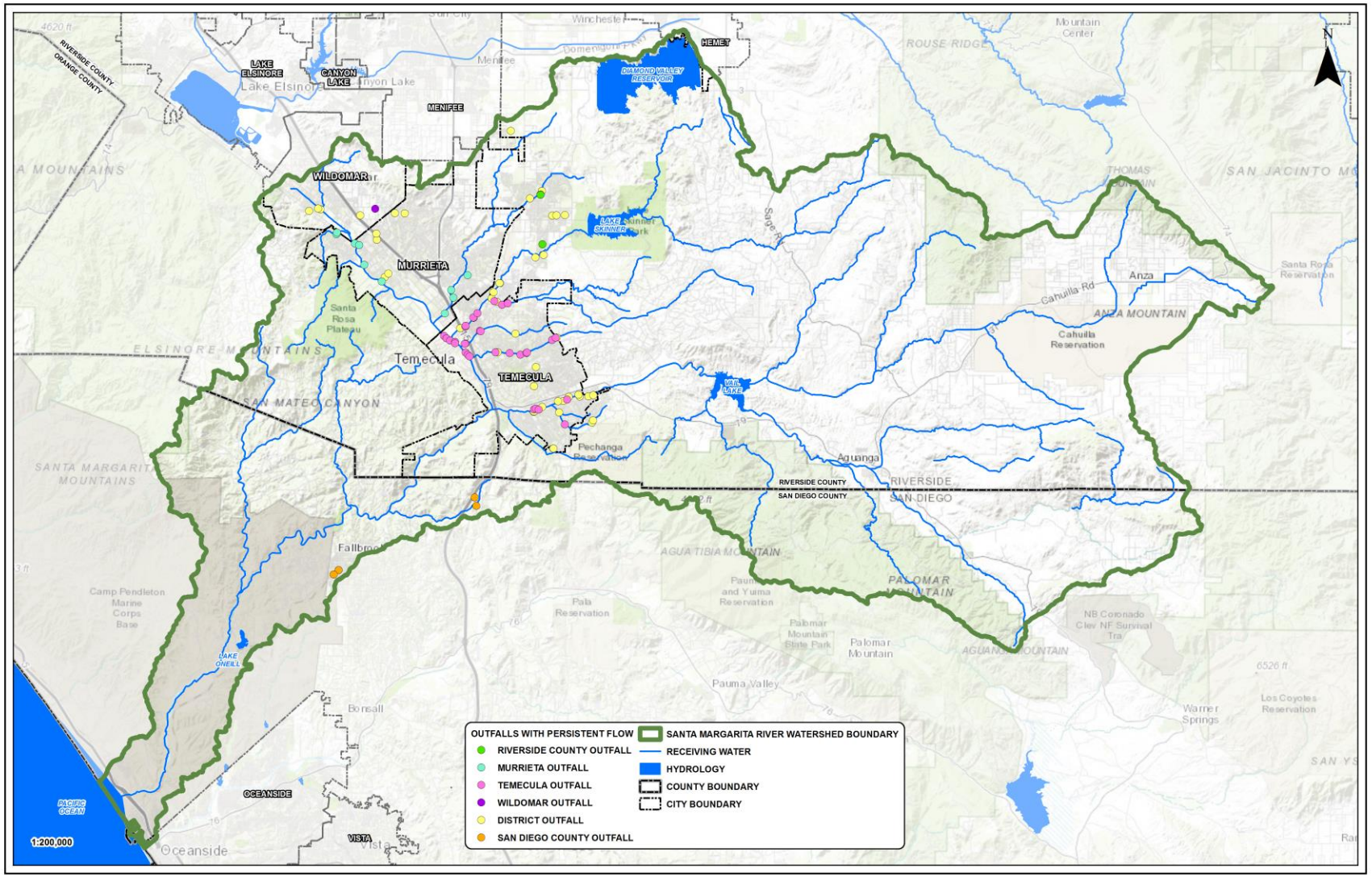

Figure 2-11. Major MS4 Outfalls Identified through Field Screening as Having Persistent Non-stormwater Discharges

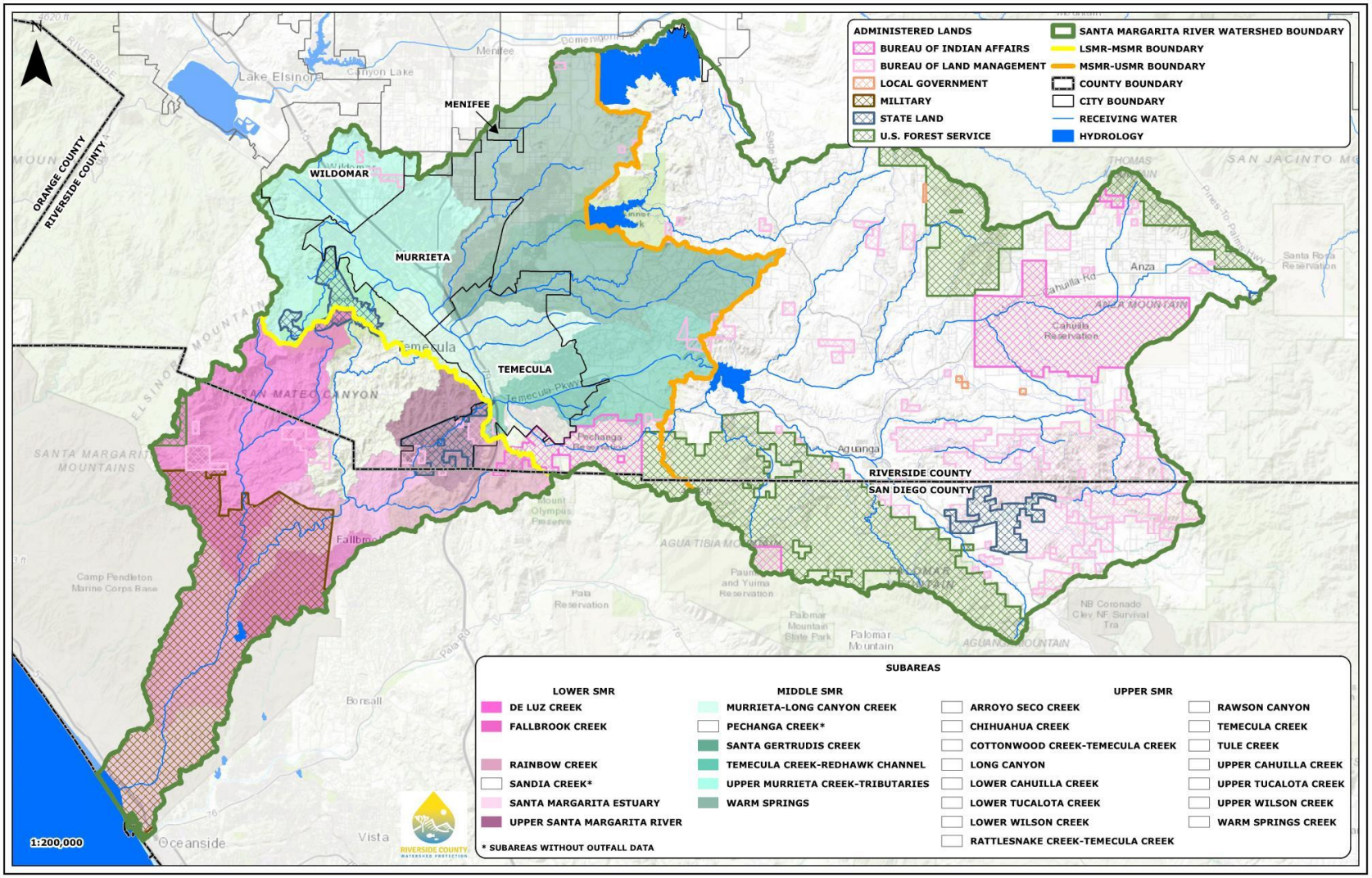

Figure 2-12. Subareas Identified Based on the Step 2 Assessment as Having MS4 Discharges that Contribute to Potential PWQCs

Table 2-31. Summary of Step 3- Potential PWQCs Identified Based on Assessment of MS4 Discharge Impacts

Beneficial Use Category	Potential PWQCs	Physical, Chemical, and Biological Indicators	Upper SMR Subwatershed	Middle SMR Subwatershed					Lower SMR Subwatershed						
			Arroyo Seco Creek	Upper Murrieta Creek and Tributaries	Warm Springs	Murrieta and Long Canyon Creek	Santa Gertrudis Creek	Temecula Creek and Redhawk Channel	Upper Santa Margarita River	Lower Santa Margarita River	Rainbow Creek	Fallbrook Creek	De Luz Creek	Sandia Creek	Santa Margarita River Estuary
Aquatic Life	Eutrophication	Algal biomass			N/A			N/A							N/A
		Benthic community indices			N/A	N/A		N/A							
		Dissolved Oxygen	(4)			N/A		N/A	(3)	N/A	N/A	N/A	N/A		N/A
	Nutrient Loading to TMDL waterbodies	Total Nitrogen			X	(1)	(1)	X		X	X	X	(1)	(4)	(3)
		Total Phosphorus		X	X	X	X	X	(3)	(1)	X	X	(1)	(4)	(3)
	Toxicity	Ammonia						1							(3)
		Pesticides				(2)			(3)						
		Metals			(1)	X					(1)			(4)	
		Toxicity				X		X							
	Physical Habitat	Sediment CRAM scores													
		Evidence of erosion and hydromodification			N/A	N/A									

Beneficial Use Category	Potential PWQCs	Physical, Chemical, and Biological Indicators	Upper SMR Subwatershed	Middle SMR Subwatershed					Lower SMR Subwatershed						
			Arroyo Seco Creek	Upper Murrieta Creek and Tributaries	Warm Springs	Murrieta and Long Canyon Creek	Santa Gertrudis Creek	Temecula Creek and Redhawk Channel	Upper Santa Margarita River	Lower Santa Margarita River	Rainbow Creek	Fallbrook Creek	De Luz Creek	Sandia Creek	Santa Margarita River Estuary
Recreation	Nuisance	Trash [5]		X	X	X	X	X				X			
	Indicator Bacteria Concentrations	Fecal Coliform		X	X	X	X	X		X	X		X		
		E. coli		X	X	X	X	X					(1)		
Water Supply	Constituents of potential concern for drinking water supplies	Nitrate								X	X				
		Title 22 Constituents[3]		X	X	X	X	X	(3)	X	X	X	X	(4)	
Agricultural Supply	Constituents of potential concern for agricultural supply	Total Dissolved Solids			(1)	X	X	X		X	X	X	X	(4)	
		Chloride													
		Boron													
Industry	Constituents of potential concern for industrial supply	pH	(4)			(1)	(1)	(1)					X		
		Total Dissolved Solids			(1)	X	X	X		X	X	X	X	(4)	

1. MS4 outfall data do not exceed in at least two samples and more than 10% of the time for this indicator.
2. Simazine is the only pesticide observed as having exceedances in receiving waters. No outfall data for simazine are available. Other pesticides, particularly bifenthrin, that may contribute to toxicity have been observed above thresholds in these outfalls, but receiving water data for other pesticides did not exceed thresholds.
3. No MS4 outfalls are located in the subarea to assess potential impacts. No MS4 outfalls are present. Upstream MS4 discharges may contribute to any PWQC identified in the receiving waters in the subarea.
4. No MS4 outfall data for this subarea so no PWQCs are identified.
5. MS4s are presumptively assumed to be contributing trash from priority land uses under the Statewide Trash Amendments.

2.5 STEP 4A PRIORITY WATER QUALITY CONDITIONS

2.5.1 Priority Water Quality Conditions (Provisions B.2.c.(1)(a-d))

PWQCs were determined based on the analysis conducted in Steps 1-3. The potential PWQCs were identified in **Table 2-30** and the potential impact of the discharges from MS4 outfalls on those potential PWQCs is shown in **Table 2-31**. As shown in **Table 2-31**, not all physical, chemical, and biological indicators can be assessed with MS4 outfall data and outfall data are not available in some areas. As a result, the PWQCs were determined using the following procedure:

1. If the MS4 contributed a chemical indicator that was associated with the PWQC to a subarea, the potential PWQC was identified as a PWQC for all indicators associated with the PWQC. For example, if a MS4 contributed nitrogen or phosphorus to a subarea and the receiving water exceeded algal biomass thresholds, eutrophication was assigned as a PWQC even though algal biomass cannot be measured in the MS4 outfalls.
2. If no MS4 outfall data were available for a subarea that receives MS4 discharges (e.g. Upper Santa Margarita River), the potential PWQC was considered a PWQC if the upstream MS4 outfall data exceeded for the indicator.

Based on this procedure, the identified PWQCs are summarized in **Table 2-32** along with the beneficial use category, geographic and temporal extent, and the responsible agency(ies) for each PWQC. The PWQCs identified for each subarea are shown in **Figure 2-13.** The industrial supply beneficial use category did not have any identified PWQCs because no industrial diversions were identified and the related exceedances of TDS are addressed by the agricultural BU category PWQCs.

Table 2-32. Priority Water Quality Conditions

BU Category	Priority Water Quality Condition	Temporal Extent	Geographic Extent	Responsible Agency(ies)
Aquatic Life Use: Eutrophication	Eutrophication (elevated algal biomass)	Dry	SMR Estuary[1], Warm Springs, Redhawk Channel	All Agencies
	Nutrient loading to waterbodies with an adopted TMDL or listed as impaired	Dry	All Middle and Lower SMR subareas, except Fallbrook Creek and Sandia Creek[1]	All Agencies
		Wet	Rainbow Creek	San Diego County
Aquatic Life Use: Toxicity	Observed toxicity	Dry	Temecula Creek and Redhawk Channel	RCFCWCD Riverside County Temecula
		Wet	Murrieta Creek and Long Canyon	Menifee Murrieta Temecula RCFCWCD Riverside County Wildomar

BU Category	Priority Water Quality Condition	Temporal Extent	Geographic Extent	Responsible Agency(ies)
Aquatic Life Use: Physical Habitat	Lowered physical habitat scores (CRAM) or evidence of hydromodification/ erosional impacts	Wet	Warm Springs, Murrieta Creek and Long Canyon	Menifee Murrieta RCFCWCD Riverside County Temecula Wildomar
Aquatic Life Use / Recreation: Nuisance Conditions	Trash	Dry	All Middle SMR subareas, Fallbrook Creek	All Agencies
		Wet	All Middle SMR subareas, Fallbrook Creek	All Agencies
Recreation	Indicator Bacteria Concentrations	Dry	Temecula Creek and Redhawk Channel and De Luz Creek	RCFCWCD Riverside County San Diego County Temecula
		Wet	Upper Murrieta Creek, Warm Springs, Murrieta Creek and Long Canyon, Santa Gertrudis Creek, Temecula Creek and Redhawk Channel	Menifee Murrieta Temecula RCFCWCD Riverside County Wildomar
Municipal Supply	Constituents of potential concern for municipal supplies (Iron, Manganese)	Dry	Murrieta Creek and Long Canyon, Temecula Creek and Redhawk Channel, Upper Santa Margarita River, Rainbow Creek, Lower Santa Margarita River, Fallbrook Creek, De Luz Creek	Murrieta Temecula RCFCWCD Riverside County San Diego County
		Wet	All Middle SMR subareas, Rainbow Creek	All Agencies
Agricultural Supply	Constituents of potential concern for agricultural supply (TDS)	Dry	Santa Gertrudis Creek, Murrieta Creek and Long Canyon, Temecula Creek and Redhawk Channel, Rainbow Creek, Lower Santa Margarita River, Fallbrook Creek	Murrieta Temecula RCFCWCD Riverside County San Diego County
		Wet	Rainbow Creek	San Diego County

1. Discharges from MS4 outfalls within these subareas may reach the SMR Estuary during dry weather and contribute to the Eutrophication PWQC in the Santa Margarita River Estuary: Upper Murrieta Creek and Tributaries, Warm Springs, Santa Gertrudis, Murrieta Creek and Long Canyon, Temecula Creek and Redhawk Channel, Upper Santa Margarita River, Lower Santa Margarita River, Rainbow Creek and De Luz Creek.

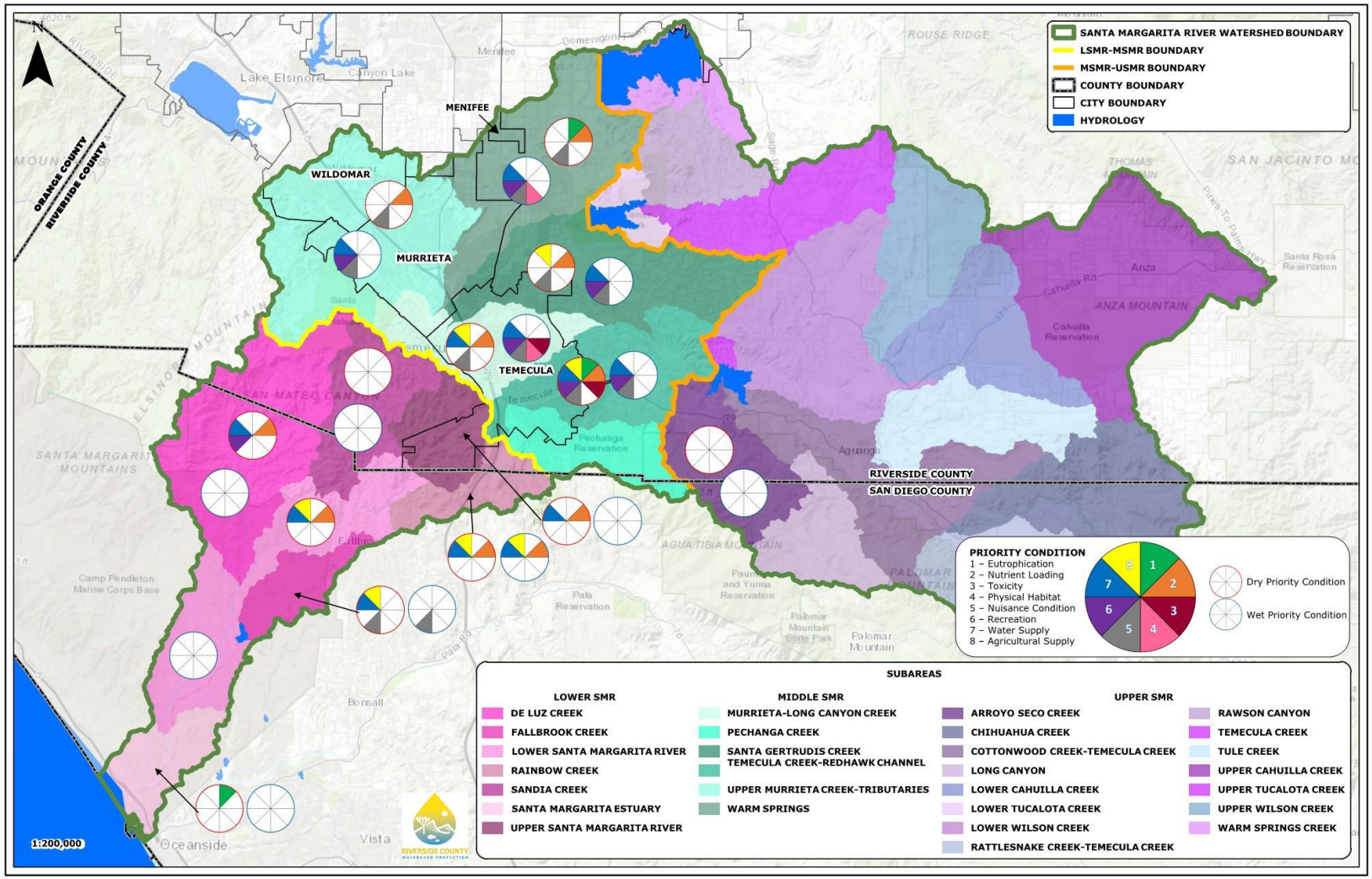

Figure 2-13. Priority Water Quality Conditions in the SMR WMA

2.5.2 Monitoring Data Adequacy and Data Gaps (Provision B.2.c.(1)(e))

Data gaps were evaluated for the SMR WMA analyses of receiving water conditions and potential impacts from discharges from MS4 outfalls.

Receiving water conditions were found to have data gaps for specific analyses, particularly for:

- Biological indices;
- Toxicity;
- Algal biomass; and
- Physical habitat.

Other datasets for receiving water assessments (e.g., chemistry) were adequate to assess receiving waters conditions in the Lower and Middle SMR Subwatersheds. However, recent receiving water data were not available for the Upper SMR Subwatershed.

Data to characterize MS4 discharges is spatially limited, particularly in the Middle SMR Subwatershed. Thus, MS4 outfall data is a limiting factor in gaining a comprehensive understanding of the MS4 contribution to watershed conditions.

Streams in the Middle SMR Subwatershed are predominantly ephemeral or intermittent. In many cases, site visits indicated that receiving waters, especially in the Middle SMR Subwatershed, were dry. Receiving water and outfall sites that were observed to be dry during site visits are indicated by a designation of "visited not sampled" or VNS. The percentage of time that a site was dry during site visits is shown in **Figure 2-14**. The limited data resulting from the ephemeral or intermittent nature of the watershed drainage network constrains the ability to fully assess MS4 impacts on receiving waters.

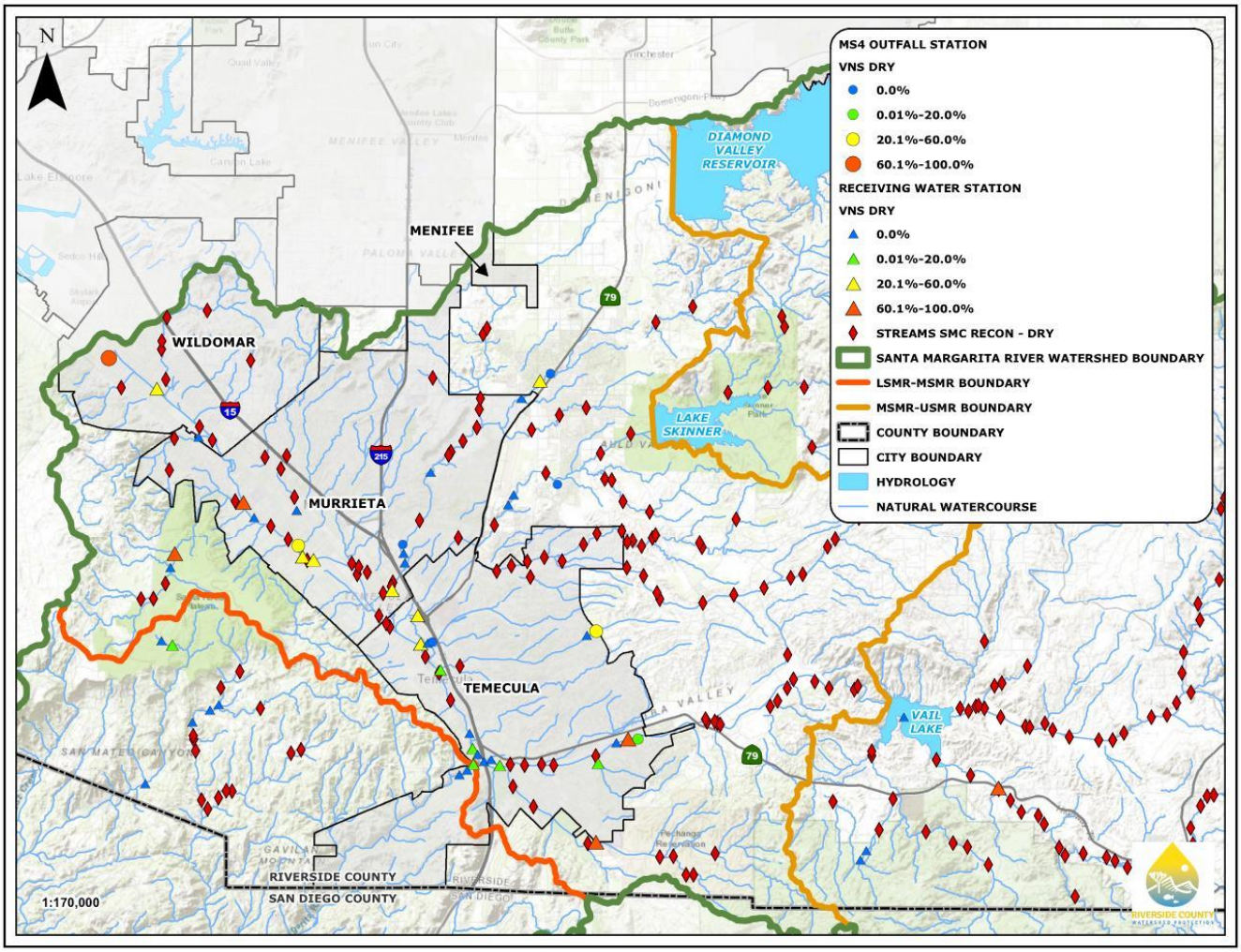

Figure 2-14. Reaches and Receiving Water Monitoring Locations within the Upper and Middle Santa Margarita River Subwatersheds and Monitored Flow Conditions (Perennial to Dry)

VNS = Visited Not Sampled (dry or discontinuous channel or outfall)

As a part of the development of goals, strategies, and the monitoring program, data gaps will be further evaluated by identifying specific questions to support assessment of watershed conditions and implementation to address PWQCs. In addition, work that could address some data gaps may be conducted as part of the SMRNIG should grant funds be available.

2.6 STEP 5B. HIGHEST PRIORITY WATER QUALITY CONDITION (PROVISION B.2.C.(2))

The HPWQC to be addressed by the WQIP (**Table 2-34**) was selected from the list of PWQCs by evaluating them against a set of ten considerations outlined in **Table 2-33**.

- The first seven considerations include many of the components evaluated in Prioritization Steps 1-4. The existence of a TMDL/significant regulatory action, impaired waters 303(d) listing, current WQO and threshold exceedances, as well as historic conditions, location, and geographic extent of the conditions were all taken into account.
- The last three considerations include potential improvements in condition of waterbodies in the WMA and MS4 discharge quality that can be achieved as stated in Permit Provisions B.2.a.(9) and B.2.b.(6) in the Permit.

Each of the PWQCs was given a binary score of 1 if it met the consideration or 0 if it did not. These scores were then summed to give a final score to each of the PWQCs out of a highest possible score of 10. These total scores were then used to rank the PWQCs such that the highest score determined the HPWQC.

Based on the assessment of HPWQC considerations, eutrophication was selected as the HPWQC (See **Table 2-34**) in comparison to other PWQCs. In general, the scoring reflects the limited geographic scope of other PWQCs and the lack of evidence of beneficial use impacts, combined with limited availability of technology available to effectively treat all constituents affecting recreation, water supply, and agricultural supply.

Given the 303(d) listings, the existing TMDL, and the TMDL Alternative under development for nutrients and biostimulatory substances that cover most subareas in the Middle and Lower Subwatersheds, the potential impact on aquatic life from those conditions, and the threshold exceedances observed in those subareas, eutrophication is the clear HPWQC for the Middle and Lower SMR Subwatersheds. The eutrophication HPWQC includes all subareas with observed eutrophication impacts (elevated algal biomass and impacted benthic scores), dry weather nutrient loading to those subareas to address the eutrophication, and dry and wet weather nutrient loading to Rainbow Creek to address the Rainbow Creek Nutrient TMDL.

The intent of the WQIP is to address the HPWQC identified through this prioritization process. As implementation progresses and more information is collected to support the prioritization process, the Copermittees and the City of Menifee could determine that other watershed conditions are of a higher priority or that addressing an identified priority may not result in the most beneficial or cost-effective way to protect beneficial uses. If this were to occur, the Copermittees and the City of Menifee may choose to change their focus, and potentially adjust their priorities, as part of the adaptive management process.

Table 2-33. Summary of Rationale for Selection of Highest Priority Water Quality Conditions

Beneficial Use Category	Aquatic Life			Aquatic Life/ Rec.			
Considerations	Eutrophication	Toxicity	Physical Habitat	Nuisance (Trash)	Recreation	Water Supply	Agricultural Supply
TMDL existing/under development (Permit Provision 2.a.(2)) or significant regulatory action	**1**			1			
303(d) Listing (Permit Provision 2.a.(1))	**1**	1			1	1	1
Threshold exceedances (to assess Permit Provision 2.a.(4)-Receiving Water Limitation, Permit Provision 2.a.(6)-analysis of physical, chemical, and biological Receiving Water data, Permit Provision 2.a.(8)-evidence adverse impacts to waterbody integrity):							
Current WQO exceedances (water chemistry)	**1**	1			1	1	1
Current threshold exceedances (other indicators) or evidence of impacts (Permit Provision 2.a.(7))	**1**		1	1	1		
Known historical compared to current conditions (Permit Provision 2.a.(5)) (increasing trends)	**1**						
Known locations of potential beneficial use impacts	**1**	1	1		1		
Geographic extent (majority of subareas have PWQC)	**1**			1	1	1	
Assessment of potential improvements in condition of WMA and MS4 discharge quality that can be achieved (Permit Provisions 2.a.(9) and 2.b.(6)) based on score from following questions:							
Feasible projects or programs that could be considered to improve PWQCs?	**1**	1	1	1	1		
If PWQCs are improved through actions taken by the Copermittees, would opportunities related to the beneficial use be realized?	**1**	1	1	1			
Are there other social benefits gained by restoring the beneficial uses?	**1**	1	1	1	1		
Total	**10**	6	5	6	7	3	2

Table 2-34. Highest Priority Water Quality Condition (Eutrophication)

Beneficial Use Category	Priority Water Quality Condition	Temporal Extent	Geographic Extent
Eutrophication	Eutrophication impacts (elevated algal biomass)	Dry	SMR Estuary [1], Warm Springs, Redhawk Channel [2]
	Nutrient loading to waterbodies with an adopted TMDL or listed as impaired	Dry	All Middle and Lower SMR subareas, except Fallbrook Creek and Sandia Creek[1]
		Wet	Rainbow Creek

1. MS4 discharges within the following subareas may reach the SMR Estuary during dry weather and contribute to the Eutrophication PWQC in the Santa Margarita River Estuary: Upper Murrieta Creek and Tributaries, Warm Springs, Santa Gertrudis, Murrieta Creek and Long Canyon, Temecula Creek and Redhawk Channel, Upper Santa Margarita River, Lower Santa Margarita River, Rainbow Creek and De Luz Creek.
2. Other subareas may be added as result of TMDL Alternative development during adaptive management process.

The geographic extent of the HPWQC is shown in **Figure 2-15**.

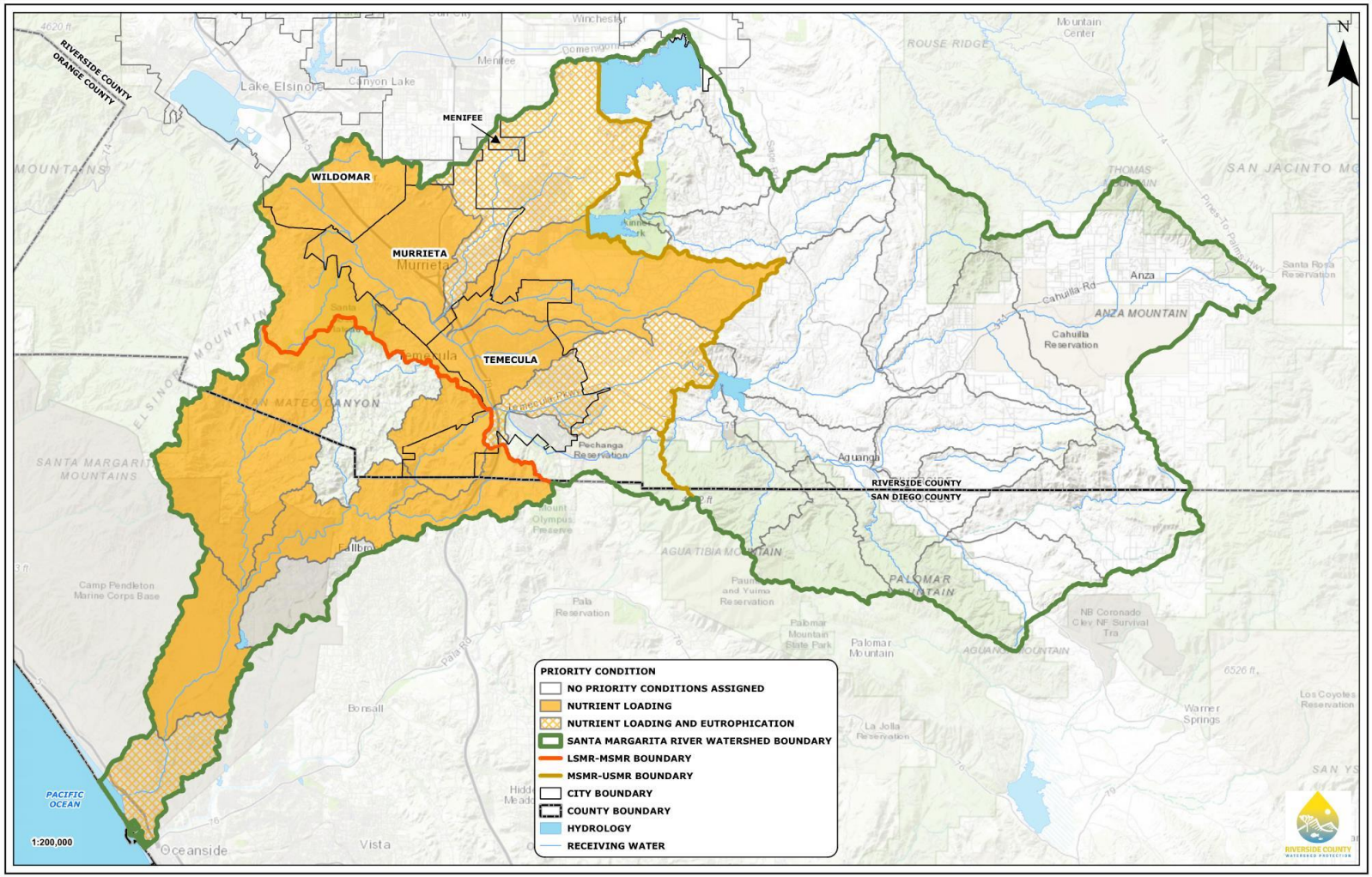

Figure 2-15. Geographic Extent of HPWQC

3 Identification of MS4 Sources of Pollutants and/or Stressors

As a part of the WQIP, the Copermittees must "identify and prioritize known and suspected sources of stormwater and non-stormwater pollutants and/or stressors associated with discharges that cause or contribute to the highest priority water quality conditions". The purpose of the source identification is to evaluate the presence or absence of key sources within the watershed that have the potential to contribute to the HPWQC. The results of the source identification will drive the selection of strategies designed to address these sources, and thereby address the HPWQC. As part of this effort, the following was considered:

- Pollutant generating facilities, areas, and/or activities within the watershed;
- Locations of the Copermittee's stormwater conveyance systems;
- Other known and suspected sources of non-stormwater or pollutants in stormwater discharges to receiving waters within the watershed;
- Review of available data; and
- Adequacy of available data to identify and prioritize sources and/or stressors associated with discharges from MS4 outfalls.

The items listed above were used to identify pollutants and stressors that potentially contribute to the identified HPWQC (eutrophication impacts/nutrient loading). This Plan considers watershed conditions and priorities in the context of the Copermittees' obligations to control MS4 discharges, and the evaluation of potential sources of the HPWQC focuses on MS4 discharges. For sources outside of the regulatory authority of the Copermittees and those impacting water quality within the WMA, the Copermittees may consider opportunities to collaborate with other entities to control the sources. Sources described in this section are not exhaustive, but are generally representative of the types of sources present within the WMA. Reducing nutrient loading from watershed sources will address both elements of the HPWQC – eutrophication impacts (elevated algal biomass) and nutrient loading to TMDL waterbodies.

The identification of sources begins with considering land uses but includes many types of other source information to identify areas and activities within the watershed that contribute total nitrogen and total phosphorus loading to the MS4 . The distribution (in acreage) of land uses (i.e., agriculture, commercial, industrial, etc.) for each agency are shown in **Table 3-1** and the land uses within the watershed are shown in **Figure 3-1**.

Table 3-1. Santa Margarita River WMA Land Use (acre) by Agency [a]

Type of Land Use [b]	City of Menifee	City of Murrieta	City of Temecula [c]	City of Wildomar [d]	County of Riverside	Riverside County Flood Control and Water	County of San Diego	Total	% of Land Use
Agriculture	0	295	0	297	21,953	0	5,389	27,934	5.9%
Commercial	8	1,028	1,476	164	884	0	112	3,672	0.8%
Industrial	0	227	1,075	40	136	0	51	1,529	0.3%
Open space	115	3,941	6,980	2,971	42,660	0	3,100	59,767	12.6%
Parks and Recreation	<1	598	794	105	1,083	0	30	2,610	0.6%
Rural Residential	585	7,185	3,408	2,910	105,475	0	6,144	125,707	26.5%
Urban Residential	35	4,919	5,947	1,586	2,956	0	839	16,282	3.4%
Streets	72	6,468	3,248	908	8,020	0	548	19,264	4.1%
>>>Total	815	24,661	22,928	8,981	183,167	0	16,213	256,763	

a. Other land uses not within the Agencies' jurisdictions comprise the remaining percentage (37%) of land uses found within the Upper, Middle and Lower Santa Margarita River Subwatersheds, totaling 156,185 acres. These land uses are comprised of federal and tribal lands, as well as vacant, undeveloped land, and waterbodies.

b. Land use Sources: Riverside County – July 2017 County Assessor Parcel Data; San Diego County, 2017 SANDAG.

c. Please note the City does not have any land uses zoned for agricultural. However agricultural operations are allowed on all residentially zoned land uses. All commercially operated agricultural operations within the city require a business license and the city uniquely identifies these in its business license inventory. There are currently no commercially operated vineyards or orchards within City limits. "Temecula Wine Country" is located outside Temecula City Limits

d. Only includes land use data within the Santa Margarita River watershed

e. Facilities owned and operated by RCFCWCD, and their respective acreage, are included in **Table 3-3** and illustrated in **Figure** 3-3.

Residential land uses (29.9%) comprise the largest proportion of land use within the jurisdiction of the Copermittees, followed by open space (12.6%). Commercial and industrial together make up about 1% of the total SMR WMA. Agriculture comprises 5.9% of land use in both subwatersheds. Forty-six percent of the land use is comprised of federal and tribal lands, as well as vacant, undeveloped land and waterbodies outside of the Copermittees jurisdiction. **Figure 3-1** illustrates the distribution of land uses within the SMR watershed.

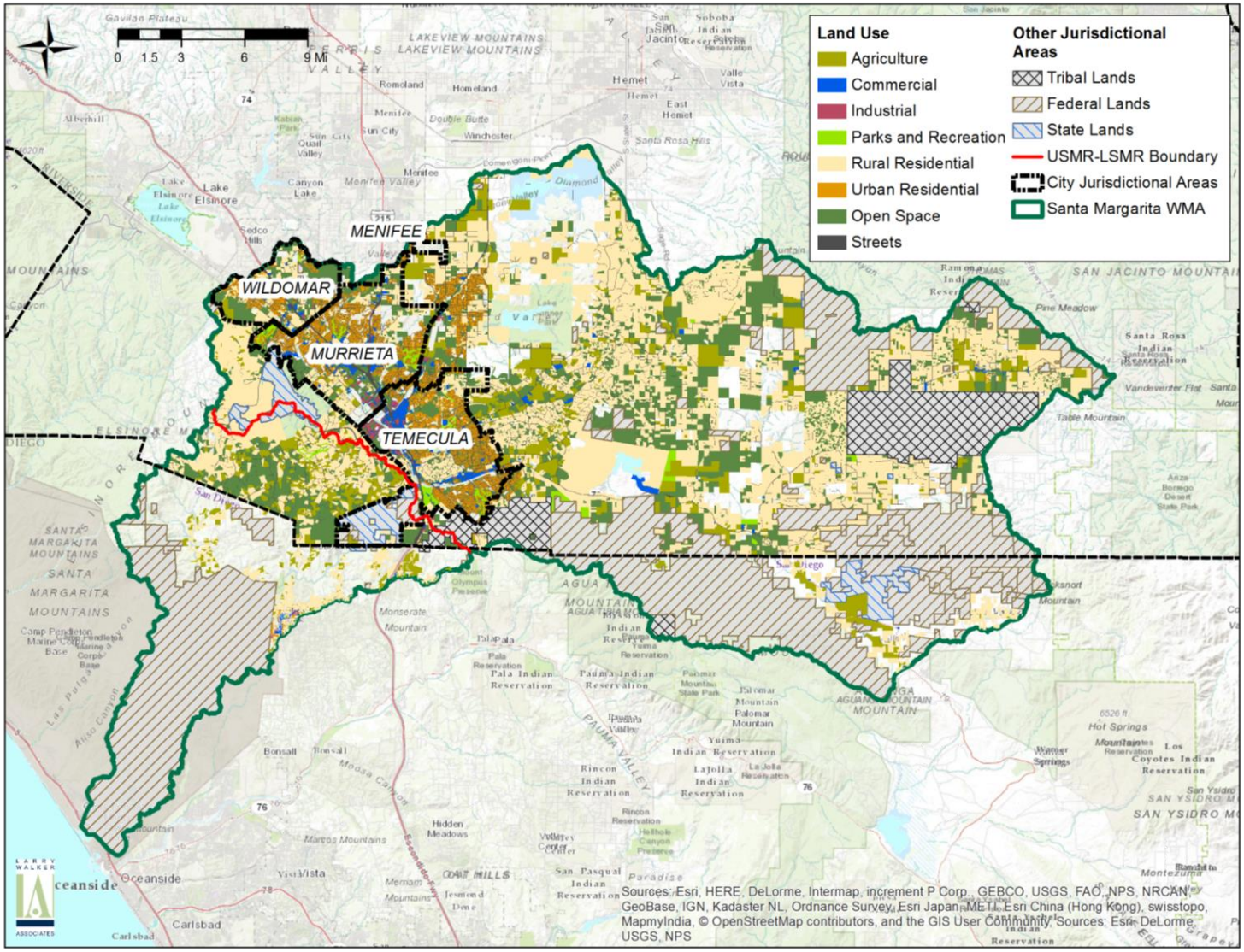

Figure 3-1. Land Uses within Santa Margarita River Watershed

3.1 POLLUTANT GENERATING FACILITIES, AREAS, AND/OR ACTIVITIES

The Copermittees and the City of Menifee considered pollutant generating facilities, areas, and/or activities within the watershed, including, but not limited to, the following:

1. Each agency's inventory of construction sites, commercial, industrial, and municipal facilities, and residential areas;
2. Publicly owned parks and/or recreational areas;
3. Open space areas;
4. All currently operating or closed municipal landfills or other treatment, storage or disposal facilities for municipal waste; and
5. Areas not within the agencies' jurisdictions (e.g., Phase II MS4, tribal lands, state lands, federal lands) that are known or suspected to discharge to MS4s.

3.1.1 Pollutant Generating Facilities, Areas, and Activities

The Copermittees and the City of Menifee maintain a list of construction sites, commercial, industrial, and municipal facilities, and residential areas that can be used to assist in identifying areas that have the potential to contribute nutrient loading to receiving waters. During dry weather, pollutants from these potential sources may reach the MS4 through illicit discharges or illegal dumping.

- All Copermittees and the City of Menifee maintain construction inventories within their jurisdictions, which can span the various types of land uses across the watershed. There is the potential for sediment discharges, primarily during the rainy season, which could transport phosphorus or other pollutants to the MS4. In particular, sites that are being converted from prior agricultural land uses may warrant specific attention when in active construction.
- Commercial sites include existing development such as restaurants, nurseries, car washes, auto repair shops, and other facilities. Based on activities at these sites and the nature of their operations, some commercial sources may be sources of nutrients (e.g., nurseries, restaurants). Restaurants and nurseries are more likely to be sources of illicit discharges due to their onsite activities (e.g., illegal washing, tail water), while any of the sites that have landscaping could contribute to nutrient loading through irrigation runoff. While they only represent approximately 1% of the land use within the watershed, commercial facilities are concentrated more in the Cities of Murrieta and Temecula and the County of Riverside than in other areas. As illustrated in **Figure 3-2**, there are very few commercial nurseries within the incorporated areas of the watershed.
- Industrial sites include, but are not limited to, manufacturing and large-scale production facilities. These sites are generally regulated through other permits (e.g., Industrial General Permit), typically have materials stored inside, and are not as likely to have illicit discharges as a result of their typical activities and operations. However, as with other facilities, those with landscaping could contribute to nutrient loading through irrigation runoff. Industrial facilities are not common within the watershed, representing <1% of the land use.

- Municipal sites include, but are not limited to, municipal buildings, offices, maintenance yards, parks, community centers, fire stations, and libraries. While these sites are not as likely to contribute nutrients through their activities, any of them with landscaping could contribute to nutrient loading through irrigation runoff. This may be particularly applicable to municipal parks, where there tends to be more grass, landscaping, and irrigation. Parks and recreation facilities only represent approximately 1% of the land use within the watershed.
- Residential areas within the watershed are the predominant land use within the agencies' jurisdictions, comprising approximately 30% of the land use within the watershed. These areas have several potential activities that could contribute to nutrient loading including, but not limited to, landscape irrigation and overwatering, small "backyard" agricultural operations, and equestrian uses.

Table 3-2 presents the current inventory of active commercial, industrial, construction, and municipal sites within the agencies' jurisdictions. The RCFCWCD does not have any commercial, industrial, or municipal sites; therefore, its facilities are summarized in **Table 3-3**.

Table 3-2. Summary of Applicable Pollutant Generating Facilities, Areas, and/or Activities by Agency within the Santa Margarita River Watershed.

Potential Pollutant Generating Sites	City of Menifee	City of Murrieta	City of Temecula[1]	City of Wildomar[3]	County of Riverside	County of San Diego	Riverside County Flood Control and Water Conservation District
Construction Sites	0	31	92	32	112	63	9[2]
Commercial Sites	3	267	648	52	196	153	0
Industrial Sites	0	6	126	2	52	18	0
Municipal Sites	0	65	53	5	43	8	0

1. Number of construction sites determined by active Construction Notices of Intent obtained from SMARTS on December 05, 2017.
2. Construction sites are listed pursuant to encroachment permits issued by the RCFCWCD or federal agreement and are not RCFCWCD projects.
3. Only within the Santa Margarita River watershed.

Table 3-3. Summary of Facilities Owned and Operated by Riverside County Flood Control and Water Conservation District

Type of Facility	Description
Linear Facilities (e.g., storm drains, channels)	435,180 linear feet (82.4 linear miles)
Basins (1 retention basin, 1 detention basin, 1 desilting basin)	3 facilities (15 acres)
Owned Parcels (e.g., basins, channels, access roads)	836 acres[1]

1. The RCFCWCD maintains the as-built capacity/lines and grades of existing flood control facilities within the 836 acres. Maintenance activities include sediment and debris removal, slope and erosion repairs, side-slope tracking and/or reshaping, vegetation maintenance, structure rehabilitation and/or replacement, rip-rap and grout repair, removal and replacement of concrete channel linings, and washout backfill and repair.

Figure 3-2 shows the location and distribution of commercial and industrial facilities within the Upper, Middle, and Lower SMR Subwatersheds based on inventories maintained by each Copermittee. Where available within inventories, the figure includes specific types of commercial facilities identified as potential sources of nutrient loading including orchards, vineyards, nurseries, and horse ranches. The RCFCWCD's facilities are illustrated in **Figure 3-3**. Additional information regarding potential commercial and industrial sources within the Lower SMR Subwatershed can be found in the Long-Term Effectiveness Assessment. (San Diego Stormwater Copermittees, 2011) Available watershed-specific loading information related to these sources is also discussed below in **Section 3.3**.

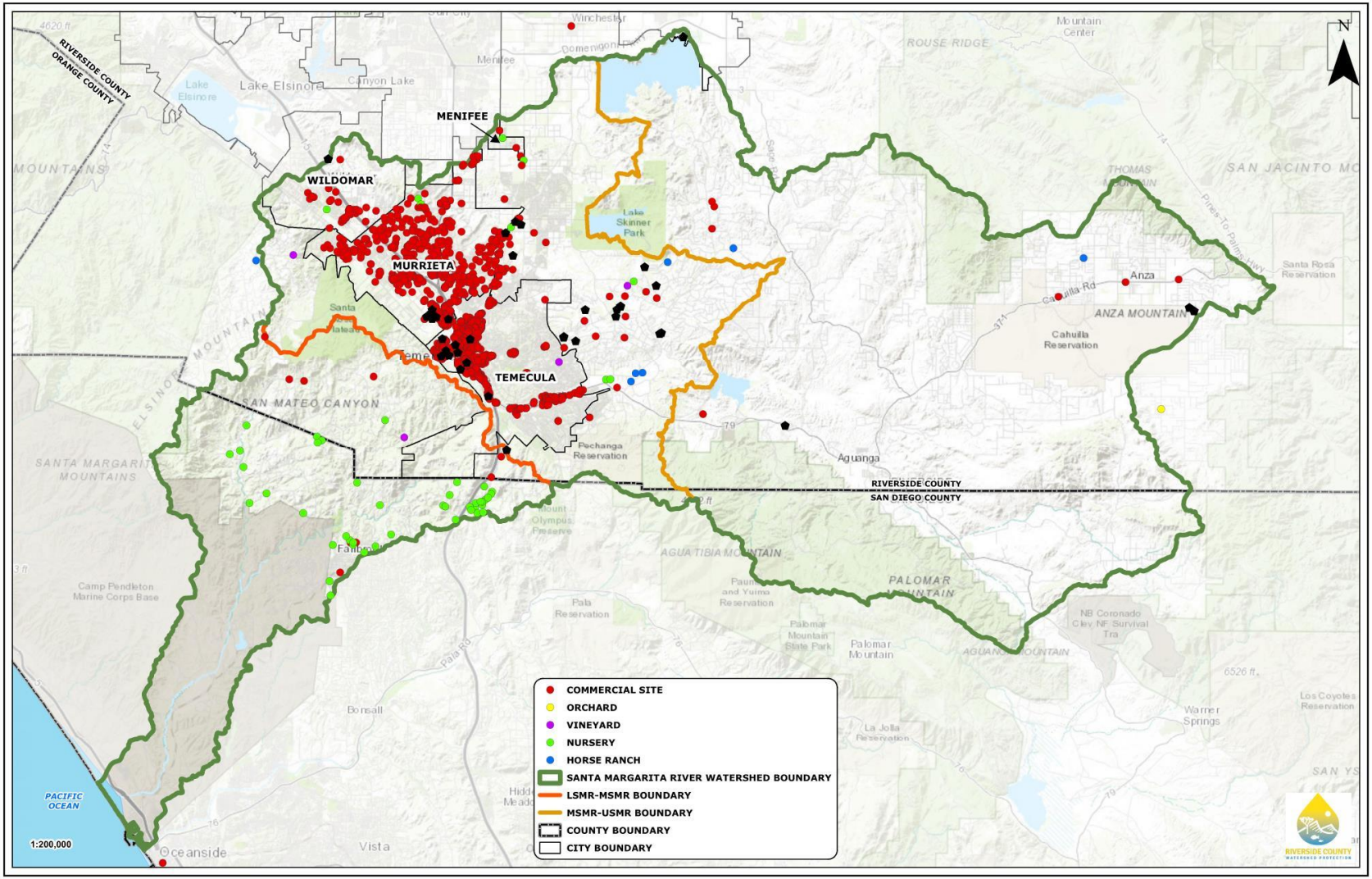

Figure 3-2. Location and Distribution of Commercial and Industrial Facilities within the Santa Margarita River Watershed

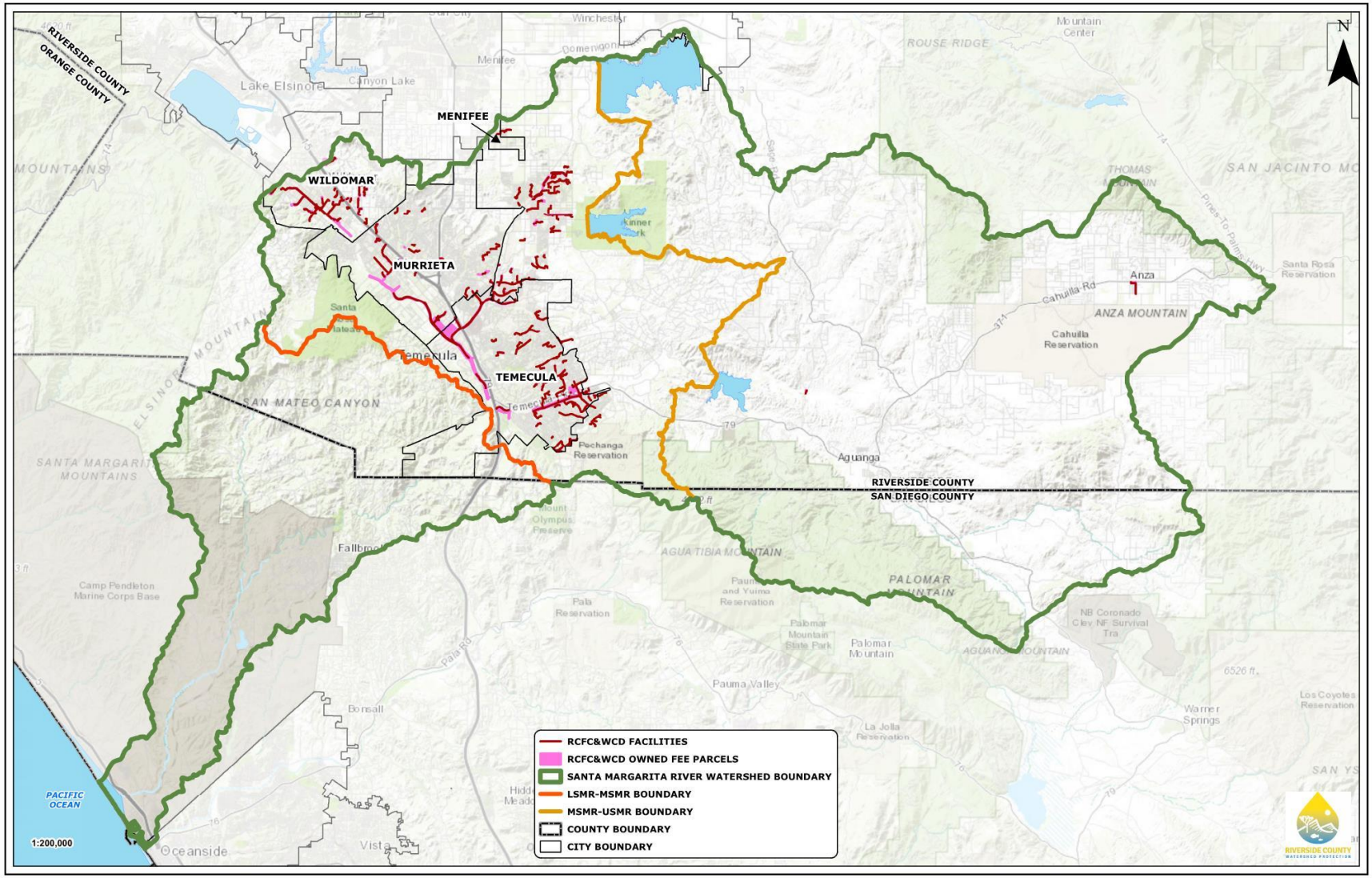

Figure 3-3. Location and Distribution of RCFCWCD Facilities within the Santa Margarita River Watershed

3.1.2 Parks, Recreational and Open Space Areas

Publicly owned parks and/or open space areas make up 13% (62,377 acres) of the SMR WMA. Overall, the area of individual parks within the agencies' jurisdictions is small (2,610 acres) as compared to the overall extent of open space throughout the watershed as a whole (59,767 acres). Parks and open space are summarized by jurisdiction in **Table 3-3**.

Table 3-4. Summary of Parks and Open Space Areas within the SMR WMA

Agency	Number of Parks	Acres of Open Space[2]
City of Menifee	0	115
City of Murrieta	50	3,941
City of Temecula	40	6,980
City of Wildomar[1]	2	2,971
County of Riverside	22	42,660
County of San Diego	1	3,100
RCFCWCD	0	0

1. Only includes land use data within the SMR Watershed.
2. Land use Source: July, 2017 County Assessor Parcel Data; 2017 SANDAG.

Open space and parks contribute to the nutrient loading for all jurisdictions included in the model analysis, further discussed in **Section 3.3**. The predicted nutrient loads from municipal parks and recreation areas are relatively low, between 0 to 2.5% of the overall nutrient loading from the MS4s, depending on the jurisdiction. Although loading from parks is estimated to be a small part of the overall nutrient load from the watershed, this may be due to the limited acreage of parks within the watershed. Because parks can be a source of nutrients and are often owned and maintained by the Copermittees, the Copermittees have developed strategies to address potential nutrient loading from these areas.

3.1.3 Landfills or Other Treatment Facilities for Municipal Waste

There are four operating or closed municipal landfills or other treatment, storage or disposal facilities for municipal waste within the agencies' jurisdictions; one located in the City of Temecula, one in the City of Wildomar (closed), one in the County of Riverside (closed), and one in the County of San Diego. There are no landfills or other treatment facilities for municipal waste within the Cities of Menifee, Murrieta, or the Riverside County Flood Control and Water Conservation District. Due to their relatively low numbers and significant regulation, these facilities are not expected to be significant sources of nutrient loads to the MS4s. Landfills in the watershed are summarized in **Table 3-5**.

Table 3-5. Number of Landfills or Other Treatment Facilities for Municipal Waste within the Santa Margarita River Watershed

Agency	Number of Landfills or Other Treatment Facilities for Municipal Waste
City of Menifee	0
City of Murrieta	0
City of Temecula	1
City of Wildomar	1[1]
County of Riverside	1[2]
County of San Diego	1
RCFCWCD	0

1. Site is closed (Bundy Canyon Landfill is partially located within the SMR watershed).
2. Site is closed (Anza).

3.1.4 Areas not Within the Agencies' Jurisdictions

Tribal lands, federal lands, state parks, and lands regulated by the State Water Board or USEPA may be located within an agency's boundary, but are outside of the jurisdictional land use authority of the agency. Regardless, each of these land uses has the potential to contribute to nutrient loading. Where these areas contribute pollutants to a Copermittee's MS4, the Copermittee will work with the land owner to ensure that any illicit discharges cease and/or notify the permitting authority. In general, while models do predict that nutrient loads from these sources could impact receiving waters, the amount of loading from these land uses entering and, therefore, discharging from Copermittees' MS4ss is very low. Specific loading predictions from these sources are further discussed in **Section 3.3**. As illustrated in **Table 3-1**, there are significant areas of land within the watershed that are outside of the Copermittees' jurisdictions, including tribal lands, state lands, and federal lands. In the Upper, and Middle SMR Subwatersheds, these areas account for approximately 70,000 acres or 20% of the land area. In the Lower SMR Subwatershed, these areas occupy approximately 60% of the land area, totaling over 40,000 acres.

3.1.5 Location of the Agencies' Stormwater Conveyance Systems

The Copermittees identified and mapped the locations of their stormwater conveyance systems, including, but not limited to, the following:

1. All MS4 outfalls that discharge to receiving waters; and
2. Locations of major structural controls for stormwater and non-stormwater (e.g., retention basins, detention basins, major infiltration devices, etc.).

The locations of the 345 major MS4 outfalls within the watershed are shown in **Figure 3-4** and the locations of major structural controls are illustrated in **Figure 3-5**. The figures were developed based on 2017 data provided by each Copermittee. **Table 3-6** presents the number of major structural controls for stormwater and non-stormwater by agency.

Table 3-6. Number of Major Structural Controls for Stormwater and Non-Stormwater Within Agencies' Jurisdictions Within the Upper & Middle SMR Subwatersheds.

Structural BMP	City of Menifee	City of Murrieta	City of Temecula [1]	City of Wildomar	County of Riverside [2]	County of San Diego [3]	Riverside County Flood Control and Water Conservation District
Retention Basins	0	11	21	0	0	0	1
Detention Basins	0	18	11	3	4	0	1
Infiltration BMPs	4	34	74	0	9	0	0
Other major Structural Controls	0	0	505	0	7	0	1
Total Number of Structural BMPs	**4**	**63**	**611**	**3**	**20**	**0**	**3**

1. Tabulation of Structural BMPs does not include over 100,000 square feet of porous asphalt or pervious pavers.
2. Number of sites containing post-construction BMPs is provided. Each site may have multiple BMPs.
3. No major, publicly-owned and operated structural controls within the County of San Diego's jurisdiction in the Lower SMR Subwatershed.

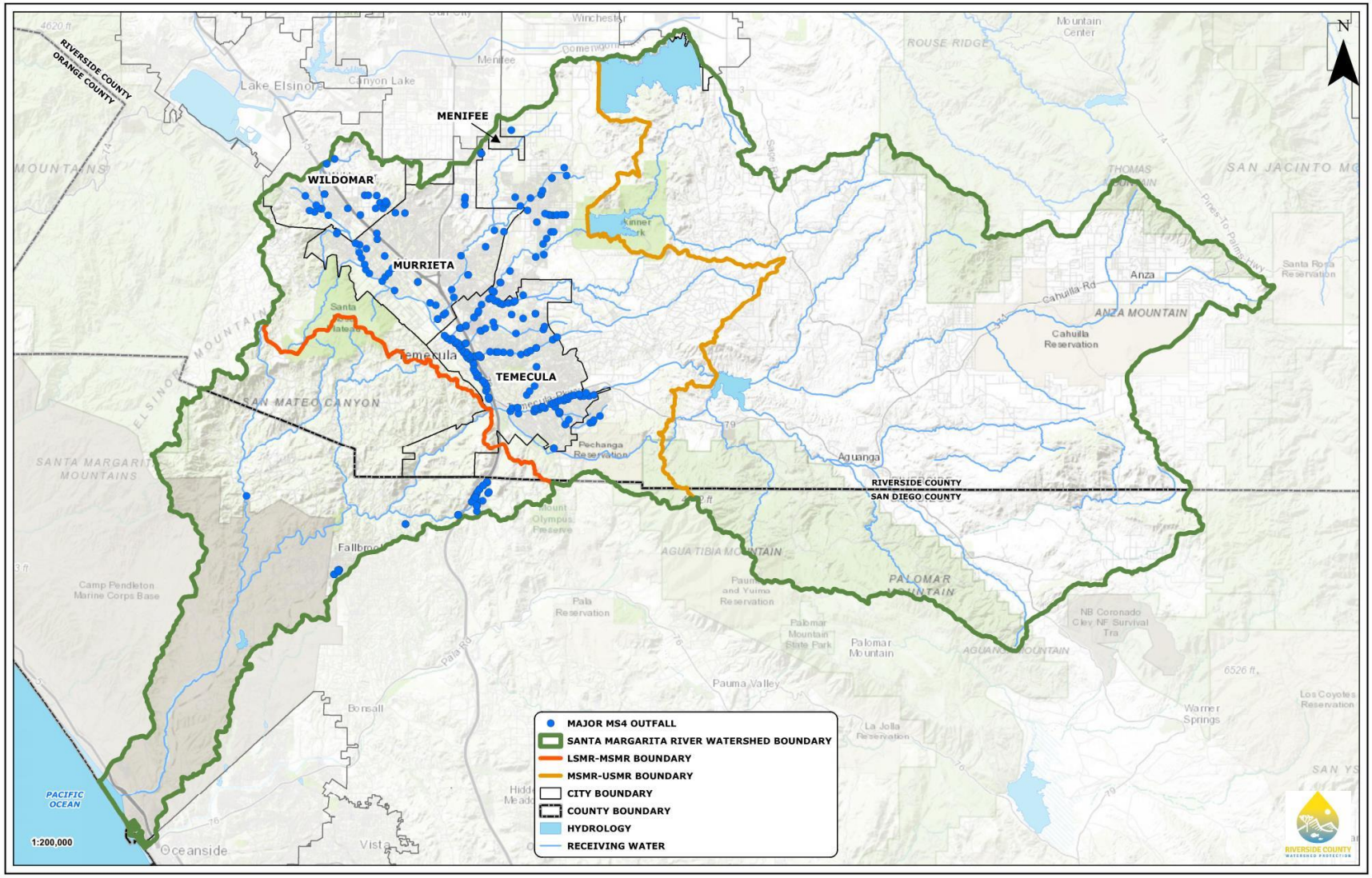

Figure 3-4. Locations of Major MS4 Outfalls within the Santa Margarita River Watershed

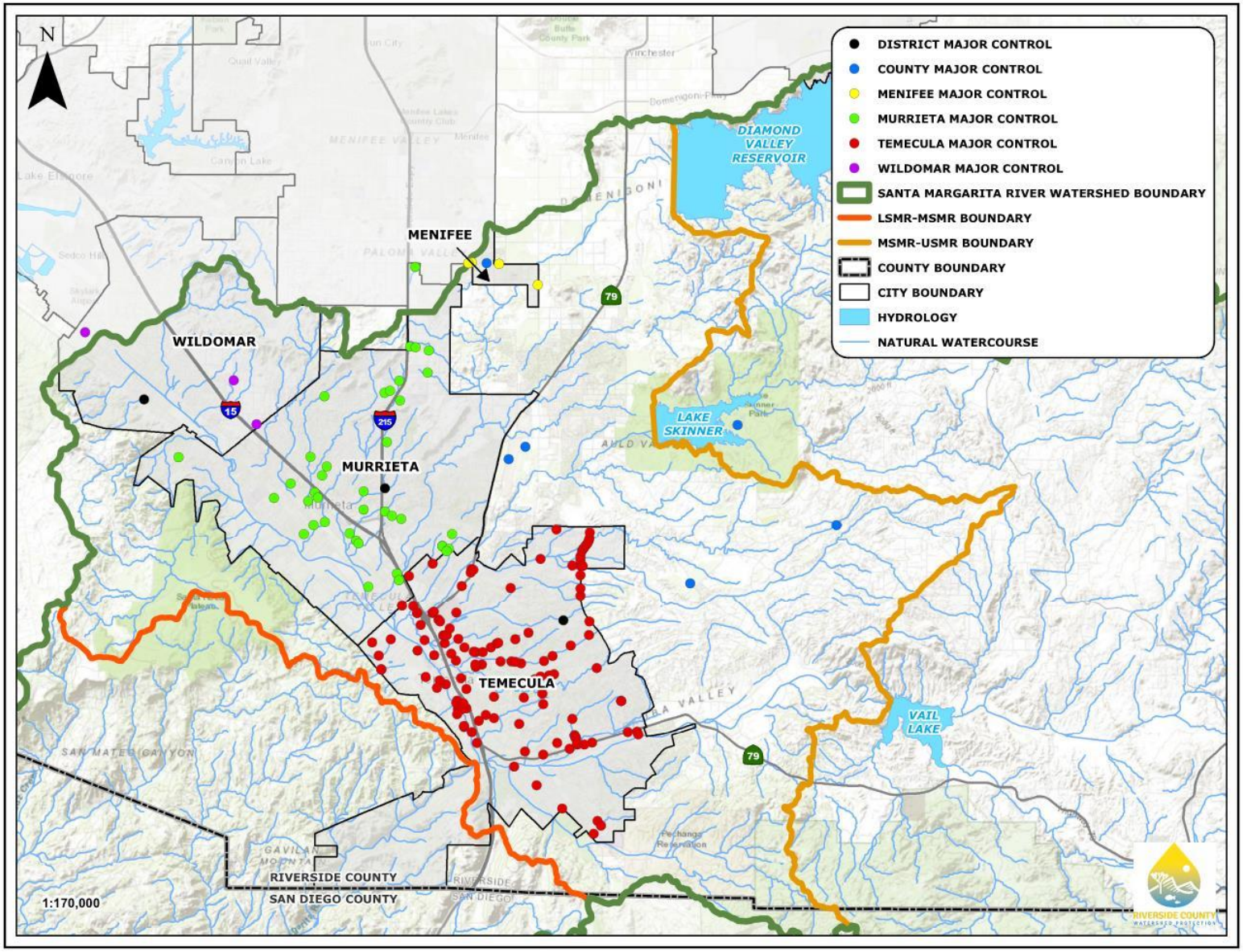

Figure 3-5. Locations of Major Structural Controls Locations within the Santa Margarita River Watershed

3.2 OTHER POTENTIAL SOURCES

Other known and/or suspected sources of non-stormwater discharges or pollutants in stormwater discharges to receiving waters within the watershed, including, but are not limited to, the following:

- Other MS4 outfalls (e.g., Phase II and Caltrans);
- Other NPDES permitted discharges;
- Any other discharges that may be considered point sources (e.g., private outfalls); and
- Any other discharges that may be considered non-point sources (e.g., agriculture, wildlife or other natural sources).

3.2.1 Other MS4 Outfalls

In addition to discharges from areas not within the agencies' jurisdictions as discussed in **Section 3.1.4**, there are entities covered by NPDES Permits issued by the State Water Board, including the Phase II MS4 Permit (California State Water Resources Control Board, 2013) and the Caltrans MS4 Permit (California State Water Resources Control Board, 2012b).

There are no traditional or non-traditional Phase II facilities within the Upper and Middle SMR Subwatersheds. Camp Pendleton, which is located on federal land in the Lower SMR Subwatershed, is currently the only non-traditional Phase II entity in the SMR WMA that is regulated under the Phase II MS4 Permit. Nutrient loading from Camp Pendleton is relatively small and does not discharge to Copermittee-owned MS4s, however, their discharges may impact conditions in the SMR Estuary and they do participate in watershed management activities with the Copermittees through the SMRNIG. For example, there are fallow agricultural fields (i.e., Stuart Mesa) on Camp Pendleton that may contribute nutrient loading to the estuary. Models developed by the SMRNIG have estimated nutrient loading from Camp Pendleton as illustrated in Figure 3-6.

Caltrans does own and operate state highways within the watershed and associated MS4 infrastructure. Discharges from Caltrans' MS4s are regulated by the State Water Board. Caltrans participates in the SMRNIG; models developed by the group have estimated nutrient loading from Caltrans as illustrated in **Figure 3-6**.

3.2.2 Other NPDES Permitted Discharges

There are point source discharges within the watershed that are regulated under other statutes by the Regional Water Board and/or State Water Board. Examples of discharges and the associated regulatory mechanisms include:

- Publicly Owned Treatment Works: Individual NPDES permits issued by the Regional Water Board;
- Industrial sites: State Water Board Industrial Storm Water General Permit Order 2014-0057-DWQ;
- Construction sites (>1 acre): State Water Board Construction Storm Water General Permit Order No. 2012-0006-DWQ; and

- Pumped Groundwater (i.e., dewatering): Multiple Regional Water Board Permits (e.g., Order R9-2008-0002).
- Caltrans MS4 Permit: Order 2012-0011-DWQ as amended by Order WQ 2014-0006-EXEC, Order WQ 2014-0077-DWQ, an Order WQ 2015-0036-EXEC; NPDES NO. CAS000003 National Pollutant Discharge Elimination System (NPDES) Statewide Storm Water Permit Waste Discharge Requirements (WDRs) for State of California Department of Transportation.

Regulation of these sources is generally performed by the permitting agency (i.e., State Water Board, Regional Water Board); however, some are regulated by both the permitting authority and the Copermittees and the City of Menifee (e.g., industrial sites, construction sites, illicit discharges). Publicly Owned Treatment Works (POTWs) (i.e., publicly owned sewage treatment plants) may also be another potential source, however, POTWs are traditionally regulated through individual NPDES permits.

3.2.3 Other Point Sources

Copermittees and the City of Menifee have not identified other point source discharges within the watershed (e.g., privately owned MS4s). However, where there are privately owned systems that contribute flows, during dry or wet weather, into an agency's MS4, these discharges are regulated by the agency through various programs and ordinances (e.g., commercial or residential inspections programs). There is also potential for the sanitary sewer collections systems within the watershed to act as a point source discharge if there are sanitary sewer overflows. These systems are regulated under State Water Board Order No. 2006-0003-DWQ. Copermittees and the City of Menifee may also address these types of discharges through their IDDE and existing development programs where appropriate.

3.2.4 Non-Point Sources

There are non-point source discharges within the watershed that are regulated under other statutes by the Regional Water Board and/or State Water Board. Non-point sources (and their regulatory mechanism, where applicable) that may contribute to nutrient loads within the watershed include:

3.2.4.1 Onsite Wastewater Treatment Systems (OWTSs): Regional Water Board Conditional Waiver #1 (California Regional Water Quality Control Board, 2007) and State Water Board OWTS Policy (California State Water Resources Control Board, 2012c)

Due to the presence of OWTSs within the watershed, the Copermittees have identified OWTSs (i.e., septic systems) as a potential non-point source discharge that could contribute nutrient loading to receiving waters. Septic systems are widely distributed throughout the Copermittees' jurisdictions in the SMR WMA. Septic systems could impact Copermittees' MS4s, and are commonly found upstream of reaches identified as impacted by eutrophication impacts or nutrient loading. A total of 3,940 parcels within the Riverside County portion of the SMR WMA are permitted to use septic systems and comprise an area of approximately 35,689 acres (**Figure 3-7**). The extent and influence of septic systems in the San Diego portion of the SMR WMA is undetermined. Leaking or malfunctioning septic systems have the potential to contribute to dry weather nutrient loads through two mechanisms: 1) direct infiltration to the receiving water, and 2) infiltration to the MS4.

3.2.4.2 Agricultural Discharges

A commercial agricultural operation is defined as any agricultural business or trade activity, including farms, nurseries, and orchards, that produces crops with the intent to make a profit. Discharges from commercial agriculture have been shown to contribute significant nutrient loads to receiving waters within the watershed as shown in **Figure 3-6**. The Regional Water Board regulates commercial agricultural operations under these agricultural waste discharge requirements (WDRs) issued in 2016:

- Regional Water Board Order No. R9-2016-0004 General Waste Discharge Requirements for Discharges from Commercial Agricultural Operations for Dischargers that are Members of a Third-Party Group
- Regional Water Board Order No. R9-2016-0005 General Waste Discharge Requirements for Discharges from Commercial Agricultural Operations for Dischargers that are not Participating in a Third-Party Group

Agricultural operations enrolled under these orders are required to implement BMPs, perform monitoring, and report on implementation and results. Agricultural operations currently enrolled under the WDRs are illustrated in **Figure 3-8**.

The SMRNIG modeling efforts demonstrate that very little loading of TN and TP is discharged from commercial agriculture operations into the MS4s within the incorporated cities in the watershed (see **Table 3-8**). Conversely, multiple commercial agricultural operations are present in the unincorporated areas within the watershed and may contribute to TN and TP loading in MS4s, as shown in **Table 3-8**.

Strategies to address nutrient sources from commercial agricultural discharges are included in **Chapter 4**. When illicit dry weather discharges and wet weather runoff with potentially high levels of nutrients from these operations are encountered, the agencies will coordinate with the agricultural dischargers and the Regional Water Board to ensure that the facilities are aware of the agricultural WDRs, as applicable, and compliant with local water quality ordinances.

Some agricultural operations are not required to enroll under the general agricultural orders. These small growing operations on residential lots are not producing with the intent to make a profit. These operations may discharge to the MS4s and will be addressed primarily through the Permittees' IDDE programs.

All Permittees within the SMR watershed maintain adequate legal authority through their stormwater ordinances to require and enforce the implementation of control strategies to address illicit discharges of nutrients to their MS4s. Examples of BMPs to be implemented by various agencies are provided below. The list is a compilation of strategies from the agencies that may be applied to agricultural operations whether or not they are enrolled under the applicable Water Board Agricultural WDRs. The list is not meant to apply to a single agency, nor is it inclusive of all options at an agency's disposal.

Dry Weather

- Enhancement of the commercial / industrial / municipal inspection programs to focus on irrigation systems;

- Utilization of municipal personnel and contractors to monitor storm water outfalls for discharges of potential illicit connections and illicit discharges; and
- Enforce escalating legal authority established for all inventoried existing development, including residential and agricultural, to conserve water and eliminate dry weather flows.

Dry and Wet Weather

- Identification, investigation, and elimination of illicit discharges to the MS4;
- Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, agricultural (e.g., large commercial nurseries), residential, and municipal properties;
- Notify agricultural business license holders of requirement to enroll in the Regional Water Board Agricultural Order;
- Develop and implement enhanced outreach programs targeting nurseries;
- Develop and distribute informational brochures for nurseries and vineyards that focus on BMPs that reduce nutrients in runoff;
- Collaborate with watershed partners to develop consistent messaging to targeted audiences, such as commercial residents to conserve water and reduce dry weather flows; and
- Implement escalating enforcement responses to compel compliance with ordinances, permits, contracts, orders, and other requirements for ICID, development planning, construction management, industrial/commercial, municipal, and residential development (including residential equestrian and livestock activities).

3.2.4.3 Groundwater Seepage

Groundwater seepage is another potential non-point source of nutrients to MS4s and receiving waters within the watershed. Modeling performed by the SMRNIG has estimated loading from groundwater to receiving waters as illustrated in **Figure 3-6**.

3.2.4.4 Homeless Encampments

Copermittees also have information indicating the presence of homeless encampments within the watershed. While these encampments are likely non-point sources of human waste to receiving waters, the impacts of encampments on water quality have not been quantified.

3.2.4.5 Natural Sources

Environmental sources are most often non-point or diffuse in nature. These include sources of pollution that are naturally present in the environment. Copermittees have limited control over these sources. Examples of environmental sources of pollution present within the WMA include atmospheric deposition, leaf litter and debris, natural wildlife sources, natural erosion, and natural groundwater, all of which may be present in open space areas. Natural sources that can be anthropogenically influenced include groundwater quality altered by imported water supplies, aerial deposition of transportation and industrial pollutants, and erosion exacerbated by

hydromodification[10]. Contributions of nutrient loads from open space have been estimated through models developed by the SMRNIG and are shown in **Figure 3-6**.

[10] In contrast to other anthropogenically influenced natural sources, erosion caused by hydromodification is addressed under the Permit through the Land Development requirements in Provision E.3.





Agriculture
TN 74,700 lb/day
TP 3,300 lb/day

MS4 Copermittee Outfalls[1]
TN 9,300 lb/day
TP 920 lb/day

Watershed Groundwater
TN 1,800 lb/day
TP 2,600 lb/day

Caltrans
TN 400 lb/day
TP 46 lb/day

Other Loads (Tribal, Open Space)
TN 37,700 lb/day
TP 2,700 lb/day

Camp Pendleton
TN 530 lb/day
TP 52 lb/day

Stuart Mesa Groundwater
TN 6800 lb/day
TP 9 lb/day

1. "MS4 Copermittee Outfalls" includes loading from agricultural operations draining to the MS4.

Figure 3-6. Sources and Associated Loads of Total Nitrogen and Total Phosphorus in the SMR Watershed (Sutula, et al., 2016)

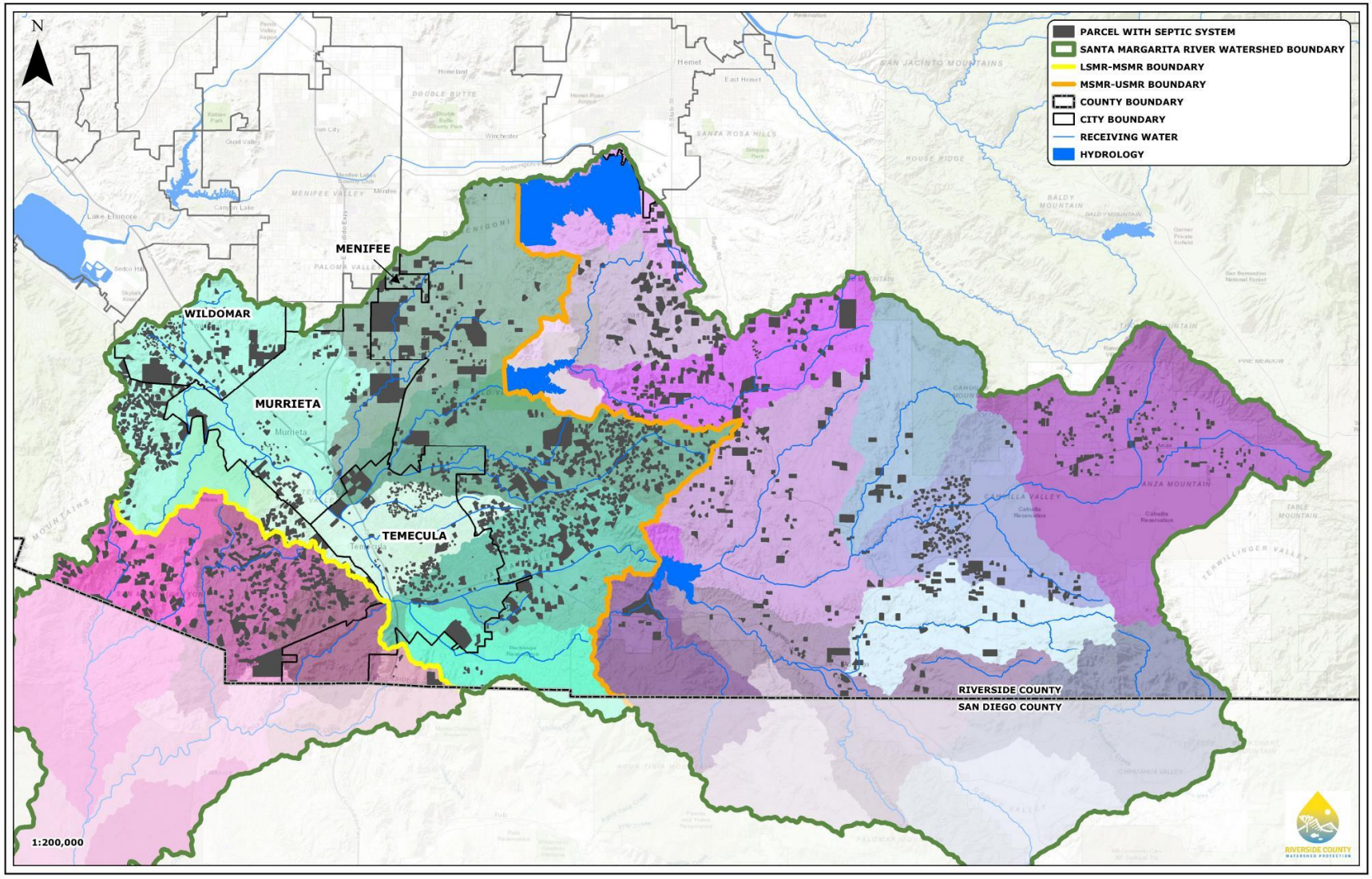

Figure 3-7. Parcels with Septic Systems within the Riverside County portion of the Santa Margarita River WMA (Source: Riverside County Department of Environmental Health)

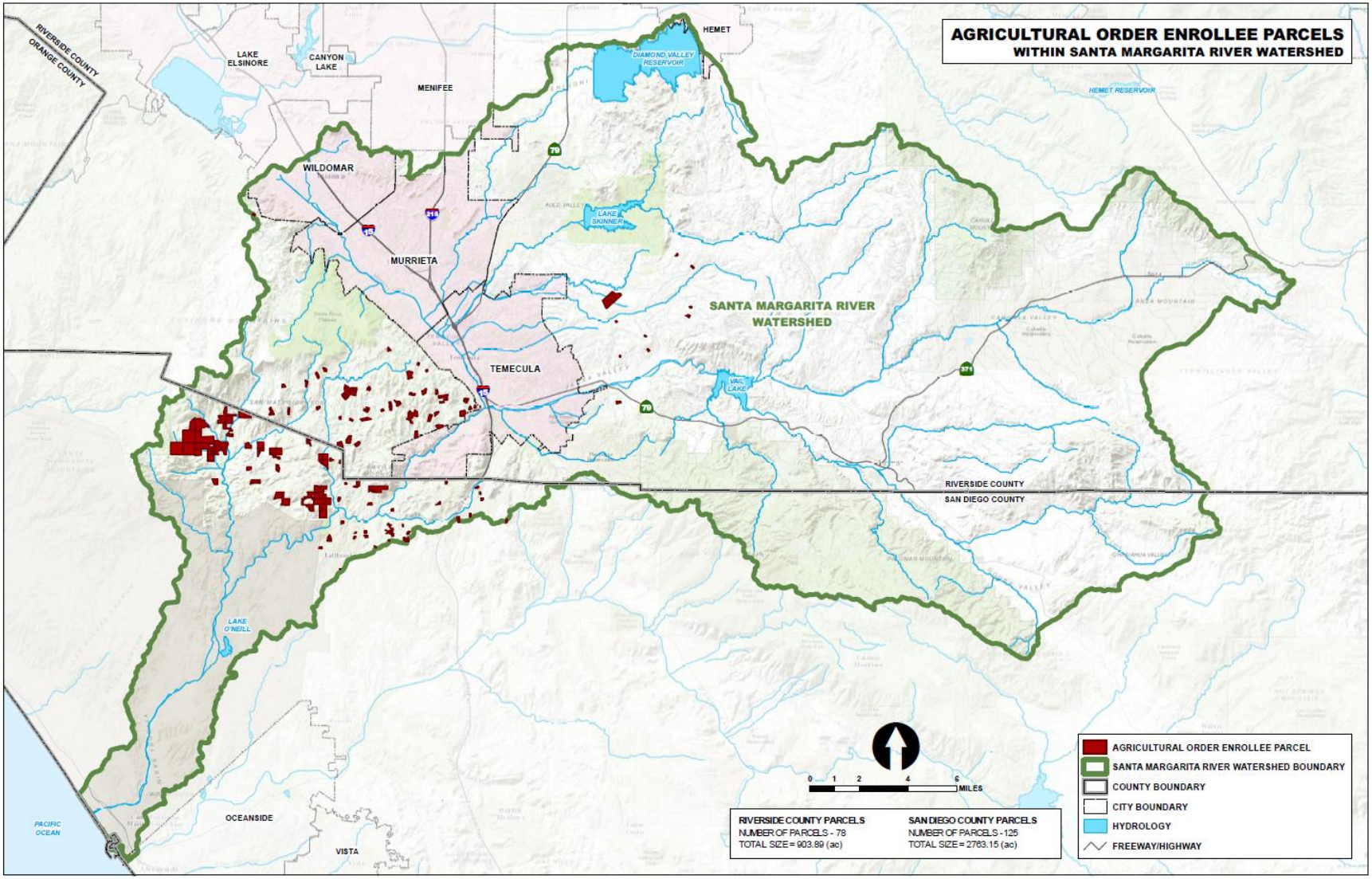

Figure 3-8. Parcels Within the SMR Watershed Enrolled in the Regional Water Board Agricultural Order

3.3 REVIEW OF AVAILABLE DATA

The Permit requires that the Copermittees provide the findings of sources of pollutants and/or stressors from the available data reviewed, including, but not limited to, the following:

- Findings from illicit discharge detection and elimination programs;
- Findings from outfall discharge monitoring, receiving water monitoring, and outfall discharge and receiving water assessments; and
- Other available, relevant, and appropriately collected data, information, or studies related to pollutant sources and/or stressors that contribute to the HPWQC.

3.3.1 Illicit Discharge Detection and Elimination (IDDE) Programs

Municipalities operate illicit discharge detection and elimination (IDDE) programs that involve conducting illegal connection/illicit discharge (IC/ID) investigations and inspections to comply with program requirements. A summary of IC/ID activities by agency is shown in **Table 3-7**. The IC/ID data was provided by the agencies with an assessment of the predominant sources most commonly associated with IC/IDs in their jurisdictions.

Table 3-7. Number of IC/ID Activities Conducted as Part of the IDDE Program

IC/ID Activities	FY 11-12	FY 12-13	FY 13-14	FY 14-15	FY 15-16	Predominant Source(s) Associated with Discharge(s)						
						Commercial	Industrial	Residential	Parks and Recreation	Horse Ranches	Orchards, Vineyards, Nurseries	Other Agricultural
City of Menifee	ND	0	0	0	0				N/A			
City of Murrieta	ND	ND	11	13	54			X				
City of Temecula	13	14	8	37	25	X	X		X			
City of Wildomar	0	0	5	6	7	X		X				
County of Riverside	ND	54	45	92	ND	X		X			X	
County of San Diego	ND	ND	78	56	56	X		X				
Riverside County Flood Control and Water Conservation District	3	4	7	8	6			X				

ND = no data; N/A = not applicable

3.3.2 Findings from Major MS4 Discharge and Receiving Water Monitoring and Associated Assessments

The Permit requires the Copermittees to present the findings of potential pollutant sources from available MS4 outfall monitoring, receiving water monitoring, and MS4 outfall discharge and receiving water assessment data. A preliminary assessment of the receiving water conditions

(Permit Provision B.2.a.) and an assessment of impacts from MS4 discharges (Permit Provision B.2.b) were conducted as the first step in the process used to develop a list of priority water quality conditions. Detailed findings from these assessments can be found in **Section 2.4**. While the monitoring data identifies concentrations of pollutants, potential sources of nutrients to the MS4s have not been well-identified in the assessments. The best assessment of sources comes from the SMRNIG technical reports which are summarized in **Section 3.3.4**. Those reports identify residential land uses as the primary nutrient source for most jurisdictions, but several other sources, including commercial, industrial, nurseries, horse ranches and other agriculture could contribute loads depending on their presence within jurisdictions.

3.3.3 Other Data or Studies Related to Pollutant Sources

The Permit requires the Copermittees to consider other available, relevant, and appropriately collected data, information, or studies related to pollutant sources and/or stressors that contribute to the highest priority water quality condition. Available other data and studies that were reviewed as part of the development of the WQIP are summarized in **Appendix 3A**.

Study results from the SMRNIG efforts are further discussed in **Section 3.3.4**. The three non-SMRNIG related studies that are relevant to nutrient loading in the watershed are discussed below.

3.3.3.1 Agricultural, Federal, Tribal, and State Input Special Study, 2014 Annual Progress Report

The Agricultural, Federal, Tribal, and State Input Special Study (Weston Solutions, 2014) was conducted in order to determine the type, quantity, and estimated loading of pollutants in runoff from discrete areas of agricultural, federal, tribal, and state lands, as well as state highway source areas.

Based upon the two years of monitoring data, the pollutant concentrations were characterized for the target source inputs. At Tribal Site 1, constituents measured above water quality criteria during at least one monitoring storm included bacteria (*Enterococcus*, *E. coli*, and fecal coliform), total phosphorus, surfactants (MBAS), turbidity, and some metals (total iron, total manganese, dissolved copper, and dissolved zinc). At Agriculture Site 8, constituents measured above water quality criteria during at least one monitored storm included bacteria (*Enterococcus*, *E. coli*, and fecal coliform), turbidity, total phosphorus, and some metals (total iron, total and dissolved manganese, and total chromium). At Federal Site 1, concentrations of turbidity, total phosphorus, and *Enterococcus* were greater than applicable water quality criteria during the monitoring storm event. Although limited in scope, this study demonstrates that agriculture, tribal, and other federal lands contribute nutrient loads to the watershed. These findings, are further supported by the modeling performed in the watershed as part of the SMRNIG, discussed in **Section 3.3.4**.

3.3.3.2 2011 Long-Term Effectiveness Assessment, San Diego Stormwater Copermittees Urban Runoff Management Programs, Final Report

As part of the Long-Term Effectiveness Assessment (San Diego Stormwater Copermittees, 2011) (LTEA) required for permit renewal in 2011, the Copermittees examined the various sources of pollutants required to be regulated by the Permit in an effort to determine which sources had the most potential to contribute loads of various pollutants of interest to the MS4 (source loading potential). The analysis looked at several pollutants/pollutant groups including nutrients and qualitatively assigned a source loading potential of none, unknown, unlikely, or likely to each of

36 source areas or activities. Although not specific to the SMR WMA, the findings align well with and support the source analysis in this Plan. The analysis concludes that the following sources have a likely potential to contribute nutrients to MS4 discharges and/or receiving waters: residential areas and activities; roads, streets, highways, and parking facilities; parks and recreational facilities; botanical or zoological gardens and nurseries/greenhouses; mobile landscaping; and animal kennels.

3.3.3.3 Geotracker Site 1120 (Camp Pendleton Marine Corps Base Site – 1120 Stuart Mesa)

Stuart Mesa West and East Agricultural Fields is an area of approximately 376 acres on the Camp Pendleton Marine Corps Base. The area is bordered on the northeast by Stuart Mesa Road, on the southwest by the Pacific Ocean, on the south and southeast by the SMR and the SMR Estuary, and by the Marine Corps Tactical Systems Support Facility (MCTSSA) on the west and northwest. The agricultural fields were used for growing tomatoes and strawberries and other agricultural uses for at least 70 years.

In March 2011, the Stuart Mesa Agricultural Fields property lease was terminated, and the fields have been fallow. However, runoff from the fallow agricultural fields has the potential to impact the SMR Estuary, as noted in a letter from the Regional Water Board to the Marine Corps Base (California Regional Water Quality Control Board, San Diego Region, 2017a). For example, unmaintained earthen berms can be erosive and contribute to nutrient loading. Since termination of the lease, the west and east agricultural fields have undergone remediation for identified areas with contaminants of potential concern. Data obtained from the Geotracker website was reviewed and it did not appear that nutrients were included in the monitoring program. However, modeling performed as part of the SMRNIG studies does indicate the site as a potential source of nutrients in the Lower SMR Subwatershed. Estimated loading of nutrients for the site is illustrated in **Figure 3-6**.

3.3.4 Findings from TMDL Alternative Technical Reports

Based on the watershed modeling performed for the SMRNIG to support development of the TMDL Alternative for the SMR Estuary (Sutula, et al., 2016), several land use categories have been identified as having potential to contribute loads of total nitrogen and total phosphorus to the SMR WMA.

- Total Nitrogen - The model identifies irrigated agriculture, orchards, vineyards and nurseries, open scrublands and grasslands, and residential land uses as the largest contributors of total nitrogen load to the Santa Margarita River.
- Total Phosphorus - The model identifies total phosphorus loading as being contributed by roads, orchards, vineyards and nurseries, open scrublands and grasslands, and residential land uses.

Figure 3-6 shows the major pathways and sources identified in the Model Application Report and subsequent technical memorandums for Total Nitrogen and Total Phosphorus.

As shown in the figure, sources of nutrients reach the SMR Estuary through several pathways. Discharges from agricultural areas, Caltrans, Camp Pendleton, and other federal lands, including tribal lands, can discharge directly to receiving waters and the SMR Estuary. Some of these sources also can enter the MS4 and contribute to loadings from the MS4, along with commercial,

industrial, and open space sources. Many of the land uses that the model identifies as contributing to nutrient loading in the SMR Estuary can be found adjacent to the reaches the Copermittees have identified as impacted by eutrophic conditions and/or nutrient loading. **Table 3-8** shows the relative contribution of each of these sources to the MS4. RCFCWCD and the City of Menifee were not included in the modeling efforts and do not have loads assigned. If determined to be necessary by the SMRNIG, these agencies may be added during future iterations of the model as part of the adaptive management process to provide a more complete understanding of nutrient loading from all agencies in the watershed.

Table 3-8. Dry Weather Sources of Total Nitrogen (TN) and Total Phosphorus (TP) within Each Jurisdiction based on the Tetra Tech Loading Analysis Memo Dated May 15, 2017 Percentage of Total Loading from MS4 Discharges Attributable to Each Source[1, 2]

	San Diego County		Riverside County		City of Murrieta		City of Temecula		City of Wildomar	
	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP
Residential	20.9%	23.3%	35.6%	33.6%	66.2%	64.2%	71.7%	70.5%	67.4%	61.0%
Commercial	1.6%	2.8%	3.6%	3.4%	10.0%	9.7%	13.2%	13.0%	3.6%	3.3%
Industrial	2.8%	3.4%	2.3%	2.1%	5.1%	5.0%	7.5%	7.4%	2.1%	1.9%
Parks and Recreation	0.4%	0.0%	1.4%	1.3%	2.5%	2.4%	2.2%	2.2%	0.0%	0.0%
Orchards, Vineyards and Nurseries	56.6%	53.4%	27.6%	26.3%	5.9%	5.8%	0.3%	0.3%	3.5%	3.2%
Horse Ranches	0.0%	0.0%	10.6%	10.0%	2.5%	2.4%	0.7%	0.7%	3.7%	3.4%
Other Agriculture	5.0%	4.5%	6.5%	6.5%	2.6%	2.7%	2.0%	2.1%	1.4%	1.7%
Open Space	12.6%	12.5%	8.4%	12.5%	5.0%	7.5%	2.2%	3.6%	18.2%	25.5%
Caltrans	0.0%	0.0%	5.0%	5.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other Federal (Tribes)	0.0%	0.0%	2.0%	2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

1. Under the Regional Water Board Designation Letter dated October 26, 2015 Menifee is required to participate in the development and implementation of the SMR WQIP and the implementation of any applicable TMDL. However, no specific load allocations have been assigned to Menifee. Menifee was not included in the modeling efforts. Because Menifee only has a small jurisdictional area in the WMA (less than 2 square miles), Menifee will participate in the overall load reduction by implementing its WQIP and LIP strategies.

The findings of the SMR technical reports demonstrate that residential sources are the most significant source of nutrients to the storm drain system for most jurisdictions with some portion of the loading coming from all other sources. Only in San Diego County orchards, vineyards and nurseries are the most significant, with residential sources secondary. As part of the WQIP development, San Diego County conducted additional modeling to separate contributions of

nurseries from orchards and vineyards in the Rainbow Creek Subwatershed and determined that nurseries are the largest source of nutrients to the storm drain system. (Tetra Tech, 2017)

3.4 DATA ADEQUACY

While the available data is considered accurate, appropriately collected, and analyzed for potential sources contributing to eutrophication impacts and nutrient loading, information to determine if the potential sources are contributing to problems in the receiving waters is relatively sparse. To provide this linkage, source information has been used in combination with efforts to model nutrient loads to provide adequate rationale for identifying and prioritizing sources and/or stressors.

3.5 CONCLUSIONS FROM SOURCE INFORMATION

Based on the available source information as discussed above, combined with information generated through local studies for eutrophication in the watershed, and best professional judgement, each agency was able to prioritize the top three types of sources within their jurisdiction that may be contributing nutrients to their storm drain system. The prioritization is intended to provide guidance to agencies in selecting appropriate strategies to address sources of nutrients contributing to the storm drain system within their respective jurisdictions. These relative source rankings are summarized in **Table 3-9**.

Table 3-9. Prioritized Sources by Agency Based on Available Information

Sources	County of San Diego[1]	County of Riverside[2]	City of Menifee[3]	City of Murrieta[4]	City of Temecula[5]	City of Wildomar[6]	RCFCWCD[7]
Residential	2	1	1	1	1	1	1
Commercial	-	-	3	2	2	3	2
Industrial	-	-	-	-	3	-	-
Parks and Recreation	-	-	-	-	-	-	-
Orchards, Vineyards and Nurseries	1	2	-	-3	-	-	3
Horse Ranches	-	3	2	-	-	2	-
Other Agriculture	3	-	-	-	-	-	-

1. The source prioritization for the County of San Diego is primarily based on modeling results produced by the SMRNIG, source information related to the TMDL for Rainbow Creek, and land use information for their areas of the watershed.
2. The source prioritization for the County of Riverside is primarily based on modeling results produced by the SMRNIG, land use information, and inventory information.
3. The source prioritization for the City of Menifee is primarily based on land use information and modeling results produced by the SMRNIG. Although no loading estimates were provided for the City of Menifee, the model does demonstrate the general significance of loading from residential areas.
4. The source prioritization for the City of Murrieta is primarily based on the City's knowledge of facilities in this portion of the City, land use information, and inventory information.
5. The source prioritization for the City of Temecula is primarily based on modeling results produced by the SMRNIG, land use information, and inventory information.
6. The source prioritization for the City of Wildomar is primarily based on modeling results produced by the SMRNIG, land use information, and inventory information.
7. The source prioritization for the RCFCWCD is primarily based on available IC/ID information, including the predominant sources of illicit discharges as identified in **Table 3-7**. Because other agencies discharge to RCFCWCD facilities, the source prioritization results for the other agencies in the Upper and Middle SMR Subwatersheds were also considered.

4 Water Quality Improvement Goals, Strategies, and Schedules

Provision B.3 of the Permit, "Water Quality Improvement Goals, Strategies and Schedules," describes the requirements to develop specific water quality improvement goals and strategies to address the PWQCs identified as per Permit Provision B.2 (and described in **Chapter 2**) for the SMR WMA. These goals and strategies must effectively prohibit non-stormwater discharges to the MS4, reduce pollutants in stormwater discharges from the MS4 to the maximum extent practicable, and protect water quality in receiving waters. In practical terms, the strategies will address the key sources of nutrients contributing to the MS4 within each jurisdiction and/or change the physical factors in the receiving water to reduce the growth of algae or improve dissolved oxygen conditions (e.g. restoration of stream channels) and the goals will be used to assess improvements in water quality and effectiveness of the strategies.

Chapter 4 defines the goals, along with strategies and schedules for achieving those goals. The goals include interim and final numeric (i.e., quantifiable) goals for the HPWQC as described in **Chapter 2**, and summarized in **Table 4-1**.

Table 4-1. Highest Priority Water Quality Condition

Beneficial Use Category	Highest Priority Water Quality Condition	Temporal Extent	Geographic Extent
Aquatic Life: Eutrophication	Eutrophication impacts (elevated algal biomass)	Dry	SMR Estuary [1], Warm Springs, Redhawk Channel [2]
	Nutrient loading to waterbodies with an adopted TMDL or listed as impaired	Dry	All Middle and Lower SMR subareas, except Fallbrook Creek and Sandia Creek[1]
		Wet	Rainbow Creek

1. MS4 discharges within the following subareas may reach the SMR Estuary during dry weather and contribute to the Eutrophication PWQC in the SMR Estuary: Upper Murrieta Creek and Tributaries, Warm Springs, Santa Gertrudis, Murrieta Creek and Long Canyon, Temecula Creek and Redhawk Channel, Upper Santa Margarita River, Lower Santa Margarita River, Rainbow Creek and De Luz Creek.
2. Other areas may be added as result of TMDL Alternative development during adaptive management process.

As shown in the table, the HPWQC consists of in-stream eutrophication impacts in the SMR Estuary, Warm Springs and Redhawk Channel. As shown in **Figure 2-8**, increased nutrient loading to the waterbody can cause eutrophication, but other factors, such as shading, temperature, flow, and substrate influence whether increased nutrient loading causes eutrophication. As a result, while nutrient loading occurs throughout the watershed, evidence of eutrophication is not present in all reaches. The other part of the HPWQC to be addressed is the nutrient loading to the waterbodies where eutrophication is occurring. Because the SMR Estuary is at the base of the watershed, all MS4 discharges that might reach the SMR Estuary during dry weather are addressed by the goals and strategies in this chapter. Additionally, nutrient loadings during wet weather to Rainbow Creek are a HPWQC.

Through the implementation of strategies developed to address potential sources of nutrients and an iterative, adaptive management approach, it is anticipated that the numeric goals will be

achieved and the water quality will be improved. Each agency will implement a JRMP or LIP that contains strategies to meet the requirements of Permit Provisions E.2 through E.7. The JRMPs/LIP contain all BMPs that will be implemented across programs as required by Provision E of the Permit. Additionally, each agency will implement additional strategies to address anthropogenic sources of nutrients that contribute pollutants via the MS4 (as described in Permit Provisions B.3.b(1)(a)(i)-(vi)). Jurisdictional strategies will address sources of nutrients within the agency's jurisdiction. Optional strategies have also been developed for each jurisdiction, but will be implemented only if certain triggers are met (e.g., where interim goals are not met). WMA strategies have been developed that are also optional (i.e., must be triggered), but are regional or multi-jurisdictional in nature.

4.1 GOALS AND SCHEDULES TO ADDRESS EUTROPHICATION AND NUTRIENT LOADING

The purpose of establishing goals is to support WQIP implementation and measure reasonable progress towards addressing the HPWQC. The Permit requires that goals be reflective of criteria or indicators to measure incremental progress towards addressing the HPWQC over the course of implementation of the WQIP. Goals for the HPWQC, and the process to achieve them, are fundamental to the WQIP. Permit Provision B.3 outlines requirements for goals, which include numeric targets for interim and final goals for the HPWQC:

- Interim Goals must be based on measureable criteria or indicators capable of demonstrating reasonable incremental progress toward achieving the final numeric goals. Each final goal must have one or more interim goal, with at least one interim numeric goal expressed as a reasonable increment toward achievement of the final numeric goal, to be accomplished during each 5-year period between the acceptance of the WQIP and the achievement of final numeric goals.
- Final Goals must be based on measureable criteria or indicators capable of demonstrating one or more of the following: (i) discharges from Copermittees' MS4s will not cause or contribute to exceedances of water quality standards in receiving waters; (ii) the conditions in receiving waters and associated habitat are protected from MS4 discharges; or (iii) beneficial uses of receiving waters are protected from MS4 discharges and will be supported.

4.1.1 Geographic Extent of Eutrophication HPWQC

The HPWQC for eutrophication was identified for three subareas in the watershed: SMR Estuary, Warm Springs and the Redhawk Channel portion of the Temecula Creek and Redhawk Channel subarea. Warm Springs and Redhawk Channel are located in the Middle SMR Subwatershed, and evidence of eutrophication was limited to one location in each of these creeks with limited sampling data (see **Chapter 2**). The 192-acre SMR Estuary is located at the base of the watershed in the southwestern portion of Marine Corps Base Camp Pendleton. The SMR Estuary receives drainage from both the Middle and Lower SMR Subwatersheds. In contrast to Warm Springs and the Redhawk Channel portion of the Temecula Creek and Redhawk Channel subarea, the SMR Estuary has been extensively studied and monitored. **Figure 4-1** shows the SMR Estuary and its location within the SMR WMA.

Eutrophication can be caused by both physical factors (flow conditions, waterbody shading, substrate, etc.) and discharges of nutrients. While the geographic extent of the evidence of eutrophication is limited to three subareas in the SMR WMA, dry weather discharges of nutrients from MS4 outfalls to all areas of the watershed have the potential to contribute to the eutrophication in the SMR Estuary. Consistent with the TMDL Alternative, dry weather is defined to include dry conditions (where there is less than 0.1 inch of rainfall within the previous 72 hours) year-round, encompassing both the dry and wet seasons[11]. The subareas with dry weather MS4 discharges that could potentially reach the SMR Estuary are: Upper Murrieta Creek and Tributaries, Warm Springs, Murrieta and Long Canyon Creek, Santa Gertrudis Creek, Temecula Creek and Redhawk Channel, Upper Santa Margarita River, Lower Santa Margarita River, Rainbow Creek, and De Luz Creek. As a result, all subareas where dry weather flows from the MS4 may occur and include nutrient loading are included in the geographic extent of the HPWQC. Upper SMR Subwatershed does not contribute flows downstream of Diamond Valley Lake, Lake Skinner, or Vail Lake during dry weather conditions.

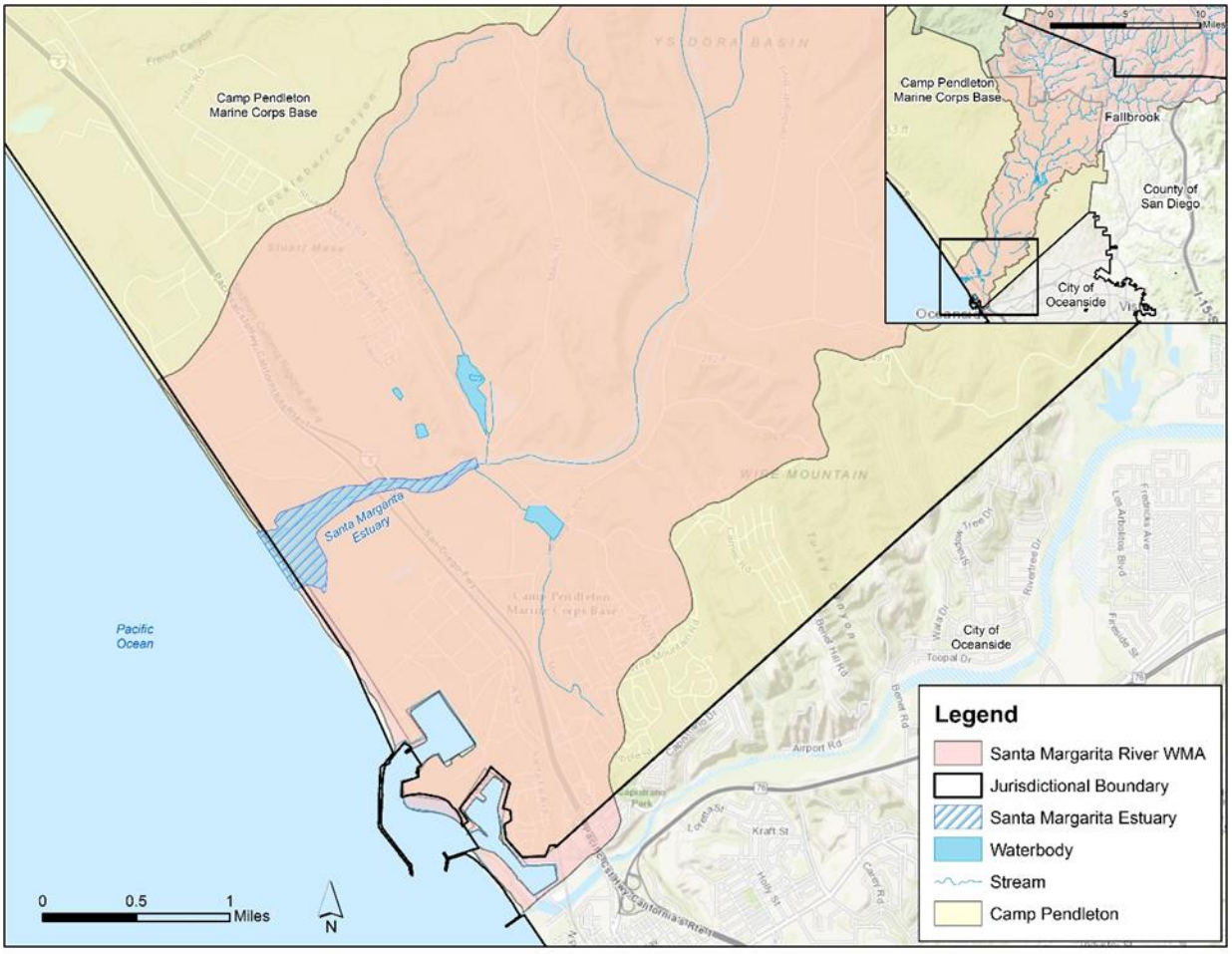

Figure 4-1. Santa Margarita River Estuary Location in the Santa Margarita River WMA

[11] Defined in Permit Provision D.1.c.

In the Middle SMR Subwatershed, goals and schedules that will address both localized eutrophication in Warm Springs and Redhawk Channel and nutrient loadings to the downstream SMR Estuary have been identified. In the Lower SMR Subwatershed, goals and schedules have been developed to address the eutrophic conditions in the SMR Estuary as well as the nutrient loading in the Rainbow Creek subarea.

All of the goals and schedules have been structured to achieve the anticipated targets for the TMDL Alternative for the Estuary, as described in more detail in **Section 4.1.2**. Differences among goals and schedules were identified to match jurisdiction and subwatershed-specific strategies and schedules. This approach provides the framework for a more accurate assessment of progress toward achieving goals within each subwatershed. Ultimately, protection of the receiving waters is the desired outcome.

4.1.2 TMDL Alternative Background

The Copermittees and the City of Menifee have developed goals to address the TMDL Alternative for the SMR Estuary that is currently under development. However, the TMDL Alternative for the SMR Estuary is not yet final, and targets and allocations are still being established. The Copermittees and the City of Menifee have utilized the available TMDL Alternative information in developing their respective goals. This section provides a discussion of the available information and how it was appropriately considered to help inform the selection of the goals.

The Basin Plan WQOs can be described as narrative WQOs with numeric guidance for interpretation of the narrative language. These numeric interpretations have been utilized historically for 303(d) listing decisions, TMDLs, and permit conditions. However, the objectives were established in the 1970s and regulatory and scientific approaches to evaluating biostimulatory objectives have since evolved. It is now recognized that due to site-specific factors (such as hydrology, shading, temperature), total nitrogen and total phosphorus concentrations and loads that can contribute to primary producer overproduction at levels that impact beneficial uses, vary greatly among streams and estuaries.

Current numeric interpretations of the narrative Basin Plan nitrogen and phosphorus WQOs do not consider site-specific factors. An alternative regulatory approach advocated by Regional Water Board staff and USEPA Region 9, is currently under development as part of the Statewide Biostimulatory and Bio-objectives Amendment (Biostimulatory Substances Amendment) being developed by the State Water Board. The State Water Board is proposing to adopt a statewide WQO for biostimulatory substances along with a program of implementation as an amendment to the Water Quality Control Plan for Inland Surface Water, Enclosed Bays and Estuaries of California (ISWEBE Plan). The Biostimulatory Substances Amendment will likely include a statewide narrative objective (with numeric guidance for interpretation), and various regulatory control options for point and non-point sources. This framework will be used to develop scientifically-sound water quality goals for biostimulatory substances that are protective of beneficial uses.

Although the State Water Board's work is still in process, the framework described above is being utilized for the TMDL Alternative development. As a result, TMDL Alternative targets for the SMR Estuary will not be set equal to the numeric interpretation of the Basin Plan objectives (i.e., 1.0 mg/L for total nitrogen and 0.1 mg/L for total phosphorus) that were used as the basis for the

303(d) listings. Instead, the TMDL Alternative for the SMR Estuary is expected to include some combination of dissolved oxygen, algal biomass, and benthic macroinvertebrate targets.

As discussed in more detail in **Section 5.2**, two models have been developed to support the TMDL Alternative development: the Estuary model and Watershed Loading model. The Estuary model was used to evaluate a range of possible water quality targets for the SMR Estuary that would align with the Biostimulatory Substances Amendment framework. The Watershed Loading model was used to estimate the amount of total nitrogen and total phosphorus loading from the watershed. Based on the analysis presented in the Model Application Report, the SMRNIG discussed potential targets for the SMR Estuary.

As of February 2017, the following targets were being considered for the TMDL Alternative for the SMR Estuary (County of San Diego, 2017a):

- A primary algal biomass target of 57 grams (dry-weight) per cubic meter [g d-wt/m^2];
- A secondary numeric target for algal biomass of 70 g d-wt/m^2;
- A dissolved oxygen target of not less than 5.0 mg/L; and
- If monitoring data confirm that the SMR Estuary is meeting the primary target of algal biomass of 57 g d-wt/m^2, this result indicates that the beneficial uses are protected. If monitoring data confirm that the SMR Estuary is meeting an algal biomass between 57 and 70 g d-wt/m^2, the Sediment Quality Objective (SQO) tool (http://www.sccwrp.org/Data/DataTools/SedimentQualityAssessment.aspx) for benthic community structure will be used to assess whether beneficial uses are protected. If the dissolved oxygen target is being met and the SQO tool indicates beneficial uses are protected, the SMR Estuary targets are being met regardless of the algal biomass concentrations.

In the TMDL Alternative analysis, year-round dry weather discharges were determined to be primarily responsible for identified impairments in the SMR Estuary. Wet weather loadings were determined to be primarily flushed to the Pacific Ocean, and modeled reductions in wet weather loads did not have an appreciable impact on improving SMR Estuary conditions. As a result, wet weather load reductions are not required by the TMDL Alternative for the SMR Estuary.[12]

The Estuary model was used to evaluate the load reductions in total nitrogen and total phosphorus needed to meet the targets based on the 2008 to 2009 Water Year simulated in the model. Based on the model results, the SMRNIG has developed a proposal for allocations for the TMDL Alternative for the SMR Estuary (County of San Diego, 2017b). The proposed allocations apply a 76% reduction equally to all controllable discharges within the SMR WMA, which are defined for the purposes of the TMDL Alternative as discharges covered by WDRs or NPDES permits. Other discharges are not subject to load reduction goals, as they are either naturally occurring (e.g., open space) or releases necessary to protect other beneficial uses (e.g., Comprehensive Water Rights Management Agreement flows). While the Regional Water Board has provided preliminary

[12] If wet weather loadings are identified in the future as a source that is required to be addressed by the TMDL Alternative for the SMR Estuary or TMDLs for the other portions of the SMR WMA, the Water Quality Improvement Plan goals and strategies will be updated as required through the adaptive management process.

positive feedback on the allocation proposal, the TMDL Alternative for the SMR Estuary is still under development and the proposal may be modified before it becomes final.

Compliance with requirements in applicable Orders is expected to attain and maintain the allowable loadings from controllable discharges in the TMDL Alternative for the SMR Estuary. Non-storm water discharges are generally effectively prohibited by the existing MS4 Permit requirements (Order No. R9-2013-0001, as amended by Order No. R9-2015-0001 and Order No. R9-2015-0100) and the agricultural orders (Orders No. R9-2016-0004 and R9-2016-0005). However, several non-controllable discharges exist in the watershed that may cause the SMR Estuary to exceed the proposed receiving water targets. Should a demonstration be made that all controllable discharges have been addressed and are meeting allocations and the SMR Estuary continues to exceed receiving water targets, modifications to the targets may be considered to reflect the impact of natural sources. Under such conditions, the TMDL Alternative for the SMR Estuary will not require additional load reductions from the controllable discharges to meet the receiving water targets in the SMR Estuary.

4.1.3 Numeric Goals and Schedules for the SMR Watershed

The Copermittees used the geographic extent of the eutrophication and nutrient loading, in combination with scientific studies and modeling performed as part of the SMR Estuary TMDL Alternative and the Rainbow Creek Nutrient TMDL, to develop numeric goals for the watershed. The goals are presented in the following sections.

4.1.3.1 Goals and Schedules to Address Eutrophication and Nutrient Loading in the Middle SMR Subwatershed[13]

The Middle SMR Subwatershed consists of six subareas (**Figure 2-3**). Copermittees have MS4 outfalls that discharge to portions of five of the six subareas. The evaluation of MS4 outfall data indicates that total nitrogen and total phosphorus discharges from the MS4 during dry conditions, which may occur year-round, have the potential to contribute nutrient loading to the SMR Estuary, Warm Springs, and Redhawk Channel. As a result, the geographic extent of the HPWQC in the Middle SMR Subwatershed include the portions of the Upper Murrieta Creek and tributaries, Warm Springs, Santa Gertrudis Creek, Murrieta Creek and Long Canyon Creek, and Temecula Creek and Redhawk Channel subareas to which MS4 outfalls discharge during dry weather. There are no MS4 outfalls that discharge to other subareas in the Middle SMR Subwatershed.

Interim and final goals and schedules for the Middle SMR Subwatershed are presented in **Table 4-2**. A multi-tiered approach to setting goals was used. The compliance pathways for agencies to meet the WQIP goals are also shown in the table. The compliance pathways are based on six different metrics. Each Copermittee in the Middle SMR Subwatershed will have the option of demonstrating compliance through one of the six pathways. As such, the pathways are presented sequentially, separated by "OR" to indicate that any one of the six pathways may be followed for compliance. Each pathway includes interim goals, with at least one goal per Permit term, to demonstrate progress toward achieving the final goals. The first two pathways support a watershed-based approach as they focus on achievement of goals in receiving waters to demonstrate progress toward meeting load reductions and targets based on the TMDL Alternative.

[13] Cities of Menifee, Murrieta, Temecula, and Wildomar, Riverside County Flood Control and Water Conservation District, and Riverside County.

The second two pathways include MS4 discharge goals, to demonstrate progress and provide jurisdictional accountability toward meeting the TMDL Alternative-based load reductions and targets. The last two pathways account for natural loading, and provide a BMP-based option through WQIP implementation. The following six pathways are presented in **Table 4-2**:

Pathway 1. *Demonstration that the discharger is attaining the load reduction goal of 76% in the Middle SMR Subwatershed in receiving waters.*

Pathway 2. *Demonstration that the Santa Margarita River Estuary targets (based on the proposed TMDL Alternative) have been attained.*

Pathway 3. *Demonstration that non-stormwater flows that are within agency control have been reduced to meet load reductions.*

Pathway 4. *Demonstration that discharger is meeting required load reductions as described in the TMDL Alternative for the SMR Estuary.*

Pathway 5. *Demonstration that exceedances of targets are due to sources outside of agency control.*

Pathway 6. *Demonstration that management actions to attain load or flow reductions are being implemented through mechanisms defined in the accepted Water Quality Improvement Plan.*

The final goals were identified based on the proposed wasteload allocations and required load reductions proposed for the TMDL Alternative for the SMR Estuary. The proposed wasteload allocations used to establish goals are annual load reductions in dry weather discharges. As discussed above, dry weather discharges were determined in the TMDL analysis to be primarily responsible for identified impairments in the SMR Estuary. As such, the Middle SMR Subwatershed agency goals are applicable under dry conditions year-round (including both summer dry and winter dry conditions). Weather is considered dry if the preceding 72 hours has been without measurable precipitation (>0.1").

The interim goals were established conservatively, to reflect the anticipated reductions that can be achieved through each step of strategy implementation. The strategy implementation process is described in **Section 4.2**. The final goals and timeframe for achieving the goals is based on the implementation schedule anticipated for the final terms of the TMDL Alternative for the SMR Estuary.[14]

[14] The final goals and schedules are preliminary and will be updated through the adaptive management process when the TMDL Alternative becomes effective.

Table 4-2. Interim and Final Numeric Goals and Schedules, HPWQC – Eutrophication Impacts and Nutrient Loading, Middle Santa Margarita River Subwatershed Agencies (County of San Diego, 2017a)

Pathway	Interim Goal (2023)	Interim Goal (2028)	Interim Goal (2033)	Final Goal (2038) [6]	Metric
1[1]	10% reduction in dry weather[2] loadings in receiving waters: TN 993 lb/yr TP 99 lb/yr	30% reduction in dry weather loadings in receiving waters: TN 2,980 lb/yr TP 300 lb/yr	50% reduction in dry weather loadings in receiving waters: TN 4,970 lb/yr TP 495 lb/yr	76% reduction in dry weather loadings in receiving waters: TN 7,550 lb/yr TP 752 lb/yr	Assessment of loadings in the Santa Margarita River (receiving water) at the base of the Middle SMR Subwatershed
OR					
2	Numeric interim and final goals to be determined based on outcome of TMDL alternative for the Santa Margarita River Estuary				Assessment of receiving water conditions in the Santa Margarita River Estuary
OR					
3	10% reduction in non-stormwater flows within agency control[3]	30% reduction in non-stormwater flows within agency control[3]	50% reduction in non-stormwater flows within agency control[3]	100% reduction in non-stormwater flows within agency control[3]	Assessment of load reductions from implementation actions (based on outfall monitoring or other assessment metrics)

			OR		
4 [4, 5]	10% reduction in dry weather loadings from Copermittees. As a Total: TN 993 lb/yr TP 99 lb/yr OR by jurisdiction: City of Wildomar: TN 79, TP 8 City of Murrieta: TN 224, TP 22 City of Temecula: TN 395, TP 39 Riverside County: TN 286, TP 28	30% reduction in dry weather loadings from Copermittees: As a Total: TN 2,980 lb/yr TP 300 lb/yr OR by jurisdiction: City of Wildomar: TN 237, TP 24 City of Murrieta: TN 673, TP 67 City of Temecula: TN 1,186, TP 118 Riverside County: TN 858, TP 85	50% reduction in dry weather loadings from Copermittees: As a Total: TN 4,970 lb/yr TP 495 lb/yr OR by jurisdiction: City of Wildomar: TN 396, TP 39 City of Murrieta: TN 1,122, TP 112 City of Temecula: TN 1,977, TP 197 Riverside County: TN 1,430, TP 142	76% reduction in dry weather loadings from Copermittees: As a Total: TN 7,550 lb/yr TP 752 lb/yr OR by jurisdiction: City of Wildomar: TN 601, TP 60 City of Murrieta: TN 1,705, TP 170 City of Temecula: TN 3,005, TP 300 Riverside County: TN 2,174, TP 217	Assessment of load reductions from implementation actions (based on outfall monitoring or other assessment metrics)
			OR		
5	Assess progress toward achieving final goal (using other pathways).			Where final goals have not been met, demonstrate that exceedances of targets are due to source(s) of nutrients outside of the control of the Copermittees and the City of Menifee.	Source investigations

OR					
6	The Copermittees and the City of Menifee develop and implement the jurisdictional strategies as described in the accepted Water Quality Improvement Plan.	The Copermittees and the City of Menifee assess progress towards goals, implement the JRMP or enhanced JRMP strategies as triggered using an iterative approach as described in the accepted Water Quality Improvement Plan.	The Copermittees and the City of Menifee assess progress towards goals, implement the JRMP, enhanced JRMP strategies, or optional jurisdictional strategies, as triggered using an iterative approach as described in the accepted Water Quality Improvement Plan.	The Copermittees and the City of Menifee assess progress towards goals, implement the JRMP, enhanced JRMP strategies, optional jurisdictional strategies, or optional WMA strategies, as triggered through an iterative approach as described in the accepted Water Quality Improvement Plan.	Implementation of JRMP, enhanced JRMP strategies, optional jurisdictional strategies, or optional WMA strategies, as triggered through an iterative, adaptive management approach.

Notes:

1. Load reductions at the base of the Middle SMR Subwatershed will be measured against the baseline loads for Riverside County. Source: Tetra Tech. SMR Estuary MS4 Nutrient Loads for WY 2008. Memorandum to Jo Ann Weber, Kyle Cook, Kyle Gallup, and Stuart McKibbin, January 6, 2017. Baseline loads are 60,796 lb/yr for Total Nitrogen and 6,004 lb/yr for Total Phosphorus.
2. Dry weather conditions are defined as those that occur on non-storm days, with storm days being defined as all days with measured precipitation greater than 0.1 inch and the 72 hours following the measured precipitation, and include both summer and winter dry periods.
3. Within agency control means, consistent with the scope of the Permit, that conditions are within the regulatory authority of the Copermittee or the City of Menifee and can feasibly be addressed or treated at the point of entry, within, or at the outlets from the MS4. This requires the availability of feasible options for treating the condition. Flows/conditions determined to be uncontrollable would not be included in the calculations related to this goal.
4. Load reductions for the Riverside County Copermittees will be measured based on the baseline loads presented in the Tetra Tech memorandum: 9,933 lb/yr for Total Nitrogen and 990 lb/yr for Total Phosphorus. Jurisdictional load reductions for the jurisdictions provided in the Tetra Tech memo are shown in the table.
5. As described in Section 1, Menifee is participating in the development and implementation of this WQIP as required by the Regional Water Board Designation Letter dated October 26, 2015. Based on Menifee's land area in the Santa Margarita watershed, for the purpose of WQIP development and implementation, Menifee is determined by the San Diego Water Board to be a less than significant contributor of nitrogen, phosphorus and other pollutants within the Santa Margarita River Watershed Management Area. There are currently no numeric nutrient load goals for Menifee since no nutrient load values for the small portion of Menifee within the Santa Margarita watershed were included in the Tetra Tech study or any other currently published study, and any nutrient loading from within the City of Menifee to the Santa Margarita River Watershed is considered to be less than significant. Until the Santa Margarita Estuary TMDL stakeholders and the San Diego Water Board determine the final load allocation regarding Menifee, if such an allocation is needed, Menifee will implement appropriate LIP strategies to address the HPWQC in the WMA and meet the WQIP goals and schedules. Furthermore, while Menifee has limited MS4 conveyance structures in the SMR WMA, there are currently no MS4 outfalls located within the portion of Menifee in the Santa Margarita watershed. Therefore, achievement of goals will be demonstrated through pathways other than pathway 4.
6. The final goals and schedules are preliminary and will be updated through the adaptive management process when the TMDL Alternative becomes effective.

4.1.3.2 Goals and Schedules to Address Eutrophication Impacts and Nutrient Loading in the Lower SMR Subwatershed[15]

The first set of goals and strategies developed for the Lower SMR Subwatershed relate to the Estuary. Studies conducted to support development of the TMDL Alternative for the SMR Estuary indicate that eutrophic conditions are caused by excessive nutrient loading, which leads to excessive growth and decomposition of algae, and low dissolved oxygen conditions. Reducing dry weather flows from the San Diego County stormwater outfalls will ultimately reduce the nutrient loading that leads to the eutrophic condition in the SMR Estuary. Numeric goals addressing this HPWQC have been established to measure and demonstrate progress toward eliminating dry weather flows. The goals take two forms, though there are multiple compliance pathways to accomplish these goals. These goals are presented in **Table 4-3**.

Efforts to mitigate dry weather flows and consideration of small-scale structural controls (as needed) will begin during the next MS4 Permit term. The final compliance goal, scheduled for FY 2038, is zero persistent discharges from the County of San Diego's MS4 outfalls to receiving waters or a 100% reduction in anthropogenic dry weather flow volume. Compliance pathways for these goals will be demonstrated through the dry weather MS4 outfall field screening program, or the TMDL Alternative (final terms expected in 2018) targets for the SMR Estuary.

[15] The County of San Diego is the only Copermittee that has Major Outfalls in the Lower SMR Subwatershed.

Table 4-3. Interim and Final Numeric Goals and Schedules for HPWQC – Eutrophication in the Santa Margarita River Estuary, Lower SMR Subwatershed – San Diego County

	Assessment Period					
Goal[1]	**Baseline**	**FY2018-FY2023**	**1st Permit Term (FY2023)**	**2nd Permit Term (FY2028)**	**3rd Permit Term (FY2033)**	**4th Permit Term (FY 2038)**
Effectively eliminate anthropogenic dry weather discharges from MS4 outfalls to the receiving water	To be established during FY16–17 using dry weather[2] flow measurements	Complete turf replacement in Rainbow Park.	Reduce the baseline aggregate flow volume by 25%.	Reduce the baseline aggregate flow volume by 50%.	Reduce the baseline aggregate flow volume by 75%.	Reduce the baseline aggregate flow volume by 100%.
Comply with TMDL Alternative	**OR**					
	Demonstrate that the Santa Margarita River Estuary targets have been attained.[3]					
	OR					
	Demonstrate that the discharger is attaining the nutrient load reduction goal of 76%.					
	OR					
	Demonstrate that the discharger is attaining the load allocations defined in the TMDL Alternative for the SMR Estuary.					
	OR					
	Demonstrate that exceedances of the targets are due to non-controllable sources.					
	OR					
	Demonstrate that management actions to attain allocations are being implemented through mechanisms defined in each applicable Order.[4]					

Notes:

1. These goals are placeholders and may be updated on the basis of the final implementation requirements for the Santa Margarita River Estuary TMDL Alternative.
2. Dry weather conditions are defined as those that occur on non-storm days, with storm days being defined as all days with measured precipitation greater than 0.1 inch and the 72 hours following the measured precipitation, and include both summer and winter dry periods.
3. Primary and secondary numeric targets for algal biomass are proposed. If monitoring data confirm that the SMR Estuary is meeting the primary target of algal biomass of 57 g d-wt/m2, this result indicates that the beneficial uses are protected. If monitoring data confirm that the SMR Estuary is meeting an algal biomass between 57 and 70 g d-wt/m2, the Sediment Quality Objective (SQO) tool for benthic community structure will be used to assess whether beneficial uses are protected. The watershed load reduction goal to meet the numeric targets is 76%.
4. Mechanisms for implementing management actions include, but are not limited to, Phase I MS4 Water Quality Improvement Plans, Agricultural Discharger Water Quality Restoration Program Plans, Phase II MS4 permit program elements, and Caltrans compliance units, cooperative implementation grants and cooperative implementation agreements.

4.1.3.3 Goals and Schedules to Address HPWQC - Nutrients in Rainbow Creek

Nutrients (including nitrate, nitrogen, and phosphorus) in Rainbow Creek are identified as a HPWQC in the Lower SMR Subwatershed and goals and schedules have been developed to address that condition as well. The Rainbow Creek Nutrient TMDL (Water Quality Control Plan for the San Diego Basin (Basin Plan) Amendment: Resolution No. R9-2005-0036) was adopted in 2006 to address water quality impairments in Rainbow Creek (San Diego RWQCB, 2006). In 2013, the Rainbow Creek Nutrient TMDL was incorporated into Attachment E.3 of the Permit.

4.1.3.3.1 Geographic Extent of HPWQC-Nutrients in Rainbow Creek

The geographic extent of the HPWQC-Nutrients in Rainbow Creek is the area that drains into stormwater outfalls connected to Rainbow Creek within San Diego County. The Rainbow Creek drainage area encompasses 7,085 acres and approximately 65 percent of the area is undeveloped (Regional Water Board, 2006). The Clean Water Act Section 303(d) list of water quality impaired segments (303(d) list) identifies impairments as a result of excessive nutrient concentrations for an approximately 5-mile stretch of the creek **(Figure 4-2**) (Regional Water Board, 2015).

Rainbow Creek supports a number of beneficial uses. The most sensitive beneficial uses are those designated for protection of aquatic life, as described in the Basin Plan (Regional Water Board, 1994) definition of the warm freshwater habitat (WARM) and cold freshwater habitat (COLD) beneficial uses.

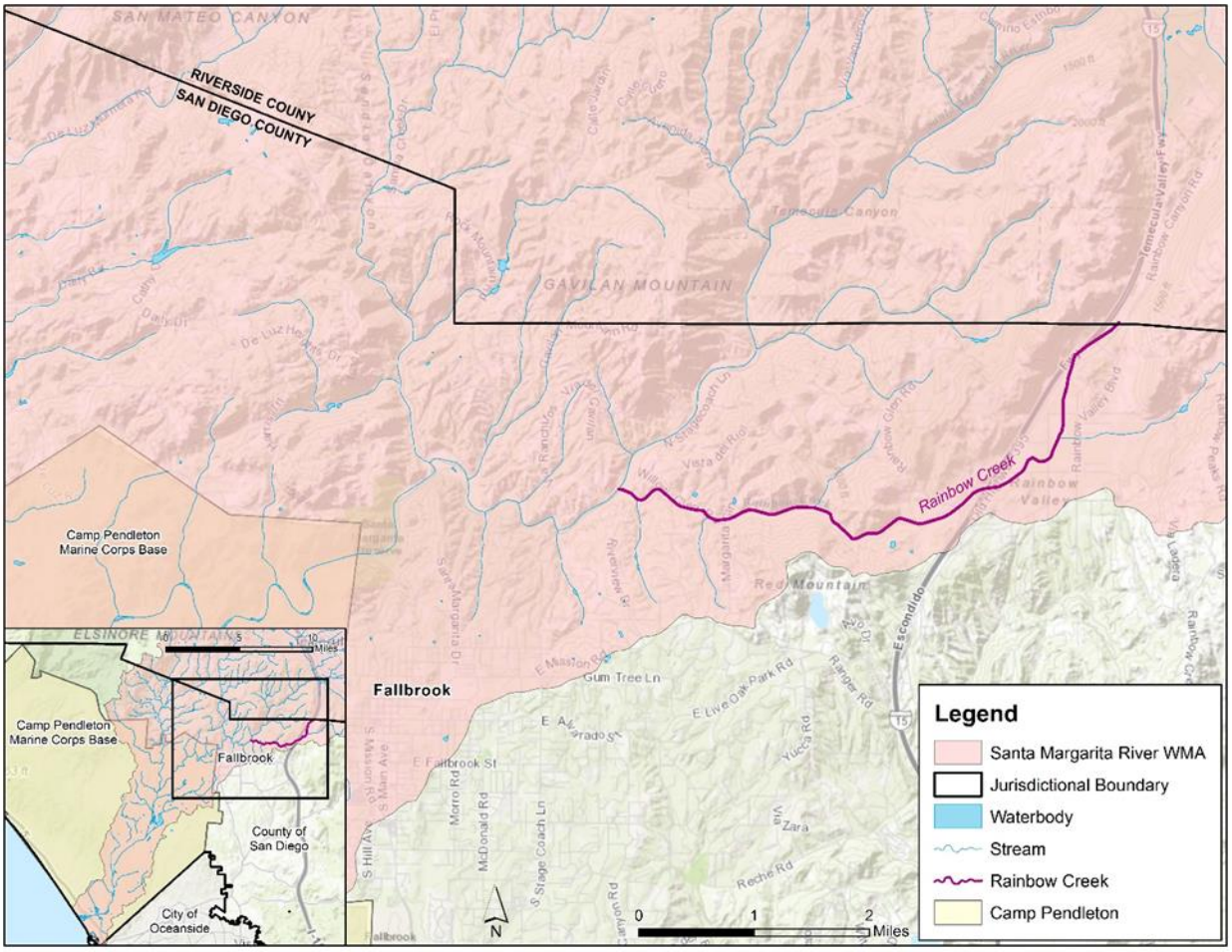

Figure 4-2. 303(d) Listed Segment of Rainbow Creek in the Santa Margarita River WMA

Water quality objectives (WQOs) for biostimulatory substances that are established by the Basin Plan (Regional Water Board, 1994) require that the substances remain below concentrations that promote algal growth to the extent that causes nuisance or adversely affects beneficial uses. The Rainbow Creek Nutrient TMDL is based on the numeric interpretation of the narrative Basin Plan WQOs for biostimulatory substances for the protection of the COLD and WARM beneficial uses: total nitrogen (1.0 milligrams per liter [mg/L] and total phosphorus 0.1 mg/L). The Basin Plan establishes that waters designated with the MUN beneficial use must not contain concentrations of nitrate in excess of the maximum contaminant levels (MCLs) set forth in California Code of Regulations Title 22. The MCL for nitrate (as nitrogen) is 10 mg/L.

4.1.3.3.2 Goals and Schedules for HPWQC Nutrients in Rainbow Creek

To comply with the Nutrient TMDL, the Permit provides multiple compliance pathways either regarding the receiving water or in stormwater discharges. Attachment E.3 of the Permit allows any of these pathways to achieve compliance (i.e., demonstration of progress toward all compliance pathways is not required), so the compliance pathways are independent of each other. The compliance pathways are based on three types of metrics:

(1) Receiving water conditions that are evaluated by comparing measured conditions with WQOs;

(2) Conditions of discharges from the MS4 outfalls that are evaluated by comparing measured conditions to WQO load reductions; and,

(3) Implementation of the WQIP (i.e., establishment of goals, implementation of strategies and schedules).

Compliance with the final water quality-based effluent limitations (WQBELs), on or before the final Nutrient TMDL compliance date, may be demonstrated via one of the following methods (Regional Water Board, 2013):

(1) There is no direct or indirect discharge from the Copermittees' MS4s to the receiving water; or

(2) There are no exceedances of the final receiving water limitations under specific Permit Provision 3.b.(2)(a) in the receiving water at, or downstream of the Copermittees' MS4 outfalls; or

(3) There are no exceedances of the final effluent limitations under specific Permit Provision 3.b.(2)(b)(i) at the Copermittees' MS4 outfalls; or

(4) The annual pollutant loads from given land uses discharging to and from the MS4s do not exceed the final effluent limitations under specific Permit Provision 3.b.(2)(b)(ii); or

(5) The Copermittees develop and implement the WQIP as follows:

   (i) Incorporate the BMPs required under specific Permit Provision 3.b.(2)(c) as part of the WQIP;

   (ii) Include an analysis in the WQIP, utilizing a watershed model or other watershed analytical tools, to demonstrate that the implementation of the BMPs required

under specific Permit Provision 3.b.(2)(c) achieves compliance with specific Permit Provisions 3.b.(3)(a), 3.b.(3)(b), 3.b.(3)(c) and/or 3.b.(3)(d);

(iii) The results of the analysis must be accepted by the Regional Water Board as part of the WQIP;

(iv) The Copermittees continue to implement the BMPs required under specific Permit Provision 3.b.(2)(c); and

(v) The Copermittees continue to perform the specific monitoring and assessments specified in specific Permit Provision 3.d, to demonstrate compliance with specific Permit Provisions 3.b.(3)(a), 3.b.(3)(b), 3.b.(3)(c) and/or 3.b.(3)(d).

The final numeric goals for nutrients in Rainbow Creek, developed based on final effluent limitations for receiving waters and MS4 discharges outlined in Attachment E.3 of the Permit, are presented in **Table 4-4**.

Table 4-4. Numeric Goals and Schedules for HPWQC – Nutrients in Rainbow Creek, San Diego County[16]

Compliance Pathway			Numeric Goal (December 31, 2021)
Water Quality Improvement Plan Implement Accepted Water Quality Improvement Plan			Implementation of a Water Quality Improvement Plan that incorporates the required BMPs; includes an analysis utilizing a watershed model or other watershed analytical tool to demonstrate that the implementation of the required BMPs achieves compliance; the results of the analysis are accepted by the Regional Water Board as part of the Water Quality Improvement Plan; the responsible Copermittees continue to implement the required BMPs; and the responsible Copermittees continue to perform the specific monitoring and assessments to demonstrate compliance.
OR			
Receiving Water Meet Receiving Water Limitations	Nitrate (as N)		10 mg/L
	Total Nitrogen		1.0 mg/L
	Total Phosphorus		0.1 mg/L
OR			
MS4 Discharges Meet Final Effluent Limitations expressed as concentrations in the storm drain discharge	Nitrate (as N)		10 mg/L
	Total Nitrogen		1.0 mg/L
	Total Phosphorus		0.1 mg/L
OR			
MS4 Discharges No Direct or Indirect Storm Drain Discharges to Receiving Water	Discharges		A 100% reduction in anthropogenic discharges from storm drain outfalls to Rainbow Creek.
OR			
MS4 Discharges Final Effluent Limitations Expressed as Annual Allowable Loads	Total Nitrogen	Commercial Nurseries	116 kilograms per year [kg/yr]
		Parks	3 kg/yr
		Residential Areas	149 kg/yr
		Urban Areas	27 kg/yr
	Total Phosphorus	Commercial Nurseries	3 kg/yr
		Parks	0.10 kg/yr
		Residential Areas	12 kg/yr
		Urban Areas	6 kg/yr

[16] See Order R9-2013-0001, as amended, Attachment E.3 – Total Maximum Daily Loads for Total Nitrogen and Total Phosphorus in Rainbow Creek Watershed.

4.2 STRATEGIES AND SCHEDULES

By building on the potential strategies developed consistent with Permit Provision B.2.e (**Appendix 3B**), each Copermittee and the City of Menifee has identified a group of strategies, consistent with Permit Provision B.3.b, that will be implemented within their jurisdiction and identified optional watershed management strategies for consideration to address eutrophication in the SMR watershed. Strategies to address eutrophication focus on reducing the discharges of nutrients, but also include strategies that change the physical factors in the receiving water to reduce the growth of algae and/or improve dissolved oxygen conditions (e.g. restoration of stream channels).

Strategies[17] to meet final goals were selected on the basis of their ability to achieve the following specific objectives:

- Effectively prohibit non-storm water discharges from the MS4 to receiving waters;
- Reduce pollutants in storm water discharges from the MS4 to the maximum extent practicable (MEP); and
- Implement programmatic or institutional BMPs.

The implementation of the WQIP will prioritize non-structural BMPs initially, with an emphasis on those that most directly address sources of nutrients. Source control measures will be implemented early on to address flows during dry weather by eliminating prohibited non-storm water discharges. Wet weather load reductions will be achieved through an iterative adaptive management process. Both non-structural and structural BMPs will be implemented as necessary, as applicable approvals are granted and funds are secured.

Within this larger framework, priorities for strategy selection include:

- BMP effectiveness, particularly for targeting nutrients, with consideration for priority water quality conditions;
- Provision of multiple benefits, including but not limited to, habitat, recreation, economic, and water resources benefits; and,
- The degree to which the strategy is sustainable, implementable, and cost-effective.

Given the varied sources within each jurisdiction, sets of strategies were developed specific to each Copermittee and the City of Menifee for each HPWQC, and are presented in the following subsections. Strategies include jurisdictional, optional jurisdictional and optional WMA strategies for each agency. Each Copermittee will implement JRMP (jurisdictional) strategies (to meet Permit Provisions E.2 through E.7), and the City of Menifee will implement its jurisdictional LIP strategies. Additionally, each Copermittee and the City of Menifee will implement additional

[17] Water quality improvement strategies selected for this Water Quality Improvement Plan may be categorized as either non-structural or structural BMPs (including both distributed and regional BMPs). Non-structural BMPs are management actions or programs designed to reduce or eliminate pollutant loading at the source. Non-structural BMPs can be municipal programmatic or regulatory measures, public education and outreach, financial incentives, or other source management programs designed to affect behavioral changes. Structural BMPs are treatment or volume mitigation BMPs implemented at the neighborhood (i.e., regional), parcel, or site scale (i.e., distributed) and include features such as green streets, rainwater harvesting, and Low Impact Development (LID)-type solutions. Funding sources for the implementation of structural BMPs have not been identified.

strategies (optional jurisdictional and optional WMA strategies), as described in Permit Provisions B.3.b(1)(a)(i)-(vi). WMA strategies may be implemented by multiple agencies.

4.2.1 Strategies to Address Eutrophication in the Upper and Middle SMR Subwatershed

This section describes the overall approach to strategy selection, prioritization, and implementation, the selected strategies, and a schedule for strategy implementation. The goals are developed to demonstrate progress towards addressing the HPWQC, but the strategies were developed to address the HPWQC, as well as other priority water quality conditions identified in **Chapter 2**. There are many strategies that will be implemented throughout the Middle SMR Subwatershed. In addition, Copermittees will select "targeted areas" for implementation of specific, focused strategies, to address the HPWQC (eutrophication impacts in the SMR Estuary, Warm Springs, and Redhawk Channel and nutrient loadings to the SMR Estuary from Upper Murrieta Creek and Tributaries, Warm Springs, Santa Gertrudis, Murrieta Creek and Long Canyon, Temecula Creek and Redhawk Channel). Strategies have been developed at jurisdictional (jurisdictional and optional jurisdictional strategies) and watershed scales (optional WMA strategies).

4.2.1.1 Approach to Strategy Selection and Implementation

The Copermittees and the City of Menifee have developed an adaptive approach for addressing the HPWQC which consists of a process for selecting, evaluating and implementing jurisdictional, optional jurisdictional, and optional WMA strategies based on program effectiveness assessments and data gathered through the monitoring program and special studies. The strategies will address the eutrophication and the effects of nutrient loading for the watershed.

Strategies were developed to target specific sources of nutrient loading to the MS4, particularly during dry weather conditions, consistent with the HPWQC. As described in **Chapter 3**, each agency has prioritized potential sources of nutrients within its jurisdiction. Based on this analysis, the top sources of nutrient loading to the MS4 within the Middle SMR Subwatershed include residential areas; commercial facilities; orchards, vineyards, and nurseries; and horse ranches. Strategies were developed to address these specific sources, as appropriate, in each jurisdiction.

The approach to the initial strategy selection and implementation is shown in **Figure 4-9**, and consists of the following steps:

- **Each Copermittee and the City of Menifee Will Implement JRMP/LIP Programs Throughout Their Jurisdiction –** Each Copermittee and the City of Menifee will develop and implement a JRMP or LIP (City of Menifee only) that contains strategies to address the requirements in Provisions E.2 through E.7 of the Permit. Jurisdictional programs, strategies, and minimum BMPs established per each agency's JRMP or LIP (City of Menifee only) will be implemented across all areas within the respective jurisdiction within 90 days of the Regional Water Board's acceptance of the WQIP. During JRMP and LIP revisions, proceeding concurrently with development of the WQIP, the JRMPs and LIPs will incorporate WQIP strategies designed to address nutrient loading to the MS4. Where practical, the JRMPs/LIPs will incorporate strategies that are designed to provide multiple benefits; that is, they will address eutrophication impacts and nutrients but will often also address one or more of the PWQCs (e.g., bacteria). JRMPs for each Copermittee in the Middle SMR Subwatershed are available at the following web link:

www.rcflood.org/npdes/SantaMargaritaWS.aspx#SMdocs. The City of Menifee will implement strategies described in its LIP, developed under their governing MS4 Permit in the Santa Ana Region (Order No. R8-2010-0033, NPDES Permit No. CAS618033).

- **Identify Target Areas to Implement Strategies to Address Specific Sources of the HPWQC –** In addition to the JRMP/LIP strategies to be implemented throughout each jurisdiction, additional strategies will be implemented to address sources of the HPWQC as required by Permit Provision B.3.b.(1)(a)(i)-(vi) (collectively referred to as enhanced JRMP/LIP strategies). In order to best address the priority sources identified in **Chapter 3**, the Copermittees identified target areas for implementation to focus on known and suspected sources of nutrients. Target areas within the SMR watershed were identified using several factors that are expected to correlate with nutrient loading discharged through the MS4. Factors used in target area selection are illustrated in **Figure 4-3**.



1. Based on models developed as part of the TMDL Alternative.
2. Information related to overwatering is supported by water usage data where available through coordination with local water districts.
3. Based on available data as discussed in Chapter 2.

Figure 4-3. Factors Considered When Selecting Target Areas

Copermittees in the Middle SMR Subwatershed selected five target areas to focus implementation. Due to their small land area and lack of MS4 outfalls, the City of Menifee did not select specific target areas. RCFCWCD also did not select target areas, as they do not have land use authority in many of the areas draining to their MS4. The selected target areas are illustrated for each Copermittee in **Figure 4-4** through **Figure 4-8**, with a figure for RCFCWCD illustrating the drainage areas contributing to their dry weather outfall monitoring locations. Consistent with an adaptive management approach, as more information becomes available, target areas may be modified to focus strategy implementation as appropriate. A diagram of the strategy implementation process for the upcoming permit term is illustrated in **Figure 4-9**.

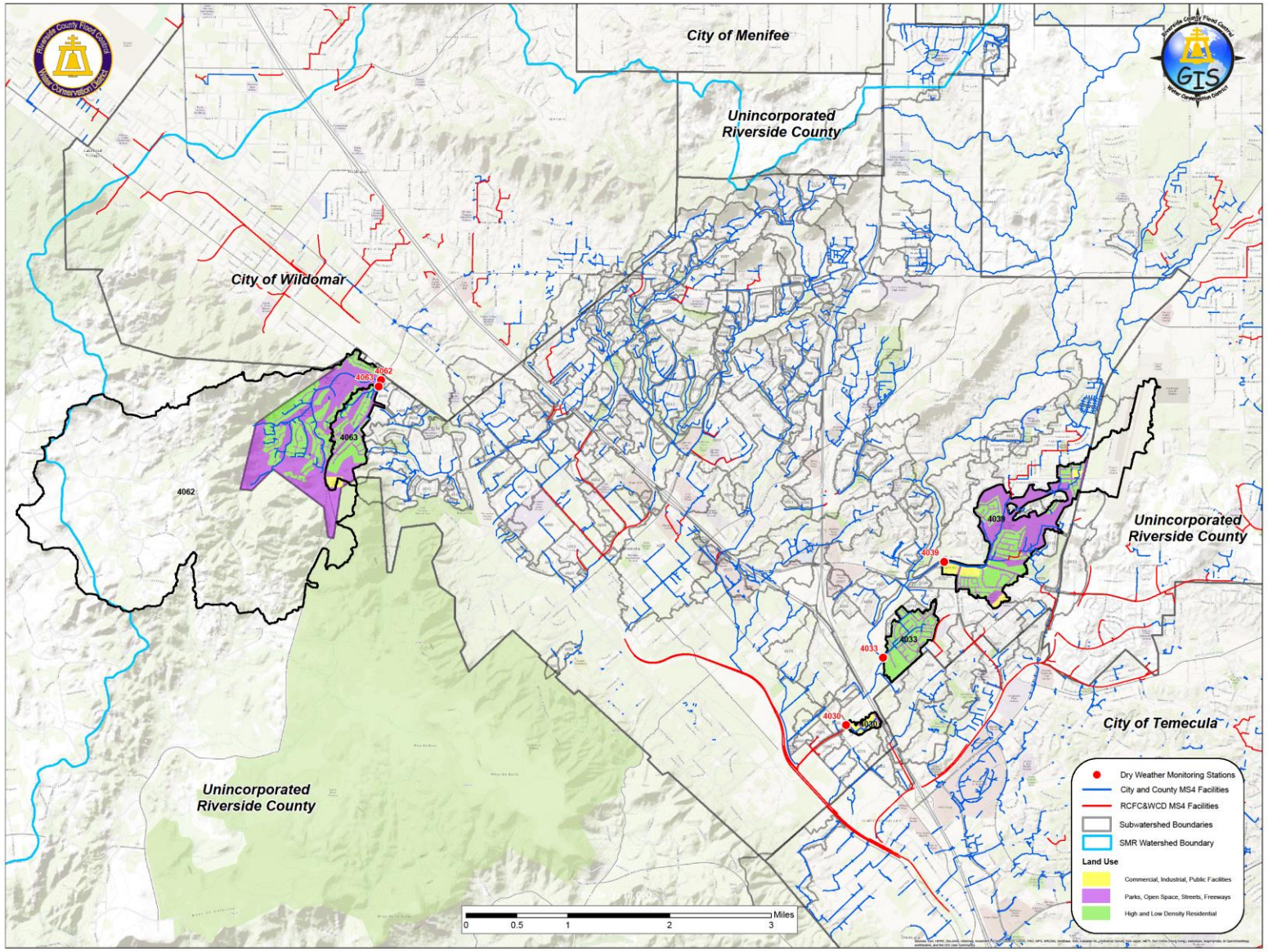

Figure 4-4. City of Murrieta Target Areas

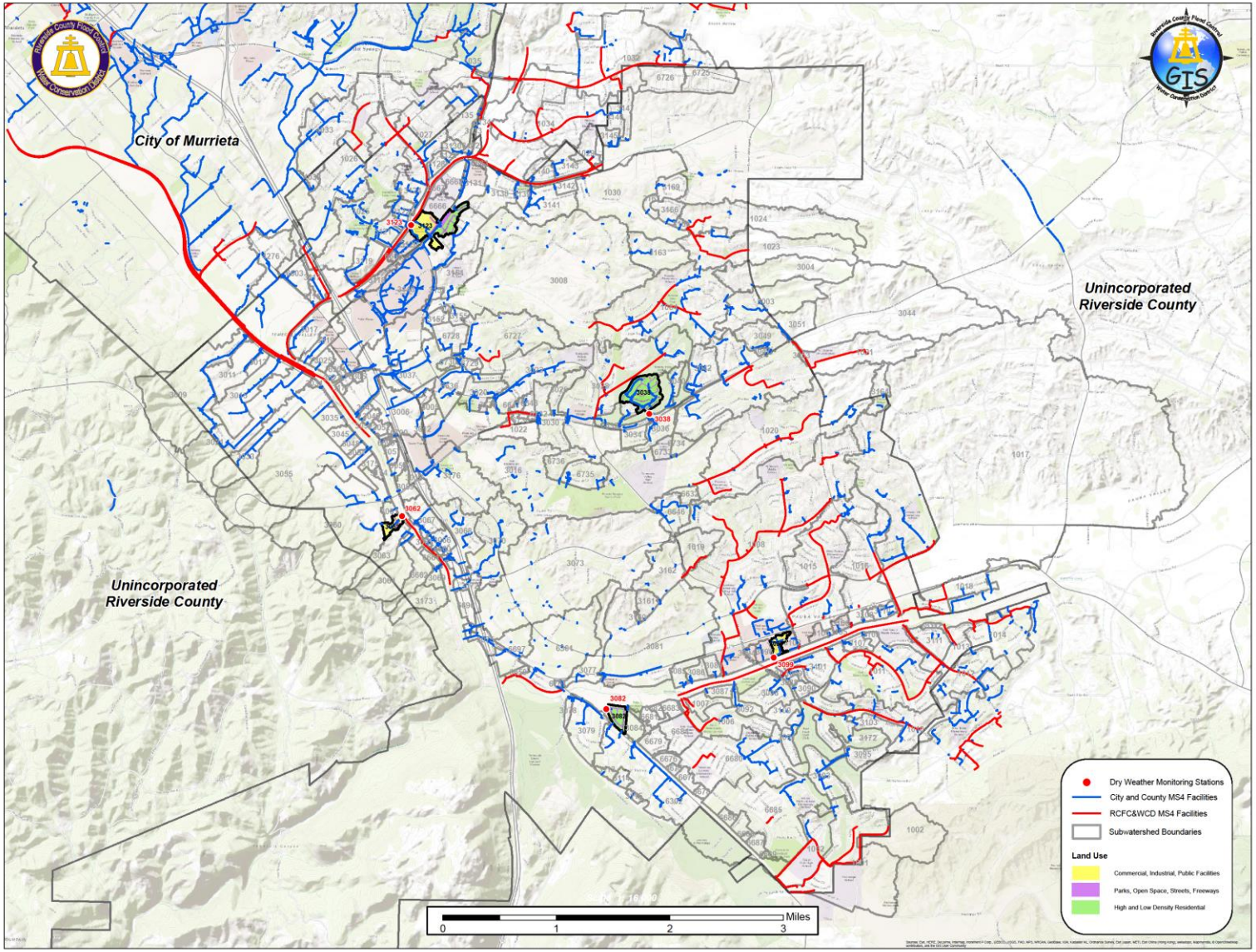

Figure 4-5. City of Temecula Target Areas

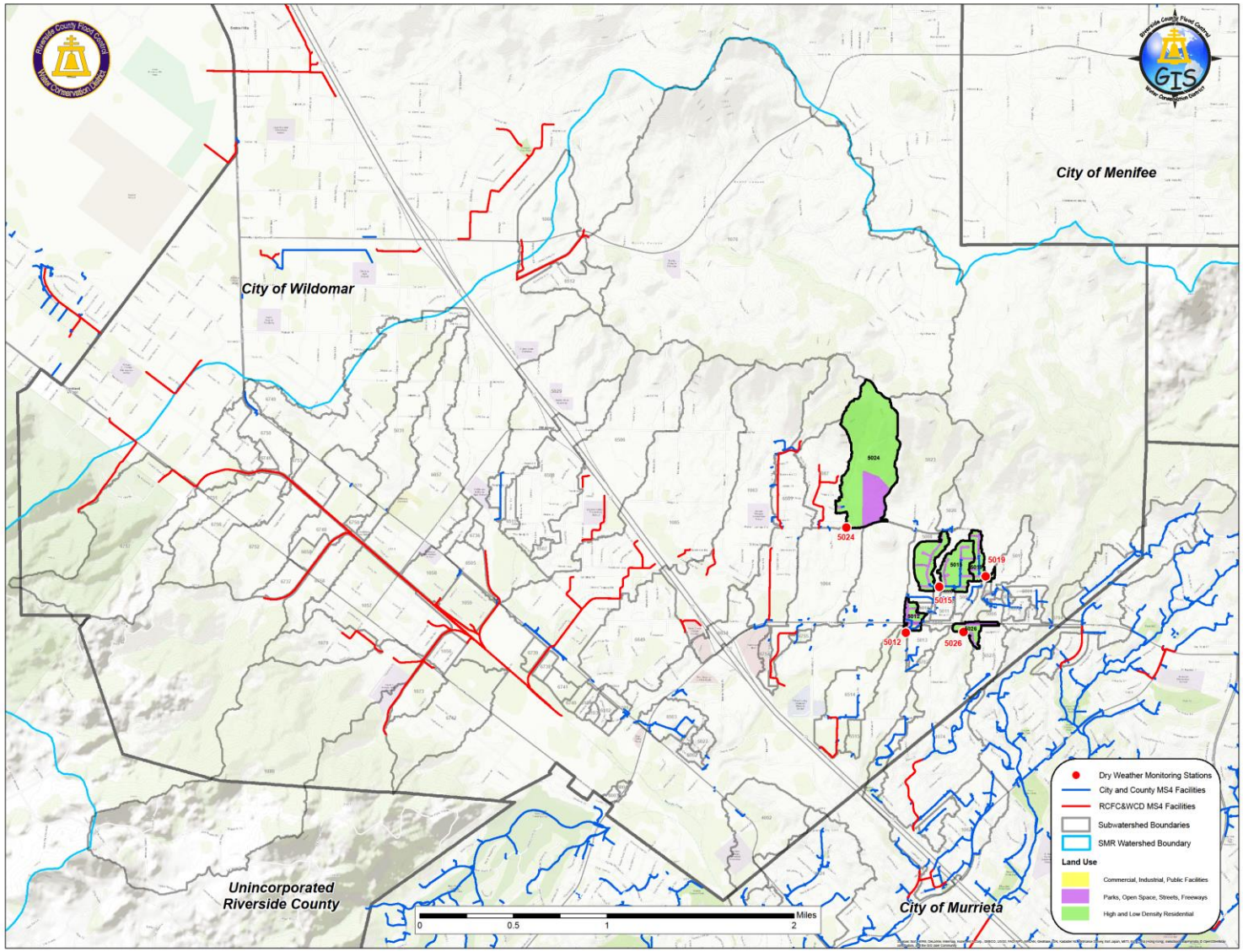

Figure 4-6. City of Wildomar Target Areas

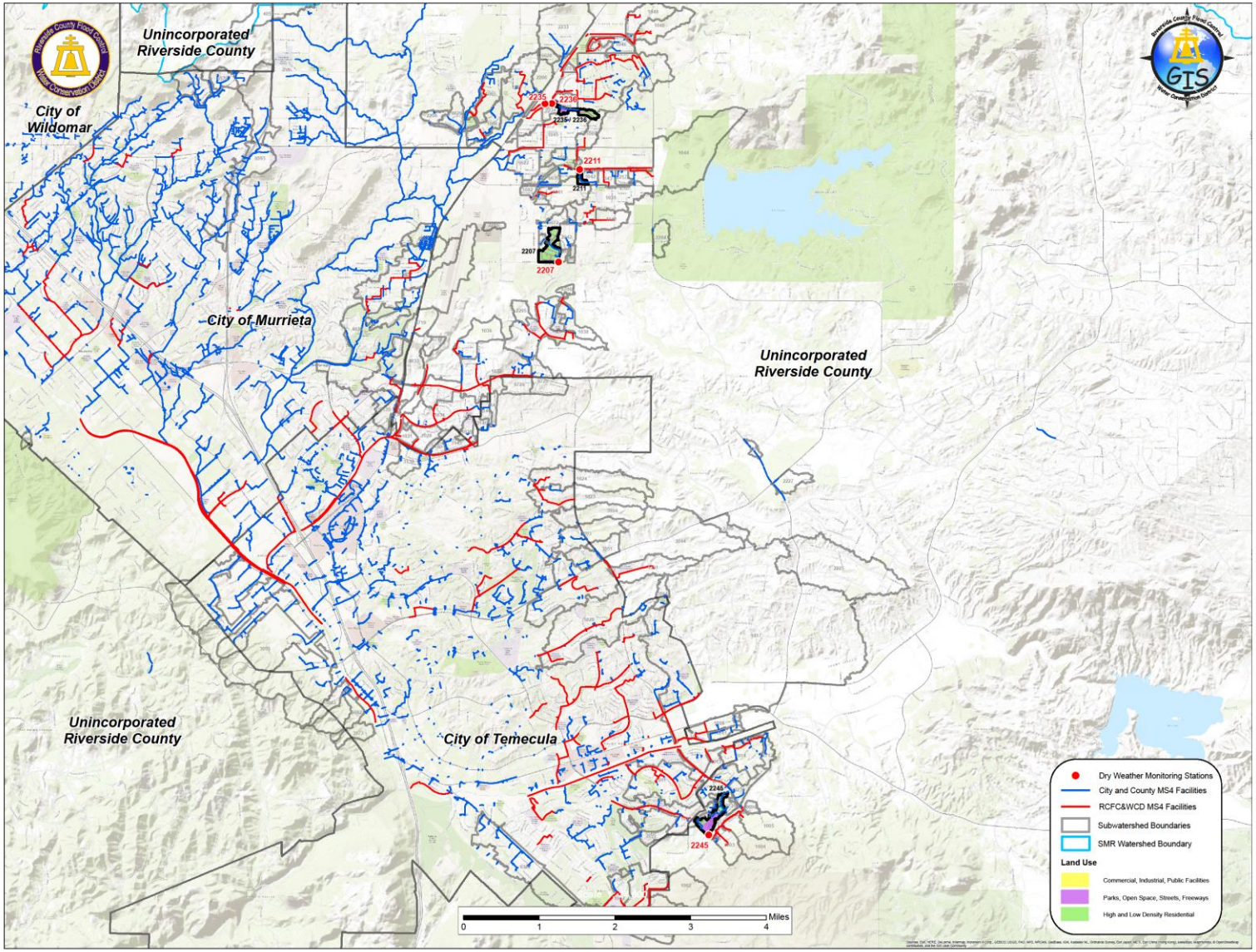

Figure 4-7. County of Riverside Target Areas

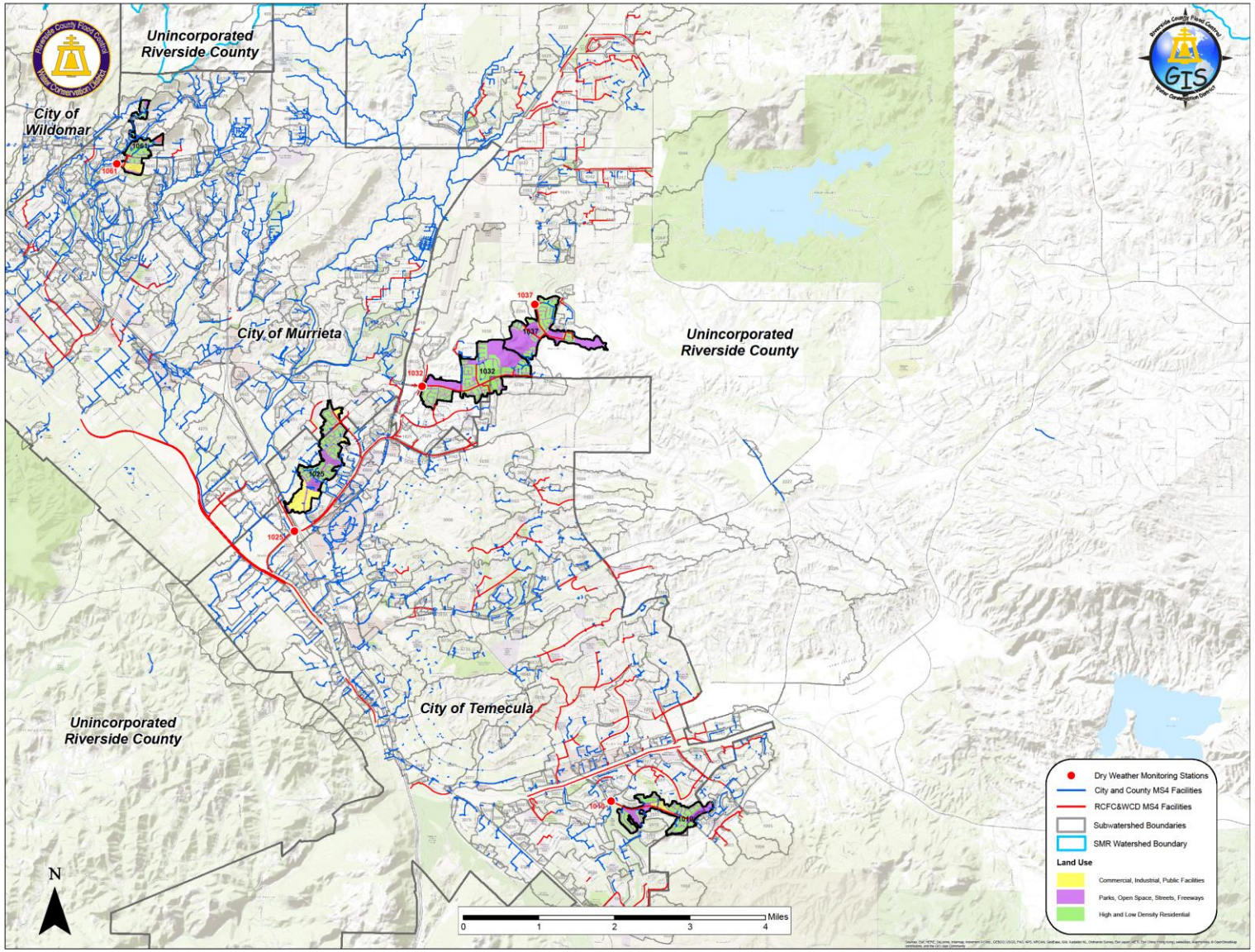

Figure 4-8. Riverside County Flood Control and Water Conservation District Dry Weather Outfall Monitoring Locations

- **Implement Enhanced JRMP/LIP Strategies in Target Areas** – Strategy implementation will include enhanced JRMP strategies that address Permit Provision B.3.b.(1)(a)(i)-(vi). Enhanced strategies are specific, locally appropriate strategies, focused in target areas where there are potential sources of nutrients contributing flows to the MS4.
    - Each Copermittee will implement enhanced JRMP/LIP strategies within their target areas. Each Copermittee has identified an initial set of enhanced strategies within applicable JRMP programs that focus on the nutrient sources within their jurisdiction, summarized in **Table 4-6** through **Table 4-11**.
    - Details of the enhanced JRMP strategies selected by each Copermittee are included in their jurisdictional strategies tables.
- **Implement Optional Jurisdictional/Optional WMA if triggered** – The Copermittees will employ an adaptive approach to implement and evaluate strategies. The Copermittees have developed optional watershed strategies that, if triggered and resourced, would be implemented through coordination amongst the Copermittees. At the time of each update of the WQIP (not less than every five years), assessments will be made regarding the degree of implementation of identified strategies versus the measured progress toward interim and final goals. If the percent of implementation is significantly higher than the percentage of the final goal achieved, jurisdictional strategies may be modified, additional enhanced strategies may be selected, or optional strategies (jurisdictional or WMA) may be triggered.

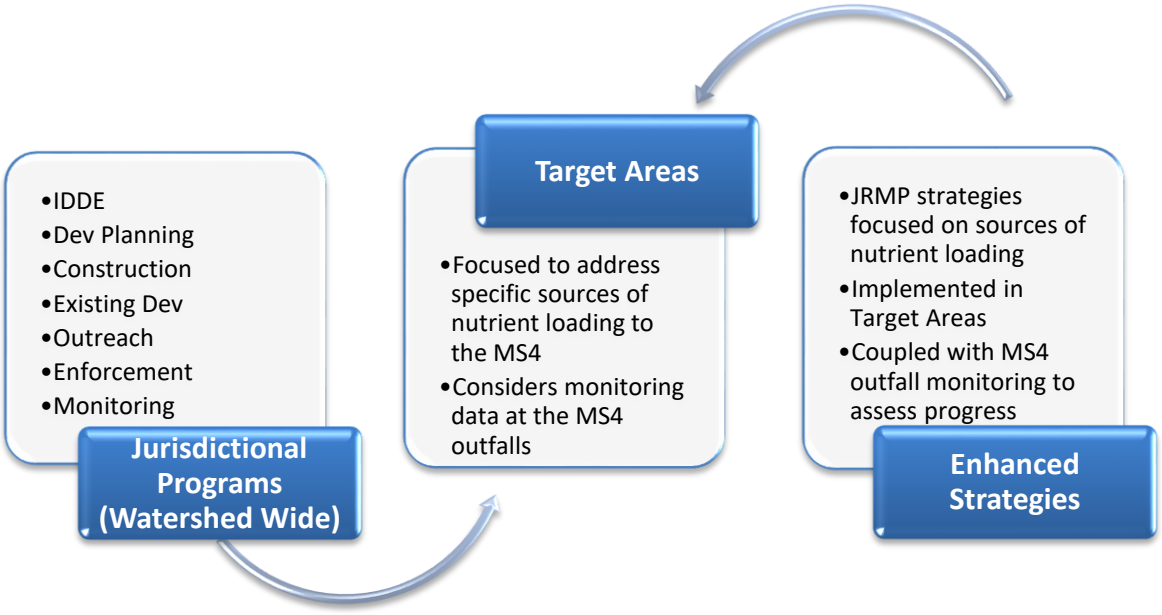

Figure 4-9. Initial Strategy Selection and Implementation, 2018 - 2023

In summary, the strategies can be categorized into three types:

1. Strategies building on the required JRMP elements in Provision E of the Permit. These include the JRMP requirements, as well as modifications and enhancements within existing programs to provide a more focused approach to specifically address sources contributing to nutrient loading and eutrophication;
2. Optional jurisdictional strategies designed to address nutrient loading and eutrophication that may be necessary to achieve goals; and
3. Optional WMA strategies involving cooperation amongst two or more Copermittees or the City of Menifee working together to address nutrient loading and eutrophication.

The strategies include suites of programmatic (i.e., non-structural) and structural BMPs that are expected to improve conditions within the watershed. The Copermittees and the City of Menifee have placed an emphasis on selecting strategies that achieve multiple-pollutant reductions, and, thus, are effective at addressing other priority water quality conditions in addition to nutrients. An overview of the adaptive management options are illustrated in **Figure 4-10**.

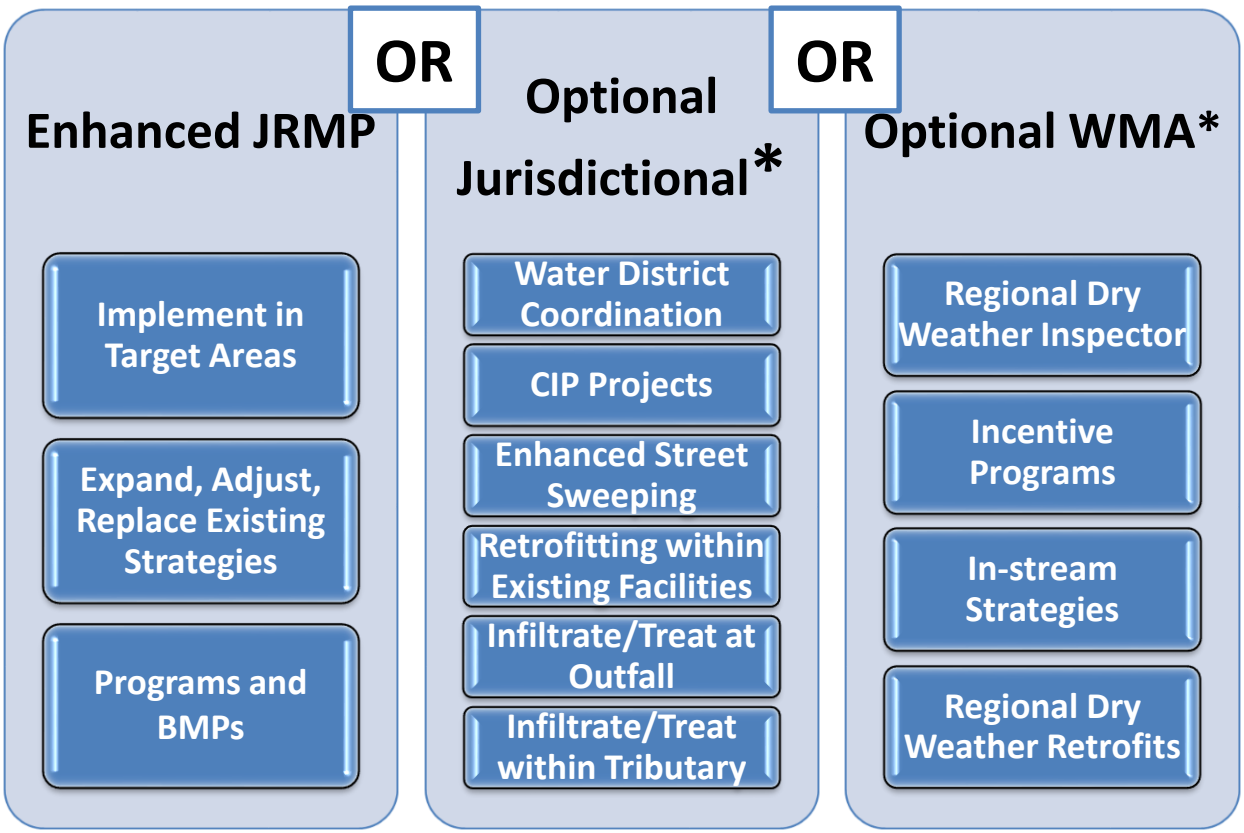

Figure 4-10. Adaptive Management Options (*as triggered and resourced)
[*see Optional Strategies Table and Jurisdictional Tables for Complete List*]

4.2.1.2 Jurisdictional Strategies

The Copermittees and the City of Menifee have identified jurisdictional strategies that will be implemented as part of their JRMP that are designed to effectively prohibit non-storm water discharges to the MS4, reduce pollutants in stormwater, and protect beneficial uses of receiving waters. Implementation of JRMP strategies and their success will ultimately be measured against the interim and final numeric goals as discussed in **Section 4.1**.

When selecting enhanced JRMP strategies, the most effective BMPs for each program will depend on characteristics of each jurisdiction (e.g., jurisdiction size, types of activities, land uses, sources); therefore, all jurisdictions will not necessarily implement the same strategies nor implement strategies on the same scale. For example, it is expected that all Copermittees and the City of Menifee will have enhanced strategies to focus on residential areas, since that is one of the highest priority sources for all; however, commercial nurseries are only present in some jurisdictions, so only those would have enhanced strategies focused on these sources. From a geographic perspective, enhanced strategies will be focused on areas where they are likely to be most effective. These enhanced strategies will be based on existing JRMP programs and permit requirements and, through the WQIP, will be tailored to the conditions within the jurisdiction that may contribute to nutrient loading and eutrophication impacts. As an example, existing development programs implemented under Permit Provision E.5 may be tailored to target specific sources identified as priorities within a jurisdiction, such as residential areas, commercial nurseries, or horse ranches. As discussed in **Chapter 3**, the Copermittees and the City of Menifee identified and prioritized suspected sources that contribute to nutrient loading. The Copermittees and the City of Menifee used that information when developing their jurisdictional programs to focus on the sources that could potentially contribute nutrients through the agencies' MS4s.

Enhanced strategies are specific, locally appropriate strategies, focused in target areas where there are sources contributing to eutrophication or nutrient loading to the storm drain system.

The Copermittees' jurisdictional programs, per Permit Provisions E2 – E7, and how they address sources of nutrients and eutrophication impacts are described below.

4.2.1.2.1 Illicit Discharge Detection and Elimination [Permit Provision E.2]

The Permit requires the effective prohibition of non-stormwater discharges through implementation of programs under Provision E.2, illicit discharge detection and elimination (IDDE). The IDDE program is intended to minimize the impacts of illicit discharge and connections to receiving waters through investigations, water quality monitoring at MS4 outfalls, and follow-up activities to abate sources of illicit discharges. This program is fundamental in effectively prohibiting non-stormwater discharges. Programs required under this provision are currently being implemented by the Copermittees and will continue. The programs can be enhanced to focus municipal training programs that target key staff regarding the effects of nutrient discharges on receiving waters in the watershed and on identifying sources of illicit discharges (e.g., residential areas, commercial nurseries) that potentially contribute nutrients. The enhanced training efforts will focus on identifying and eliminating non-stormwater flows, since that will reduce nutrient loading and address persistent dry weather flows in outfalls.

While the focus is on nutrients, IDDE programs and enhanced strategies will address multiple pollutant sources and constituents through reduction and elimination of non-stormwater flow. The Copermittees maintain inventories of commercial, industrial, residential, and municipal facilities, all of which can contribute to illicit discharges and nutrient loads. Specifically, Copermittees will focus on inventoried facilities likely to have non-stormwater discharges resulting from over-irrigation, such as commercial facilities, residential areas, and municipal parks. The Copermittees will focus on land uses that meet the following criteria: 1) the land use is likely to be over-irrigated, and 2) areas tributary to a MS4 facility.

Inspections are performed on an as-needed basis as part of the IDDE program, most often in response to complaints from municipal staff or residents, or as a result of field investigations. Inspections will continue to be performed on an as-needed basis, but may be performed on a more frequent basis in response to outfall screening results and assessments in targeted areas aimed at eliminating non-stormwater flows.

4.2.1.2.2 Development Planning [Permit Provision E.3]

The previous municipal stormwater permit in 2010 (Order No. R9-2010-0016) designated specific types of new development and redevelopment projects as "priority development projects" or PDPs, requiring specific site design, source control, and structural treatment control BMPs to be implemented for qualifying projects. The 2010 Permit also required certain PDPs to implement controls to mitigate increases in peak flow and volumes of stormwater. With the 2015 Permit, these requirements were further intensified with the new requirement for full on-site retention of the 24-hour, 85th percentile storm volume. With limited exceptions, new development and redevelopment projects are required to retain or treat and detain stormwater and its associated pollutants (including nutrients) on-site, to reduce the impacts on receiving waters during storm events. In most cases, the post-construction BMPs are also designed to intercept and infiltrate dry weather flows, providing significant pollutant reduction, and often full elimination under ambient conditions. The implementation of baseline Permit requirements for new development and redevelopment projects will mitigate pollutants (including nutrients and other PWQCs) and ensure that these projects do not cause degraded water quality conditions downstream of the project site.

In addition to the baseline requirements, the Copermittees may implement enhanced strategies as part of the Development Planning program that will focus efforts on mitigating sources of nutrients. The enhancements could include modified LID requirements, smart irrigation conditions of approval, and/or revised post-construction guidelines to eliminate dry weather discharges from new development and redevelopment. In addition, development standards and guidelines could be developed or updated to eliminate dry weather discharges; promote swale grading and reduce the use of private area drains directly connected to the curb; and/or require BMPs or catch basins at all site entrances and exits which are sloped towards public right-of-way to ensure that any dry weather run-off is routed to an on-site treatment system. Copermittee BMP design manuals could be amended to address priority sources (e.g., over-irrigation in residential areas) supplemented by internal staff training on updated BMP design manual or other enhancements that target nutrients.

The Copermittees maintain inventories and perform inspections of treatment control BMPs to verify that the required BMPs are constructed properly, maintained appropriately, and operating as designed. Copermittees will continue to inventory and inspect treatment control BMPs as required under Permit Provision E.3. Through this program, it is anticipated that non-stormwater flows (and, therefore, any nutrients in the non-stormwater flows) will be reduced or eliminated

from new development and redevelopment and that nutrients in stormwater will be reduced through biofiltration, retention, or other BMPs. As new development and redevelopment continues, increased amounts of the existing landscape will have treatment control BMPs and contribute less to nutrient loads and other PWQCs identified in **Chapter 2**.

4.2.1.2.3 Construction Management [Permit Provision E.4]

Construction sites have the potential to contribute to nutrient loading primarily through ineffective erosion control that can lead to phosphorous-borne sediment entering the receiving waters. The Copermittees have been implementing construction stormwater programs for several NPDES permit terms. Over this time, agency staff and the construction community have become well trained in construction stormwater management. Additional oversight is required per the State Construction General Permit (Order 2009-0009-DWQ) for sites greater than one acre. With this amount of focus, the limited sources of nutrients related to construction are well addressed via the existing Permit requirements. For this reason, the Copermittees will focus on the baseline programs as required under the 2013 Permit. These requirements include a set of minimum BMPs for construction sites, articulated in each Copermittees' JRMP, and routine inspections of construction sites to ensure that BMPs are implemented as required. Where necessary, enforcement measures may be used to gain compliance.

4.2.1.2.4 Existing Development Management [Permit Provision E.5]

The Existing Development Management program requires comprehensive inventories, periodic inspections, and enforcement for existing development (i.e., commercial, industrial, municipal, and residential) to ensure that BMPs are implemented to reduce water quality pollutants and runoff. This program also includes municipal operations and maintenance practices, such as storm drain cleaning and street sweeping. The source prioritization in **Chapter 3** will be used in conjunction with Copermittee inventories to identify and target specific sources potentially contributing to the eutrophication impacts and nutrient loading. Existing development programs will be implemented per Permit Provision E.5 and may also include enhanced strategies (e.g., increased inspection frequencies for facilities, with the potential to contribute nutrients, included in the inventories). Select strategies within the Existing Development Management Program that the Copermittees identified for addressing nutrients, and other priority water quality conditions, are described below.

4.2.1.2.4.1 Street Sweeping

Street and median sweeping is a common practice for reducing street sediment and vegetative and anthropogenic debris, and, therefore, urban runoff pollutant loads from transportation land uses. High-efficiency street sweeping equipment, such as regenerative air sweepers or vacuum assisted sweepers can significantly increase the amount of sediment removed from roadways. Street and median sweeping within the watershed may be an effective program for managing the sediment transport of pollutants (e.g. nutrients, metals, oil and grease, bacteria) into the MS4. Street sweeping BMPs provide water quality benefits for multiple pollutants of concern through transportation-related source load mitigation and the removal of multiple associated pollutants. Street sweeping is currently implemented per each Copermittee's JRMP, but may also be selected as an enhanced strategy and implemented at higher frequencies within targeted areas. Street sweeping addresses improved areas of existing development (e.g., residential, commercial, industrial, municipal areas with curb and gutter).

4.2.1.2.4.2 Existing Development Inspections

The source evaluation and prioritization in **Chapter 3** included inventories of potential sources contributing to eutrophication impacts and/or nutrient loading. Specific potential sources include industrial and commercial facilities, especially those with irrigation systems, residential areas, municipal facilities, such as parks and recreation areas, onsite wastewater treatment systems, sanitary sewer systems, streets, and landfills. The Copermittees could choose to enhance their inspection programs to focus on sources that potentially contribute to nutrient loading within the selected target areas as part of their enhanced JRMP Programs. The enhancements may include increasing inspection frequencies at facilities identified to be potential sources of nutrients within the target areas, beyond the minimum requirements in the Permit of once every five years.

In addition, the focus of both residential and commercial/industrial programs will be targeted toward identifying and eliminating over-irrigation to better address nutrient loading from irrigation runoff. Areas identified as sources will be targeted through tailored and enhanced inspections. Through inspections, the Copermittees can conduct outreach to home and business-owners about smart irrigation controllers and/or other financial incentive programs that decrease watering volume. Effective methods to reduce irrigation runoff from residential, commercial, and agriculture may include development of targeted outreach materials, increased inspections surveys, punitive measures for overwatering, tiered water rates, or distribution of smart irrigation controllers and/or other financial incentive programs that decrease watering volume. Irrigation runoff reduction programs can also be integrated with BMPs that encourage landscaping and smart gardening practices that reduce the load of fertilizers and chemicals that enter stormwater, such as integrated pest management, reducing fertilizer and pesticide use, xeriscaping, and turf conversion. To facilitate the use of these source control approaches, ordinances, education and outreach, and financial incentives may be implemented. Increased irrigation runoff controls and incentives in commercial and residential land uses could result in pollutant load reductions at the MS4 outfalls.

Additionally, areas of existing development where erosion is identified as a potential problem will be evaluated and addressed as appropriate since nutrient loads can increase as a function of sediment transport during wet weather events.

4.2.1.2.4.3 Inspection of Onsite Wastewater Treatment Systems (OWTS)

Leaking or failing septic systems may contribute to nutrient loads and other PWQCs (e.g., bacteria) during dry and wet weather conditions. Approximately 1,500 acres of land within the watershed are known to contain septic systems. In selected targeted areas, the Copermittees could enhance their residential programs to add a focus on failing septic systems (e.g., focused internal training for field staff). An effective septic survey and enforcement program addresses nutrients and other PWQCs by preventing the transport of nutrients, sediment, and bacteria from failing OWTS to MS4s and surface waters.

4.2.1.2.5 Enforcement Response Plans [Permit Provision E.6]

The use of enforcement actions to correct violations will support existing programs and enhanced strategies across all JRMP programs and has been shown to increase their effectiveness. Enforcement activities, such as inspections or escalating enforcement responses to compel compliance with statutes, ordinances, permits, orders, and other requirements, could significantly increase the success of other BMP programs (e.g., IDDE, existing development). Escalating

enforcement actions will be implemented in accordance with each Copermittee's enforcement response plan, developed per Permit Provision E.6 and included in their JRMP.

4.2.1.2.6 Public Education and Participation [Permit Provision E.7]

The Public Education and Participation programs are an integral part of program implementation, targeting key internal (i.e., Copermittee staff) and external (i.e., public) audiences that may contribute to nutrient loading or other PWQCs identified within the watershed. Public education and participation is an important approach to heighten watershed stewardship and mindfulness of water quality. The Copermittees develop and distribute outreach materials; perform outreach presentations at public events; provide outreach to large residential properties and mobile landscaping businesses; and provide educational workshops. More recently, some Copermittees are beginning to use social media as an outreach mechanism. The enhanced strategies related to education and participation will focus on sources of nutrients (e.g., nurseries, homeowners' associations, septic systems), but will provide a multi-pollutant benefit in promoting general water quality awareness. Examples of outreach strategies that Copermittees may implement to address nutrient loading and potential sources include:

- Incentive programs (e.g., for irrigation runoff reduction in coordination with water districts);
- Encouraging BMPs that include landscaping and smart gardening practices that reduce the load of fertilizers and chemicals that enter stormwater; and
- Promoting integrated pest management by reducing fertilizer and pesticide use, increasing xeriscaping, and implementing turf conversion.

Programmatic approaches, primarily non-structural BMP implementation, through the JRMP programs and enhanced WQIP strategies, form the basis for anticipated improvements in the watershed. These programs are focused on the key sources identified in **Chapter 3**. The key sources for each Copermittee and the relative loading of nutrients from those sources to the Copermittee's MS4s provide the foundation for strategy selection. The priority sources and relative nutrient loading are summarized for each Copermittee in **Table 4-5**.

Overall, the identified strategies for the SMR watershed include robust jurisdictional programs that include baseline programs and enhanced strategies to minimize, to the maximum extent practicable, the effects of nutrients discharged through MS4 conveyances to receiving waters. Copermittees will continue to implement their baseline JRMPs per Permit Provisions E.1 – E.8. Due to their different programs under the Santa Ana MS4 Permit, the City of Menifee will implement strategies based on their LIP. Within target areas, Middle SMR Subwatershed Copermittees have selected enhanced strategies. Copermittee strategies are summarized in **Table 4-6** through **Table 4-11**.

Table 4-5. Summary of Key Sources of Nutrients by Agency

Copermittee	Key Sources	Total Nitrogen[1]	Total Phosphorus[1]
City of Menifee	Residential Areas/Activities Horse Ranches (Residential) Commercial Facilities	N/A[2]	N/A[2]
City of Murrieta	Residential Areas/Activities	66.20%	64.20%
	Commercial Facilities	10.00%	9.70%
	Orchards, Vineyards, Nurseries	5.90%	5.80%
City of Temecula	Residential Areas/Activities	71.70%	70.50%
	Commercial Facilities	13.20%	13.00%
	Industrial Facilities	7.50%	7.40%
City of Wildomar	Residential Areas/Activities	67.40%	61.00%
	Horse Ranches	3.70%	3.40%
	Commercial Facilities	3.60%	3.30%
County of Riverside	Residential Areas/Activities	35.60%	33.60%
	Orchards, Vineyards, Nurseries	27.60%	26.30%
	Horse Ranches	10.60%	10.00%
RCFCWCD	Residential Areas/Activities Commercial Facilities Orchards, Vineyards, Nurseries	N/A[3]	N/A[3]

1. As a percentage of the total loading to the Copermittee's MS4.
2. Under the Regional Water Board Designation Letter dated October 26, 2015 Menifee is required to participate in the development and implementation of the SMR WQIP and the implementation of any applicable TMDL. However, no specific load allocations have been assigned to Menifee. Menifee was not included in the modeling efforts. Because Menifee only has a small jurisdictional area in the WMA (less than 2 square miles), Menifee will participate in the overall load reduction by implementing its WQIP and LIP strategies.
3. Nitrogen and phosphorus loads for the RCFCWCD were not calculated or included in the SMRNIG model. Nonetheless, the RCFCWCD will implement their JRMP, including the strategies identified in Table 4-11 to address the HPWQCs and PWQCs. If determined necessary by the SMRNIG, loading estimates may be developed in the future, at which time, they will be included within the WQIP through the adaptive management process.

As programs and progress towards goals are assessed, Copermittees and the City of Menifee will implement an iterative process of implementing additional enhanced strategies, followed by optional jurisdictional and optional WMA strategies as necessary to achieve their goals. Structural solutions are included as optional jurisdictional and optional WMA strategies and will be considered through the adaptive management process as triggered.

Table 4-6. Jurisdictional Strategies Selected to Address Eutrophication Impacts in the Middle SMR Subwatershed – City of Menifee

(Note: Only a small portion of the City of Menifee totaling less than 1.3 square miles is located in the Santa Margarita River Watershed Management Area. This area consists primarily of residential area, the majority of which is rural residential properties larger than 2 acres.)

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Illicit Discharge, Detection, and Elimination (IDDE) Program (Prov E.2)															
IDDE-1	Entire Jurisdiction	Illicit Discharges, mainly residential (e.g. discharges related to equestrian and livestock activities) and commercial (e.g. nursery activities) for the SMR WMA	Implement an Illicit Connection and Illegal Discharge (IC/ID) Program. LIP requirements include: maintaining an MS4 map, using municipal personnel and contractors to identify and report illicit discharges, maintaining a hotline for public reporting of illicit discharges, monitoring MS4 outfalls, and investigating and addressing any illicit discharges.	Both	X	X		X	X	X	X	X	X	Continuous	The City of Menifee conducts outfall monitoring per the Santa Ana MS4 Permit requirements. City staff receive storm water complaints directly by phone and email, and from the regional reporting hotline. City and contract staff work to immediately address and eliminate illegal discharges. Refer to LIP Section 4.
Development Planning (Prov E.3)															
DEV-1	Entire Jurisdiction	New and redevelopment of all land uses	For all development projects, administer a program to ensure implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area, where applicable and feasible.	Both	X	X	X	X	X	X	X	X	X	Continuous	All development projects are required to implement minimum BMPs. The City of Menifee follows the development requirements outlined in the Santa Ana MS4 Permit. Refer to Local Implementation Plan (LIP) Section 6.
DEV-2	Entire Jurisdiction	New and redevelopment of all land uses	For Priority Development Projects, administer a program requiring implementation of structural BMPs to control pollutants and manage hydromodification. Includes confirmation of design, construction, and maintenance of structural BMPs.	Both	X	X	X	X	X	X	X	X	X	Continuous	All Priority Development Projects are required to implement and maintain post construction BMPs. The City of Menifee follows the development requirements outlined in the Santa Ana MS4 Permit. Priority Development Projects that require a Water Quality Management Plan (WQMP) must follow the guidance of the Santa Ana Watershed WQMP. Refer to LIP Section 6.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Construction Management (Prov E.4)															
CON-1	Entire Jurisdiction	Construction waste management	Administer a program to oversee implementation of BMPs during the construction phase of land development. Includes inspections at an appropriate frequency and enforcement of requirements. Menifee does not have any known agricultural land in the SMR WMA. Therefore, it is not anticipated that any construction projects will involve conversion of agricultural land.	Both		X		X	X			X	X	Continuous	All construction sites are required to implement minimum BMPs. Inspections are tracked to ensure that they meet the minimum inspection frequencies required by the Santa Ana MS4 Permit. **Frequencies:** High priority sites are inspected at least once monthly during the rainy season. Medium priority sites are inspected at least twice during the rainy season. Low priority sites are inspected at least once during the rainy season. All sites are inspected as-needed during the dry season. Refer to LIP Section 7.
Existing Development Management (Prov E.5)															
EXIST DEV-1	Entire Jurisdiction	Commercial - general, Commercial - nurseries, Industrial	Administer a program to require implementation of minimum BMPs for industrial and commercial development that are specific to the facility, area types, and pollutants generated, as appropriate. Includes inspection of existing development at appropriate frequencies.	Both	X	X		X	X	X	X	X	X	Continuous	All industrial and commercial facilities are required to implement minimum BMPs. Inspections are tracked to ensure that they meet the minimum inspection frequencies required by the Santa Ana MS4 Permit. **Frequencies:** High priority facilities are inspected at least once per year. Medium priority sites are inspected at least once every other year. Low priority sites are inspected at least once every five years (during a Permit term). Refer to LIP Section 8. Menifee does not have any known agricultural land within the Santa Margarita Watershed. However, if inspectors identify any facilities engaged in agricultural or livestock activities that are required to file for coverage under an agricultural conditional waiver program, these facilities will be reported to Regional Board staff.
EXIST DEV-2	Entire Jurisdiction	Industrial	Notify Regional Board of industrial businesses subject to the Industrial General Permit so that the businesses may obtain coverage as required.	Both	X	X		X	X	X	X	X	X	Continuous	The City of Menifee will share inspection results with Regional Board staff and notify of non-filers or potential noncompliance with other IGP requirements, especially requirements specifically related to discharges of nutrients. Refer to LIP Section 8

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
EXIST DEV-3	Entire Jurisdiction	Municipal	Administer a program to require implementation of minimum BMPs at municipal facilities. Includes inspection of facilities at appropriate frequencies.	Both	X	X		X	X	X	X	X	X	Continuous	All municipal facilities are required to implement minimum BMPs. Inspections are tracked to ensure that they meet the minimum inspection frequencies required by the Santa Ana MS4 Permit. **Frequency:** All fixed municipal facilities and field operations identified in Table 5-3 of the Drainage Area Management Plan (DAMP) are required to be inspected annually. The City also inspects its public parks annually to ensure that the parks are not a contributor to storm water pollution. Refer to LIP Section 5.
EXIST DEV-4	Entire JurisdictionCollaboration with RCFCWCD	Residential	Promote and encourage implementation of minimum BMPs at residential areas.	Both	X	X		X	X	X	X	X	X	Continuous	The City of Menifee participates in regional activities to facilitate the proper collection and management of used oil, toxic and hazardous materials, and other household wastes. The City also promotes the Riverside County Watershed Protection Program, which provides educational materials for landscaping and gardening and pet owners, among others. Refer to LIP Section 9.
EXIST DEV-5	Entire Jurisdiction	Residential - (Specifically Equestrian and Livestock Activities)	Require proper management of animal waste by residents to prevent transport of wastes and wash water offsite.	Both	X	X						X	X	Continuous	The City of Menifee has adopted a Manure Management and Disposal Ordinance (Order 2013-131U) to address the threat to water quality posed by the accumulation of manure on properties. The ordinance outlines best management practices and establishes regulations for the proper handling, temporary storage, collection, and disposal of manure in the City of Menifee. Refer to LIP Section 3.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
EXIST DEV-6	Entire Jurisdiction Collaboration with RWQCB	Streets within all land uses	Implement operation and maintenance activities (inspection and cleaning) for MS4 and related structures (catch basins, storm drain inlets, open channels, detention basins, etc.) for water quality improvement.	Both	X	X			X			X	X	Continuous	The City of Menifee inspects catch basins annually before the rainy season and cleans basins when accumulated materials are present. Large storm drain pipes, as well as open channels and detention basins in the City are owned and maintained by the Riverside County Flood Control and Water Conservation District. Refer to LIP Section 5.
EXIST DEV-7	Entire Jurisdiction Collaboration with County of Riverside Transportation Dept.	Streets within all land uses	Implement operation and maintenance activities for streets.	Both	X			X	X	X	X	X	X	Continuous	Street sweeping is done on selected routes twice per month by the County of Riverside. Refer to LIP Section 5.
Enforcement Response Plans (Prov E.6)															
ENF-1	Entire Jurisdiction	Illicit Discharges, Development, Construction, Industrial, Commercial, Municipal, Residential	Implement escalating enforcement responses to compel compliance with ordinances, permits, contracts, orders, and other requirements for ICID, development planning, construction management, industrial/commercial, municipal, and residential development (including residential equestrian and livestock activities)	Both	X	X		X	X	X	X	X	X	Continuous	The City has established the legal authority to require BMP implementation, including preventing illegal discharges, through the Stormwater Ordinance (Chapter 15.01 of the Municipal Code). When noncompliance is noted, the City initiates an enforcement process to bring about correction. Refer to LIP Section 3.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Public Education and Participation (Prov E.7)															
PUB ED-1	Entire Jurisdiction Collaboration with RCFCWCD	Industrial, Commercial, Municipal, and Residential	Implement a public education and participation program to promote and encourage development of programs, management practices, and behaviors that reduce the discharge of pollutants in storm water prioritized by high-risk behaviors, pollutants of concern, and target audiences.	Both	X	X		X	X	X	X	X	X	Continuous	Direct education is provided through interaction with the public during inspections, complaint response investigations, and plan review comments. The City educates businesses and residents about sources of pollutants, including waste management, erosion prevention (sediment), proper fertilizer use (nutrients), and discharge prevention, during inspections and complaint response investigations. Educational materials on a variety of storm water topics are available on the Riverside County Watershed Protection program website. This includes information related to residential gardening and overwatering prevention tips that can be shared with residents in the Santa Margarita Watershed. Refer to LIP Section 10 and DAMP Section 10 for details on the regional public outreach program.
PUB ED-2	Entire Jurisdiction Collaboration with RCFCWCD	Industrial, Commercial, Municipal, Residential, Illicit Discharges, Development, Construction.	Provide municipal staff training.	Both	X	X		X	X	X	X	X	X	Continuous	Staff are trained on BMP requirements and implementation. Target audiences include Engineering, Public Works, construction inspectors and plan reviewers. Training may be internal or provided by Riverside County Flood Control and Water Conservation District. Refer to LIP Section 11.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Optional Jurisdictional Strategies															
OPT-1	Target Area(s)	Residential	Develop and implement a residential inspections program. Areas covered would include mainly rural residential and some urban residential.	Both	X	X		X	X	X	X		X	FY18/19-Continuous	**Triggers:** The City plans to implement this strategy upon approval of the WQIP and will continue annual implementation provided the following trigger is met: 1) staff resources are identified and secured. **Approach:** The Santa Ana MS4 Permit does not require residential storm water inspections. However, since the majority of the City's 1.3 square miles within the Santa Margarita Watershed is rural residential, the City will develop and implement an annual residential drive-by inspection program to identify illicit connections, illegal discharges, and other potential pollutant discharges within residential areas in the Santa Margarita River Watershed. Inspectors will also look for evidence of improper BMP implementation related to manure management (see Strategy EXIST DEV-5) in rural residential areas with equestrian and livestock activities. The City will establish Standard Operating Procedures and develop an inspection checklist as part of the residential inspection program. **Funding:** Funding and resources have been secured for FY18. Funding for future fiscal years is contingent on annual budget approval by City Council. Funds anticipated to come out the general fund.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
OPT-2	Target Area(s)	Residential	Enhance public education and outreach for residents.	Both	X	X		X	X	X	X			Once triggered, as resources allow	**Triggers:** This strategy may be implemented at the City's discretion if the following triggers are met: 1) significant storm water deficiencies are observed during residential inspections in a given year, 2) it has been determined by City of Menifee staff through adaptive management that implementation is necessary, and 3) staff resources are identified and secured. **Approach:** Develop and implement a targeted outreach and education program for residents in the Santa Margarita Watershed based on the results of annual residential inspections. Educational topics will be based on issues identified during inspection (e.g. If equestrian washing were noted as an issue during inspection, educational materials targeting proper washing BMPs could be developed). Distribution methods and media type (i.e. online vs. print) to be determined based available resources and inspection staff input. **Funding:** Funding for future fiscal years is contingent on annual budget approval by City Council. Potential funding sources anticipated to be general fund and/or grant sources.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
OPT-3	Target Area(s)	Commercial - nurseries and animal facilities	Increase inspection frequency for highest nutrient pollutant potential businesses within the Santa Margarita Watershed.	Both	X	X		X	X	X	X			Once triggered, within 1 year (contingent upon timing of annual inventory prioritization)	**Triggers:** This strategy may be implemented at the City's discretion if the following triggers are met: 1) An interim goal has not been met, 2) it has been determined by City of Menifee staff through adaptive management that implementation is necessary, and 3) staff resources are identified and secured. **Approach:** Commercial non-agricultural animal facilities and commercial nurseries are generally assigned a medium priority, which translates to a stormwater inspection at least every other year. Under this strategy, if these businesses are identified as having high potential for contributing nutrients to the Santa Margarita Watershed, they would be elevated to high priority, increasing the minimum inspection frequency to once per year. **Funding:** Funding for future fiscal years is contingent on annual budget approval by City Council. Anticipated source would be the general fund.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
OPT-4	Target Area(s)Collaboration with County of Riverside Transportation Dept.	Open Space/Stream Restoration	Coordinate with Riverside County Transportation during review of an encroachment permit to support an integrated mitigation project.	Wet	X	X	X	X	X	X	X			Once triggered. Overall implementation timeline dependent on project schedule as determined by County of Riverside Transportation	**Triggers:** This strategy will be implemented if the following trigger is met: 1) Riverside County Transportation submits project application for encroachment permit to the City of Menifee. **Approach:** Riverside County Transportation is planning an integrated mitigation project which would result in the creation of over 1,500 linear feet of new intermittent channel and seasonal wetlands. The 75-acre site is located south of Scott Road and west of Briggs road in the County of Riverside. The project will preserve, restore and enhance the existing un-named creek (which is tributary to Warm Springs Creek), ephemeral drainages, and associated wetland habitats. The area is immediately outside of the City jurisdiction; however, the project will require infrastructure in the City of Menifee. Because of that, the City will work closely with Riverside County Transportation to facilitate the approval of an encroachment permit. **Funding:** Project funding to be secured by County of Riverside. Per County, the project is partially funded with CFD funds, with the remainder yet to be determined.

Table 4-7. Jurisdictional Strategies Selected to Address Eutrophication Impacts in the Middle SMR Subwatershed – City of Murrieta

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy		HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
				Dry Weather/ Wet Weather/ Both	Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Illicit Discharge, Detection, and Elimination (IDDE) Program (Prov E.2)															
IDDE-1	Entire Jurisdiction	Residential, commercial, nurseries, industrial, parks and recreation, open space	Enhanced municipal training programs and curriculum targeting key field staff. Programs will focus on the water quality improvement plan, HPWQC, NNE requirements as related to illicit discharges and elimination of dry weather flows.	Dry Weather	X	X		X	X	X	X		X	Upon WQIP acceptance, FY 18-19	Public Works, CSD field staff and Code Enforcement will be provided enhanced municipal training. This training would also include training on the system used to record/track illicit discharges. GIS map to be developed and updated with illicit discharges database.
IDDE-3	Entire Jurisdiction	Residential, commercial, nurseries, industrial, parks and recreation, open space	Plot IDDE incidents in GIS to identify clusters where community outreach and workshops would be effective in eliminating dry weather flows.	Dry Weather	X	X		X	X	X	X		X	Upon WQIP acceptance, FY 19-20	Coordinate with GIS to create a layer that show IC/ID incidents based on information from reporting/tracking system.
Development Planning (Prov E.3)															
DEV-1	Entire Jurisdiction	Residential, commercial	Smart irrigation conditions of approval	Dry Weather	X	X		X		X	X	X	X	Ongoing	Condition PDPs to demonstrate that the irrigation controller and heads are set so irrigation runoff does not enter the street or MS4s.
DEV-2	Entire Jurisdiction	Residential, commercial	BMP Design Manual Training	Wet Weather	X	X		X		X	X		X	Upon WQIP acceptance, FY 17-18	Provide BMP Design Manual training to all applicable staff.
Construction Management (Prov E.4)															
CON-1	Entire Jurisdiction	Residential, commercial	Provide internal staff training related to construction storm water management	Dry and Wet Weather	X	X		X		X	X		X	Upon WQIP acceptance, FY 17-18	Internal staff to attend construction storm water management trainings.
Existing Development Management (Prov E.5)															
ED-6	Entire Jurisdiction	Residential, commercial, nurseries, industrial, parks and recreation, open space	Enhanced municipal training programs and curriculum targeting inspections staff. Programs will focus on the water quality improvement plan, HPWQC, NNE requirements as related to the inspections programs and specific nutrient issues.	Dry Weather	X	X		X	X	X	X		X	Upon WQIP acceptance, FY 18-19	Inspections staff will be provided enhanced municipal training. This training would also include training on the system used to record/track illicit discharges. GIS map to be developed and updated with illicit discharges database.
ED-3	Focus Areas Only	Commercial, industrial, parks and recreation, open space	Enhance commercial / industrial / municipal inspections programs to focus on irrigation systems.	Dry Weather	X	X		X		X	X			Upon WQIP acceptance, FY 20-21	Identify target areas through field screenings and annual inspections. Increase inspection frequencies as necessary.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
ED-4	Focus Areas Only	Residential	Enhance residential inspections programs to focus on over-irrigation.	Dry Weather	X	X		X		X	X			Upon WQIP acceptance, FY 20-21	Identify target areas through field screenings and annual inspections. Increase inspection frequencies as necessary.
ED-2	Focus Areas Only	Residential, commercial, nurseries	Increase inspection frequencies at facilities identified on Copermittee inventories to be sources of nutrients	Dry Weather	X	X		X	X	X	X			Upon WQIP acceptance, FY 21-22	Identify target areas through field screening and annual inspections. Increase inspection frequencies as necessary. If any sources of nutrients are identified, i.e. nurseries, inspections would be appropriately conducted.
ED-7	Focus Areas Only	Residential, commercial, nurseries	Enhanced enforcement program targeting identified, problematic, sources of nutrients	Dry Weather	X	X		X	X	X	X			Upon WQIP acceptance, FY 21-22	Identify problematic areas through field screening and annual inspections. Increase follow up efforts as necessary.
Enforcement Response Plans (Prov E.6)															
ERP-1	Entire Jurisdiction	Residential, commercial, industrial, nurseries	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.	Dry Weather	X	X		X		X	X	X	X	Ongoing	Escalating enforcement strategies will initially start with a Notice of Violation, written or verbal, a follow up, and if violator is not working towards compliance, the Administrative Citation process will begin increasing fines for non-compliance.
Public Education and Participation (Prov E.7)															
PubEd-2	Focus Areas Only	Residential	Enhanced outreach programs targeting homeowner's associations/residential communities.	Dry Weather	X	X		X	X	X	X			Upon WQIP acceptance, FY 22-23	Identify target areas amongst homeowner's associations/residential communities. Distribute targeted informational brochures/pamphlets.
Optional Jurisdictional															
OPT-1	Focus Areas Only	Residential	Water District Coordination - Coordination with Water Districts to pinpoint problem sources of dry weather flows.	Dry Weather	X	X		X		X	X			Upon WQIP acceptance and if triggered	This optional strategy may be triggered if 1) an interim dry weather goal has not been met; 2) it is determined by the City that this strategy would effectively address dry weather flows; and 3) available grant funding. Implementation of strategy would occur the following fiscal year after obtaining necessary approvals and procurement of funding.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy		HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
				Dry Weather/ Wet Weather/ Both	Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
OPT-2	Focus Areas Only	Residential	Water District Coordination - Coordination with Water Districts on inspection and enforcement efforts.	Dry Weather	X	X		X		X	X			Upon WQIP acceptance and if triggered	This optional strategy may be triggered if 1) an interim dry weather goal has not been met; 2) it is determined by the City that this strategy would effectively address dry weather flows; and 3) available grant funding. Implementation of strategy would occur the following fiscal year after obtaining necessary approvals and procurement of funding.
OPT-3	Entire Jurisdiction	Municipal, parks and recreation	Establish semiannual meetings among Engineering and Community Services District to evaluate opportunities for improving water quality at MS4s, streets, parking lots, parks and other landscaped areas.	Dry and Wet Weather	X	X		X	X	X	X			Upon WQIP acceptance and if triggered	This optional strategy may be triggered if 1) an interim dry weather goal has not been met; and 2) it is determined by the City that this strategy would effectively address dry weather flows. Implementation of strategy would occur 6 months after it has been determined that an interim dry weather goal has not been met.
OPT-4	Entire Jurisdiction	Residential, commercial, nurseries, industrial, parks and recreation, open space	Establish semiannual meetings to discuss potential ordinance changes.	Dry and Wet Weather	X	X	X	X	X	X	X			Upon WQIP acceptance and if triggered	This optional strategy may be triggered if 1) an interim dry weather goal has not been met; and 2) it is determined by the City that this strategy would effectively address dry weather flows. Implementation of strategy would occur 6 months after it has been determined that an interim dry weather goal has not been met.
OPT-5	Entire Jurisdiction	Municipal	Establish semiannual meetings among CIP staff to identify opportunities to rehabilitate channels or habitats.	Wet Weather	X	X	X	X						Upon WQIP acceptance and if triggered	This optional strategy may be triggered if 1) an interim dry weather goal has not been met; and 2) it is determined by the City that this strategy would effectively address dry weather flows. Implementation of strategy would occur 6 months after it has been determined that an interim dry weather goal has not been met.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Optional WMA Strategies															
OPT-6	Entire Jurisdiction	Residential	Partner with Water Districts to implement incentive program.	Dry Weather	X	X	X	X		X	X			Upon WQIP acceptance and if triggered	Optional WMA strategy may be triggered if: 1) an interim dry weather goal is not met; 2) it is determined by the City that this strategy would effectively address dry weather flows; and 3) available grant funding. Implementation of strategy would occur the following fiscal year after obtaining necessary approvals and receipt of grant funding.
OPT-7	Entire Jurisdiction	Residential	Regional inspector to inspect areas watershed-wide for anthropogenic sources of dry weather flows.	Dry Weather	X	X		X		X	X			Upon WQIP acceptance and if triggered	Optional WMA strategy may be triggered if: 1) an interim dry weather goal is not met; 2) it is determined by the City that this strategy would effectively address dry weather flows; and 3) available grant funding. Implementation of strategy would occur the following fiscal year after obtaining necessary approvals and receipt of grant funding.

Table 4-8. Jurisdictional Strategies Selected to Address Eutrophication Impacts in the Middle SMR Subwatershed – City of Temecula

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Illicit Discharge, Detection, and Elimination (IDDE) Program (Prov E.2)															
IDDE-1	City of Temecula - Entire Jurisdiction	Commercial - general, Commercial - nurseries, Industrial, Residential (including OWTS), Municipal, Sanitary Sewer, Parks and recreation, Streets, Orchards/Vineyards and other agriculture discharging to the MS4.	Update ordinances to reflect current illicit discharge and connections requirements and strategies to reduce non-stormwater discharges to the MS4 during dry and wet weather.	Both	X	X	X	X	X	X	X	X	X	Once a Permit Term	This strategy will provide the city legal authority to enforce discharge prohibitions as required in the permit. The City of Temecula will have the resources in place to eliminate illicit discharges and improper disposal into the MS4, or otherwise require the discharger to apply for and obtain a separate NPDES permit. IDDE inspection frequencies will be concurrent with construction, business, existing development and other inspections and as reported by public and City staff.
IDDE-2	City of Temecula - Target Area(s)	Commercial - general, Commercial - nurseries, Industrial, Residential (including OWTS), Municipal, Sanitary Sewer, Parks, Streets, Landfills, Orchards/Vineyards and other agriculture discharging to the MS4.	Post signage adjacent to open channels providing information to report any observed illicit discharges. Signage will focus on sources of non-stormwater discharges such as illegal dumping and over-irrigation.	Both	X	X	X	X	X	X	X			FY 19-20, one time only	This strategy is expected to increase the number of illicit discharge and connections reported. The City of Temecula will have the resources in place to eliminate illicit discharges and improper disposal into the MS4, or otherwise require the discharger to apply for and obtain a separate NPDES permit. Signage will be inspected as part of existing development inspections.
IDDE-3	City of Temecula - Entire Jurisdiction, Receiving water; collaboration with the Police Department, resource agencies, Flood Control, Environmental Community	Homeless encampments are known to be located in areas such as Parks and recreation, Streets, Open Space, and Multiple Species Habitat Conservation Program areas.	Responsible Compassion for the Homeless Program will be implemented to address homeless problems throughout the City, thereby reducing their impacts on water quality through trash, illegal dumping, and direct discharge of human waste.	Both	X	X	X	X	X	X	X	X	X	Continuous	The City of Temecula directs homeless individuals to resources to seek housing which reduces the likelihood that homeless individuals will contribute to the loading of pollutants associated with the HPWQC and PWQCs. These areas are monitored continuously by 4 full time dedicated deputy sheriff assigned to support homeless outreach efforts.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Development Planning (Prov E.3)															
DEV-1	City of Temecula - Entire Jurisdiction	Commercial - general, Commercial - nurseries, Industrial, Residential, Municipal, Parks and Recreation, Streets, Orchards/Vineyards and other agriculture that is permitted through the City.	Modified Low Impact Development requirements for new and redevelopment to specifically address nutrients during dry and wet weather through increased use of disconnected impervious surfaces, on-site retention of dry weather flows, and treatment of stormwater prior to discharge.	Both	X	X	X	X		X	X			FY 18-19	The City of Temecula will review its Low Impact Development requirements for new and redevelopment and modify the requirements to promote attainment of the goals identified within this WQIP as part of its adaptive management program.
DEV-2	City of Temecula - Entire Jurisdiction	Commercial - general, Commercial - nurseries, Industrial, Residential, Municipal, Parks and Recreation, Streets, Orchards/Vineyards and other agriculture that is permitted through the City.	Amend BMP design manuals to address sources of HPWQCs and PWQCs on new and redevelopment projects (e.g., irrigation design standards, LID implementation) and conduct internal staff training on updated BMP design manual	Both	X	X	X	X	X	X	X			FY 19-20	The City of Temecula will review the BMP design manuals and amend the manuals as necessary to promote attainment of the goals identified within this WQIP. Staff will be trained annually to ensure proficiency with the elements of the amended BMP design manuals
Construction Management (Prov E.4)															
CON-1	City of Temecula - Entire Jurisdiction	Active construction sites.	Require implementation of BMPs that reduce the potential of HPWQC and PWQC loading, that are site specific and appropriate to the construction phase, year round.	Both	X	X	X	X	X	X	X	X	X	On-going	Implement as part of the JRMP Construction Management Program; ensure that sources of HPWQC/PWQCs have BMPs implemented year round (e.g., erosion/sediment control, materials storage, trash management).
CON-2	City of Temecula - Entire Jurisdiction, former agricultural lands	Active construction on parcels previously used for agriculture.	Where former agricultural lands are issued grading permits for development/ redevelopment, the sites will be deemed high priority for BMP implementation and inspection in accordance with the City's JRMP.	Both	X			X				X		On-going, As Applicable	Modify grading approval and construction site inspections process to ensure that former agricultural lands are deemed high priority, regardless of other factors (e.g., size, slope, proximity) and inspected accordingly. High priority sites are inspected twice per month from Oct 1 - Apr 30 and at least once in August or September each year.
CON-3	City of Temecula - Entire Jurisdiction	Active and inactive construction sites	Impose legal authority to ensure inventoried construction projects are in compliance with all requirements.	Both	X	X	X	X	X	X	X	X	X	On-going	Enforce stormwater, grading, and erosion control ordinances in accordance with the City's Enforcement Response Plan on all active and inactive construction sites through inspections and follow-up. Frequencies for both active and inactive construction site inspections vary based upon the assessed priority of the site as discussed in the City of Temecula JRMP.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Existing Development Management (Prov E.5)															
ED-1	City of Temecula - Entire Jurisdiction	Commercial, Industrial, Residential, OWTS, Municipal, Sanitary Sewer, Parks, Streets, Landfills	Enhanced municipal training programs and curriculum targeting inspections staff. Programs will focus on specific nutrient related activities that inspectors might encounter in the field such as non-stormwater flows and their sources (e.g., over-irrigation, illegal washing/dumping) and materials storage BMPs (e.g., coverage and containment) within existing development.	Dry	X			X		X				FY18-19	The City of Temecula will develop a curriculum that educates its inspection staff regarding the HPWQC and particular sources and areas of focus so as to reduce the potential loading from properties being inspected. Training will be conducted on an annual basis.
ED-2	City of Temecula - Target Area(s); collaboration with Rancho California Water District	Commercial, Industrial, Residential, Municipal, Parks	Install weather based irrigation controllers in municipal parks and promote incentive programs elsewhere (as available) to address sources of over-watering and irrigation runoff within existing development.	Dry	X	X	X	X		X	X		X	On-going for New Parks	The City of Temecula will install weather based irrigation controllers to reduce the potential for runoff and contact Rancho California Water District to discuss opportunities to provide incentives for their use elsewhere.
ED-3	City of Temecula - Entire Jurisdiction; collaboration with CR&R	Residential, Streets	Weekly street sweeping in residential areas to reduce pollutant buildup (e.g., organic debris, trash, metals) on streets and curb/gutter areas, thereby reducing transport of pollutants to the storm drain system via non-stormwater and stormwater flows.	Both	X	X		X	X	X		X	X	On-going	All residential streets are swept by the City's contractor the day following the trash service day. If trash service is provided on Friday, the streets are swept on Monday. Signs are posted asking residents to please refrain from parking on the residential streets on both trash collection and street sweeping days in order allow the City's contractor to provide efficient trash collection and street sweeping services.
ED-4	City of Temecula - Entire Jurisdiction	Agricultural	Modify City JRMP to include any Agricultural business operation as a high priority business inspection similar to industrial business. Report any Non-filing businesses to the Regional Board.	Both	X	X	X	X	X	X	X		X	Annual	This strategy will be incorporated into the City Business inspection component.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Enforcement Response Plans (Prov E.6)															
ERP-1	City of Temecula - Entire Jurisdiction	Construction Sites, New Development Projects, Redevelopment Projects, Existing Development Sites (Residential, Industrial, Commercial, Nurseries, Parks and Recreation, Orchards, Vineyards, Nurseries, horse ranches/ equestrian, other agriculture draining to the City's MS4)	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.	Both	X	X	X	X	X	X	X	X	X	On-going, As Needed	The City will enforce all applicable ordinances using a progressive enforcement approach as described in the City's Enforcement Response Plan
Public Education and Participation (Prov E.7)															
PUB-1	City of Temecula - Target Area(s)	Residential areas with Homeowners Associations (HOAs).	Enhanced outreach programs targeting homeowners associations to educate homeowners and HOAs about outdoor water usage, the effects of over-irrigation, and specific BMPs they can implement to reduce runoff from over-irrigation.	Both	X	X		X	X	X	X			FY18-19, Annual	The City of Temecula will review the literature and develop an enhanced outreach program for homeowners associations that utilizes the strategies that have been identified as most successful for this target audience on an annual basis.
PUB-2	City of Temecula - Target Area(s)	Commercial - general, Commercial - nurseries, Industrial, Residential, Municipal, Parks and recreation, Streets, Orchards/Vineyards and other agriculture discharging to the MS4.	Enhanced outreach materials focused on sources of nutrients (e.g., door hangers, pamphlets, other media). Outreach materials will focus on non-stormwater discharges to the storm drain system (e.g., septic system maintenance, equestrian facility BMPs, outdoor water usage, the effects of over-irrigation, and specific BMPs they can implement to reduce runoff from over-irrigation).	Dry	X			X		X				FY18-19, Annual	The City of Temecula will review the literature and develop enhanced outreach materials focused on sources of nutrients during dry weather that utilize the strategies that have been identified as most successful for this condition on an annual basis.
PUB-3	City of Temecula - Entire Jurisdiction	Agricultural	Notify agricultural business license holders within City Jurisdiction of requirement to enroll in the Regional Water Board Agricultural Order.	Both	X	X	X	X	X	X	X		X	Annual	This strategy will be incorporated into the City Business inspection component.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Optional Strategies (Prov B.3.b.(1)(b))															
Opt-1	At project site as further detailed within the project description and City of Temecula Capital Improvement Plan.	Municipal, Parks	Implement Parks Improvement Program that will provide landscaping, irrigation, and on-site drainage improvements that will reduce the potential for pollutant discharges (e.g., irrigation runoff, fertilizer) from municipal parks.	Both	X	X		X		X	X			Upon being triggered and all funds and/or resources being secured (approximately two years from determination that trigger has been met); One Time	This project would facilitate rehabilitation and improvement projects at various City parks. The rehabilitation and improvement projects could include, but are not limited to, landscaping and irrigation system efficiency upgrades and on-site drainage improvements to reduce the loading of nutrients and other pollutants contributing to PWQCs associated with irrigation and stormwater runoff. [1][2]
Opt-2	At project site as further detailed within the project description and City of Temecula Capital Improvement Plan; Coordination with Riverside County Flood Control and Water Conservation District	Municipal, Parks	Flood control channel repair and rehabilitation to prevent erosion and the transport of sediment-bound pollutants.	Both	X		X	X						Upon being triggered and all funds and/or resources being secured (approximately two years from determination that trigger has been met); One Time	This project repairs and reinforces the earth and berms between specific park sites and flood control channels and rehabilitates the banks to support vegetation and prevent further erosion into the park sites and the transport of sediment-bound nutrients and other pollutants contributing to PWQCs. [1][2]

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Opt-3	To be determined based on information obtained from the Monitoring and Assessment Program; Coordination with Eastern Municipal	Commercial - general, Commercial - nurseries, Industrial, Residential, Municipal, Parks and recreation, Streets, Orchards/Vineyards and other agriculture discharging to the MS4.	Implement dry weather infiltration, diversion to sanitary sewer, to eliminate non-stormwater discharges to the MS4.	Dry	X	X	X	X	X	X	X			Upon being triggered and all funds and/or resources being secured (approximately two to five years from determination that trigger has been met); One Time	This strategy would address persistent dry weather flow in outfalls due to over-irrigation. Outfalls which are persistently flowing due to over-irrigation and which contribute significantly high nutrient loads would be evaluated for potential dry weather infiltration or diversion to sanitary sewer. [1][3]

[1] Implementation of these strategies may be triggered at the City of Temecula's discretion or if (1) persistent dry weather flows are identified; and (2) an interim goal has not been met; or it is determined that implementation is necessary to meet future goals; and (3) the project would help to reduce nutrient loading to receiving waters under dry or wet conditions; and (4) all necessary resources and permits have been secured for the project. Once triggered, it is estimated that it would take approximately two years to procure resources, proceed with engineering, landscape design, and construction to implement the strategy. Because implementation would be within City parks, environmental permitting would not be necessary.

[2] The funding-sources that must be secured to implement this optional strategy are: capital dollars identified in the approved CIP budget (funded through parks and/or drainage fees); staff time for project management and construction (funded through the general fund and/or development fees); budget for operations and maintenance of constructed BMPs (funded through the drainage fees and/or general fund). Once triggered, it is estimated that it would take approximately two years to procure resources, proceed with engineering/design, secure environmental permits, and proceed with construction necessary to implement the strategy.

[3] Funds and/or resources that must be secured to implement this optional strategy are the following: 1) In-field evaluation of suitable sites for infiltration, diversion to sanitary sewer, or treatment BMPs (funded through drainage fees and/or general fund); 2) Evaluation of feasibility (funded through drainage fees and/or general fund); 3) Engineering design plans (funded through drainage fees and/or general fund); 4) Capital Improvement Program funding secured to support 5 - 7 (through drainage fees or another fee supported funding mechanism); 5) Land acquisition and/or private-public partnership agreements (as necessary); 5) Construction contract bid/award; 6) Project construction; 7) Adequate resources for facility operation and maintenance. Once triggered, it is estimated that it would take two - five years to procure resources, proceed with engineering and design work, secure necessary environmental permits, and proceed with construction. Timing will depend on location, scope of the project, and environmental impacts.

The City of Temecula has included a summary of its land uses in chapter 3 table 3-1. Please note the City does not have any land uses zoned for agricultural. However agricultural operations are allowed on all residentially zoned land uses. All commercially operated agricultural operations within the city require a business license and the city uniquely identifies these in its business license inventory. There are currently no commercially operated vineyards or orchards within City limits. "Temecula Wine Country" is located outside Temecula City Limits.

Table 4-9. Jurisdictional Strategies Selected to Address Eutrophication Impacts in the Middle SMR Subwatershed – City of Wildomar

(Background: The City of Wildomar covers an area of approximately 24 square miles. The City is primarily located within the Santa Margarita River Watershed. About 33% of the City extends into the Santa Ana River Watershed. Low Density and Medium Density residential land uses predominantly characterize the City of Wildomar's current landscape. Many of the roads within the City are unimproved (i.e. dirt roads), partially improved (i.e. developed on one side), or are paved but do not have curb or gutter. More recently developed areas within the City do have full street improvements and drainage conveyance systems. As of 2015, the City's population was estimated to be 45% of the total expected population.).

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy		HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
				Dry Weather/ Wet Weather/ Both	Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2017	FY2018	Future Fiscal Years	
Illicit Discharge, Detection, and Elimination (IDDE) Program (Prov E.2)															
IDDE-1	City of Wildomar: - Entire Jurisdiction	Residential Commercial Industrial Parks and Recreation Horse Ranches/Equestrian Nurseries Other Agricultural	Assess IDDE incidents to identify clusters, if any, where targeted efforts may be effective in eliminating dry weather flows.	Dry	X	X	X	X	X	X			X	Continuous	Assess clusters to determine if there are target areas which require special attention, education, enforcement, or any additional/specific resources or targeted follow-up.
IDDE-2	City of Wildomar: - Entire Jurisdiction	Residential Commercial Industrial Parks and Recreation Horse Ranches/Equestrian Nurseries Other Agricultural	Update ordinances to reflect current illicit discharge and connections requirements and strategies.	Dry	X	X	X	X	X	X			X	Each Permit Term	
IDDE-3	City of Wildomar: - Entire Jurisdiction	Residential Commercial Industrial Parks and Recreation Horse Ranches/Equestrian Nurseries Other Agricultural	Utilize service request forms to improve internal and external reporting of IDDE incidents, to help staff more efficiently identify, report, and respond to IDDE incidents.	Dry	X	X	X	X	X	X			X	Continuous	
Development Planning (Prov E.3)															
DEV-1	City of Wildomar: - Entire Jurisdiction	Residential Commercial	Smart Irrigation Conditions of Approval	Dry	X	X	X	X	X	X		X	X	Ongoing	City Council has adopted the WATER EFFICIENT/CONSERVATION LANDSCAPE STANDARDS MANUAL. Items required in the manual are verified during development plan review and during inspections for projects which require landscape plans.
DEV-2	City of Wildomar: - Entire Jurisdiction	Residential Commercial	Revised post-construction guidelines to eliminate potential dry weather discharges from new and redevelopment	Dry	X	X	X	X	X	X	X		X	Continuous	Update plan review guidelines to require that, where feasible, areas of a site which may contribute to potential dry weather discharges are captured and directed to a treatment BMP to eliminate dry weather flows and potential nutrient loading (and other pollutants) from being transmitted downstream. Condition new projects accordingly and incorporate guidelines into Development Plan Check Guidelines.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy		HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
				Dry Weather/ Wet Weather/ Both	Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2017	FY2018	Future Fiscal Years	
DEV-3	City of Wildomar: - Entire Jurisdiction	Residential Commercial Industrial	Amend BMP design manuals to address priority sources and conduct internal staff training on updated BMP design manual	Both	X	X	X			X			X	Each Permit Term	Complete update through cooperation with other SMR Copermittees.
DEV-4	City of Wildomar: - Entire Jurisdiction	Commercial Residential	Require new development projects to develop and submit a Storm Water Quality Training Materials for employees. Require new development projects with CC&Rs to address stormwater pollution prevention practices.	Dry	X	X	X	X	X	X		X	X	Ongoing	Condition commercial development projects to require the development of Storm Water Quality Training Materials for employees to ensure that employees of new businesses are educated regarding stormwater pollution prevention and thereby reduce the potential for non-stormwater discharges. For all development projects requiring CC&Rs, require that the CC&Rs address stormwater pollution prevention requirements and practices. Require documentation (e.g. Employee Training Materials, CC&Rs, etc...) as applicable to each project to be submitted for review and for file, recordation, etc... prior to certificate of occupancy. Comment on documentation, as necessary, to ensure that the materials adequately target the applicable post-development activities. Education may target different sources by helping to reduce or eliminate unpermitted non-stormwater management discharges and the potential for nutrients and other pollutants to be transported through non-stormwater discharges.
DEV-5	City of Wildomar: - Entire Jurisdiction	Construction	Require Delineation of Jurisdictional Areas on Development Plans and Require Enhanced Sediment Control BMPs to be Shown Adjacent to Jurisdictional Areas on Development Plans	Both	X		X		X			X	X	Ongoing	Require all development projects to delineate and label jurisdictional areas on or immediately adjacent to the project site on grading or improvement plans and to add a note to the plans requiring delineation of jurisdictional areas on the project site in the field. Also require the plans to identify enhanced Sediment Control BMPs in locations adjacent to jurisdictional areas. Delineation of jurisdictional areas is intended to help reduce unintended construction impacts within these areas and protect and preserve physical habitats, reduce the amount of construction debris that may be deposited in these areas, and by reducing the potential for soil disturbance reduce the potential for nutrients to be transported downstream by sediment. Additional sediment controls adjacent to jurisdictional areas is also intended to limit the potential for nutrients to be transported downstream by sediment.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy		HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
				Dry Weather/ Wet Weather/ Both	Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2017	FY2018	Future Fiscal Years	
DEV-6	City of Wildomar: - Entire Jurisdiction	Streets Residential	Provide Street Sweeping Services for New Streets	Both	X	X	X	X	X	X		X	X	Ongoing	Require all new private development projects to annex into the Community Facilities District (CFD). CFD services will typically include street sweeping for newly developed streets (where applicable) that will be publicly maintained. Street sweeping can help eliminate sediment and other pollutants which may be transported downstream and which may transport nutrients downstream.
Construction Management (Prov E.4)															
CON-1	City of Wildomar: - Entire Jurisdiction	Construction Nurseries Other Agriculture	Implement, or require the implementation of, enhanced construction BMPs on specific projects.	Both	X	X	X	X	X	X			X	Continuous	Implement, or require the implementation of, enhanced construction BMPs on projects with applicable permit activities that have an historical land use normally associated with higher levels of nutrients than other land uses (e.g. project sites with an historical agricultural land use, project sites with known septic systems currently or previously installed onsite, etc...) to reduce the potential for nutrient rich soils to discharge from the project site during construction either by non-stormwater or stormwater related discharges.
CON-2	City of Wildomar: - Entire Jurisdiction	Construction	Provide enhanced focus on specific items during construction inspections.	Both	X	X	X		X				X	Per JRMP	Provide enhanced focus on landscape material storage BMPs during NPDES construction inspections to reduce the potential for materials with nutrients to leave the project site, either by non-stormwater or stormwater related discharges.
CON-3	City of Wildomar: - Entire Jurisdiction	Construction	Require Delineation of Jurisdictional Areas on Project Sites and Require Enhanced Sediment Control BMPs Adjacent to Jurisdictional Areas	Both	X		X		X			X	X	Ongoing	Require all development projects to have all onsite jurisdictional areas delineated prior to or by the pre-grading meeting. Require the continued delineation of such areas throughout the duration of construction, as applicable to each project. Ensure that jurisdictional areas are clearly identified in the field at pre-grading meetings and during grading inspections. Require development projects to implement enhanced Sediment Control BMPs in locations that are adjacent to jurisdictional areas. Delineation of jurisdictional areas is intended to help reduce unintended construction impacts within these areas and protect and preserve physical habitats, reduce the amount of construction debris that may be deposited in these areas, and by reducing the potential for soil disturbance reduce the potential for nutrients to be transported downstream by sediment. Additional sediment controls adjacent to jurisdictional areas is also intended to limit the potential for nutrients to be transported downstream by sediment.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2017	FY2018	Future Fiscal Years	
Existing Development Management (Prov E.5)															
ED-1	City of Wildomar: - Entire Jurisdiction	Municipal (Parks, Cemetery, Fire Station) Streets Illicit Discharges	Enhanced municipal training programs and curriculum targeting key field staff. Programs will focus on the water quality improvement plan, HPWQCs, NNE requirements as related to illicit discharges and elimination of dry weather flows.	Dry	X	X	X	X	X	X			X	Per JRMP	Complete training through cooperation with SMR Copermittees. Conduct additional internal training as necessary.
ED-2	City of Wildomar: - Entire Jurisdiction	Illicit Discharges from Over Irrigation	Install weather based irrigation controllers in public landscaped areas.	Dry	X	X	X	X	X	X		X	X	Ongoing	Public landscaped areas maintained by City maintenance districts have weather based controllers installed which help reduce the potential for over-irrigation and irrigation runoff.
ED-3	City of Wildomar: - Entire Jurisdiction	Illicit Discharges from Failing Septic Systems	Address failed septic systems that are discharging effluent to the ground surface.	Both	X	X	X			X	X	X	X	Ongoing	Coordinate with property owners through various City Departments and potentially coordinate with other agencies to eliminate unpermitted surface discharges from septic systems and to the extent possible, encourage property owners to repair/replace the failing septic system(s).
ED-4	City of Wildomar: - Entire Jurisdiction	Other Agricultural	Report potential Agricultural Permit Non-Filers to the Regional Board.	Both	X	X	X			X			X	Continuous	When the City is made aware of an agricultural operation that appears to require coverage under the Regional Board's Agricultural Order, notify the Regional Board.
ED-5	City of Wildomar: - Entire Jurisdiction	Residential Commercial Industrial Parks and Recreation Streets	Clean out catch basins.	Both	X	X	X	X	X	X		X	X	Continuous	Perform scheduled clean-out activities of publicly maintained catch basins to eliminate accumulated sediment, debris, and trash. Catch basin clean-out activities can help eliminate pollutants which may be transported downstream and which may transport nutrients downstream.
Enforcement Response Plans (Prov E.6)															
ERP-1	City of Wildomar: - Entire Jurisdiction	Residential Commercial	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan.	Dry	X	X	X	X	X	X		X	X	Ongoing	Implement the ERP as described in the JRMP.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2017	FY2018	Future Fiscal Years	
Public Education and Participation (Prov E.7)															
PubEd-1	City of Wildomar: - Entire Jurisdiction	Nurseries	Enhanced outreach programs targeting nurseries	Both	X	X	X	X	X	X			X	Annually	Identify nurseries (a potential source of nutrients) located within City limits using City's Business Registration Database. Mail Targeted Public Education Materials to registered nurseries to help reduce the potential for pollutants (including nutrients) to be present in stormwater discharges. Complete Commercial Inspections for registered nurseries. Repeat process annually prior to each rainy season.
PubEd-2	City of Wildomar: - Entire Jurisdiction	Horse Ranches/Equestrian Residential	Enhanced outreach programs targeting animal facilities	Both	X	X	X	X	X	X			X	Continuous	Provide focused educational materials to property owners with livestock/equestrian operations regarding Best Management Practices to reduce the potential for non-stormwater discharges and to reduce the potential for pollutants (including nutrients) to be present in stormwater discharges.
PubEd-3	City of Wildomar: - Entire Jurisdiction	Commercial Residential Industrial Nurseries	Public Education for businesses and residents.	Both	X	X	X	X	X	X			X	Continuous	Provide targeted educational materials for businesses as identified in JRMP. Provide targeted stormwater pollution prevention information to all City based businesses, even if not required in JRMP (e.g. over-irrigation handouts to home-based businesses, septic system maintenance handouts to home-based business with septic systems, landscape maintenance handouts to home-based businesses, etc...) to reduce the potential for non-stormwater discharges which may contain nutrients and to reduce the potential for pollutants (including nutrients) to be present in stormwater discharges. Potentially provide contact information handout to business registration applicants which may include contact information for waste haulers, water districts, City, etc...) as well as general stormwater pollution prevention information. (NOTE: This item may require additional coordination and resources before it is determined that it can be implemented.) Place stormwater pollution prevention educational materials at City Front Counter for residents/developers/contractors/businesses. Include Storm Water related message in applicable Email Signatures.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2017	FY2018	Future Fiscal Years	
Optional Strategies															
OPT-1	City of Wildomar: - Target Areas identified Through Cooperation with the Water Districts	Residential Commercial	Coordination with Water Districts to pinpoint and address problem sources of dry weather flows; potential implementation actions could include rebate/incentive programs, irrigation retrofits, or other programs as appropriate and effective.	Dry	X	X	X	X	X	X				As Triggered: Within six (6) months of trigger, establish coordination meeting with Water Districts to proceed with strategy.	Implemented starting in the following fiscal year after triggered. Implementation of this strategy may be triggered if (1) persistent dry weather flows are identified; and (2) an interim dry weather goal has not been met; or it is determined that implementation is necessary to meet future goals; and (3) it is determined that coordination with a water district would be an effective strategy to address the source(s) of the identified dry weather flow. Grant Funding for either the City or the Water District(s) would likely need to be secured for incentive programs.
OPT-2	City of Wildomar: - SMR Region	Open Space Residential Commercial Industrial Parks and Recreation Horse Ranches/Equestrian Nurseries Other Agricultural	Consider and Prioritize, where possible, Multi-Benefit Master Drainage Plan Projects that have both Flood Control and Channel or Habitat Rehabilitation Benefits	Both	X		X		X					As Triggered: Within six (6) months of trigger, establish internal coordination meeting with Public Works Staff to discuss re-prioritization process for Master Drainage Plan Projects.	Implemented starting in the following fiscal year after triggered. Implementation of this strategy may be triggered if (1) persistent dry weather flows are identified; and (2) an interim dry weather goal has not been met; or it is determined that implementation is necessary to meet future goals; and (3) it is determined that prioritizing such multi-benefit projects would be an effective strategy to address the High Priority Water Quality Condition. If determined to be an effective strategy, funding for planning of such projects would be contingent on Area Drainage Plan Funding, Master Drainage Plan Funding, and any additional funds needed in excess of these two sources.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2017	FY2018	Future Fiscal Years	
OPT-3	City of Wildomar: - Entire Jurisdiction	Streets	Enhancements and/or adjustments to street sweeping practices, frequencies, and routes, as determined by jurisdiction.	Both	X	X	X	X	X	X				As Triggered: Within six (6) months of trigger, establish coordination meeting to discuss enhancement and adjustment of street sweeping and procedure to move forward.	Enhance existing street sweeping by assessing deficiencies on existing routes and making applicable modifications. Work with waste haulers to increase street sweeping to include City Arterial Streets and to provide litter pass services in areas with known trash accumulation to reduce pollutants which may be transported downstream by non-stormwater or stormwater discharges. Implemented starting in the following fiscal year after triggered. Implementation of this strategy may be triggered if (1) persistent dry weather flows are identified; and (2) an interim dry weather goal has not been met; or it is determined that implementation is necessary to meet future goals; and (3) it is determined that enhancements or adjustments to street sweeping would be an effective strategy to address the High Priority Water Quality Condition; and (4) implementation of this strategy is supported by cooperation with City waste haulers and legislative approval. Funding for enhancements and adjustments to street sweeping may involve increased waste hauling fees and City Council approval. Other enhancements may involve funding from the General Fund.
Optional WMAA Strategies															
The City of Wildomar will implement Optional WMA Strategies through cooperative agreements with the Santa Margarita River Copermittees. The Optional WMA Strategies that will be implemented are identified in the Riverside County Flood Control and Water Conservation District (RCFCWCD) WQIP Strategy Table. Please refer to the RCFCWCD WQIP "Optional WMA Strategies and Schedules" in Table 4-11 (Section 4.2) of the WQIP for details.															

Definitions:

Ongoing	- A strategy that the City currently implements (entirely or to some extent) and will continue to implement throughout WQIP implementation. Implementation will occur as triggered and is not limited to a specific frequency. See Specific Strategy Descriptions for events triggering implementation of this type of strategy.
Continuous	- A strategy that the City will begin implementing upon WQIP acceptance and will continue to implement throughout WQIP implementation. Strategy implementation will occur as required or triggered and is not limited to a specific frequency. See Specific Strategy Descriptions for events triggering implementation of this type of strategy.
Per JRMP	- A strategy that will be implemented based on a schedule or frequency that is identified in the City's Jurisdictional Runoff Management Plan.
Each Permit Term	- A strategy that will be implemented once per permit term, at a minimum.
Annually	- A strategy that will be implemented once per year, at a minimum.

Table 4-10. Jurisdictional Strategies Selected to Address Eutrophication Impacts in the Middle SMR Subwatershed – Riverside County

(Note: The following is the County of Riverside's WQIP strategies table. Specific focus is given to Nutrient source Target Areas (i.e. Agriculture (nurseries, equestrian and other livestock operations) and Residential Uses), then source areas of the other Priority Water Quality Pollutants. As part of the iterative adaptive management process, these strategies will be reviewed as part of the WQIP annual reporting analysis. If interim goals are not met, the strategies may change. Implementation of new strategies would be subject to funding, consistency with the General Plan and/or other regulatory requirements, and securing the necessary resources (e.g., staffing, partnerships, etc.).

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
Illicit Discharge, Detection, and Elimination (IDDE) Program (Prov E.2)												
1	County of Riverside	Illicit Discharge and Illegal Connections County-wide	Utilize municipal personnel and contractors to identify and report Illicit Connections and Discharges (with emphasis on over-irrigation).	✓	✓	✓	✓	✓	✓	✓	Continuous*	Utilize MS4 GIS mapping to focus these efforts for Nutrient Loading Land Uses including Residential and Agricultural as well as providing focused training to field staff/contractors. Identify areas through GIS analysis that need particular attention such as increased surveying and public education.
2	County of Riverside	Illicit Discharge and Illegal Connections County-wide	Develop a reporting mechanism for incidental observations of IC/ID by County staff field personnel.	✓	✓	✓	✓	✓	✓	✓	Continuous	Provide County field staff with IC/ID field forms with emphasis in locating sources of dry weather flows from Residential and Agricultural land uses. These forms are to be submitted to the County NPDES Administrator to initiate investigations, tracking and resolution. Follow up training will provide updates on the success of this Program and help identify additional strategies that could be incorporated.
3	County of Riverside	Illicit Discharge and Illegal Connections County-wide	Develop a procedure to map IC/ID cases in GIS to assist in ongoing identification of IC/ID target areas.	✓	✓	✓	✓	✓	✓	✓	Upon WQIP Approval	Field forms, as described above, shall be submitted to Transportation GIS to map specific IC/ID locations involving PWQP's, with emphasis on Nutrient sources. Scheduling inspections of IC/ID observations in Nutrient Loading Land Use Sources will be given priority.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
4	County of Riverside	Illicit Discharge and Illegal Connections County-wide	Conduct IC/ID - IDDE focused training for County Department field staff.	✓	✓	✓	✓	✓	✓	✓	Annually	Can be expedited through a "Train the Trainer Program" to disseminate training to County employees who work in the field. Emphasis will be given to identification and resolution of Nutrient and other PWQP land use sources and activities that are known to cause erosion and dry weather flows (such as agricultural activities).
5	County of Riverside	Illicit Discharge from Septic System Failures	Respond, educate and require mitigation on septic system failures where observed. Coordinate investigations with Environmental Health (County Regulatory Agency for Septic Systems). Focus on elimination of nutrient loading from phosphorus sources and bacteria loading to MS4 from septic failure. Educate property owners on proper septic maintenance and the importance of eliminating discharges to the MS4.	✓	✓	✓	✓	✓	✓	✓	Continuous	
6	County of Riverside	Illicit Discharge Detection and Elimination	Implement practices and procedures to address accidental spills (with emphasis on identifying Nutrient and other PWQP sources) with the potential to enter the storm drain system. Implement employee spill notification/reporting focused training County-wide.	✓	✓	✓	✓		✓	✓	Continuous	Can be expedited through a "Train the Trainer Program" to disseminate training to County field staff. Training shall focus on importance on identifying and resolving the sources of Nutrient and other PWQP loading to our Receiving Waters.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
New Development and Redevelopment Planning (Prov E.3)												
1	County of Riverside	New and Redevelopment of all Land Uses	Update BMP Design Manual procedures to specify storm water requirements applicable to development and redevelopment projects, identify and design appropriate BMPs, establish maintenance criteria, and establish alternative compliance options. Specific consideration to BMP implementation will be given to reducing/eliminating Nutrient and other PWQP loading to the MS4 and receiving waters.	✓	✓	✓	✓	✓		✓	Each Permit Term or as deemed necessary	
2	County of Riverside	New and Redevelopment of all Land Uses	Conduct training on the updated BMP Manual.	✓	✓	✓	✓	✓		✓	Continuous. Continue to require Annual Training to appropriate staff identified in the JRMP.	Training shall incorporate BMP implementation emphasis for Residential and Agricultural land uses to reduce/eliminate erosion and Nutrient and other PWQP loading to MS4 and receiving waters.
3	County of Riverside	New and Redevelopment of all Land Uses	Prepare drought tolerant Guidelines and Standards for new development and BMP retrofits (e.g. water smart irrigation controllers, turf replacements programs, residential landscape evaluation program).	✓	✓	✓	✓		✓	✓	Continuous or as deemed necessary	Landscape Ordinance and Educational Brochures provide guidelines that describe the importance of eliminating over irrigation, specifically for Residential and Agricultural land uses. Additional new guidelines will be developed to describe why these land uses are of particular concern (i.e., Nutrient and other PWQP loading to MS4 and receiving waters).
4	County of Riverside	County Capital Improvement Projects	Develop a NPDES DATA FORM for Design Teams to identify project-related NPDES data to facilitate: identification of HPWQC and PWQP sources, analyze HPWQC and PWQP source reduction in CEQA/NEPA document, and design of post-construction BMPs to address HPWQC and PWQPs loading reduction and hydromodification.	✓	✓	✓	✓	✓		✓	Upon WQIP Approval	Update form template as needed. Form shall provide footnote describing types of land uses (e.g., Residential and Agricultural) and activities (i.e., on-going grading, tilling, excavation, fertilizer use, etc.) that require particular attention to post-construction BMP implementation.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
5	County of Riverside	New and Redevelopment of all Land Uses	Update County codes, ordinances, and landscape design standards consistent with the permit, including but not limited to prohibition of over irrigation; and the updated BMP Manual.	✓	✓	✓	✓	✓	✓	✓	Upon WQIP Approval	Implement upon obtaining internal and Board of Supervisors' approvals.
Construction Management (Prov E.4)												
1	County of Riverside	Construction Erosion and Sediment Controls; and Waste Management	Require implementation of enhanced BMPs that reduce the potential of HPWQC and PWQP loading, and that are specific to the grading phase, year round.	✓	✓	✓	✓	✓		✓	Continuous	Could potentially be achieved through liquidated damages provisions in Capital Improvement Projects construction contracts
2	County of Riverside	Construction Erosion and Sediment Controls; and Waste Management	Make updates to County ordinances related to construction; reference to existing grading ordinance and requirement to implement enhanced BMPs to mitigate erosion and dry weather flows to MS4 and receiving waters in the SMR.	✓	✓	✓	✓	✓	✓	✓	As deemed necessary	
3	County of Riverside	Construction Erosion and Sediment Controls; and Waste Management	Ensure grading activities are classified as HIGH priority if land is surrounded by or was previously used for agricultural operations.	✓	✓	✓	✓	✓	✓	✓	Upon WQIP Approval, then Continuous	This Strategy is to prevent discharge of sediment with high levels of Nutrients and other PWQP's.
Existing Development (Prov E.5)												
1	County of Riverside	Existing and New Businesses	Enhance the Business Registration Program by educating owners on Nutrient and other PWQP source reduction.	✓	✓	✓	✓	✓	✓	✓	Continuous	Handout appropriate educational brochures to business owners.
2	County of Riverside	MS4 Sources	Implement a prioritized schedule of operation and maintenance activities for the storm water conveyance system draining Nutrient and PWQP source land uses (e.g. Residential and Agricultural).	✓	✓	✓	✓	✓	✓	✓	Continuous	

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
3	County of Riverside	Commercial, Industrial Residential, Agricultural and Municipal Land Uses	Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, agricultural (e.g., large commercial nurseries), residential, and municipal properties. Includes education, verifying permits and certifications.		✓	✓		✓		✓	Continuous	
4	County of Riverside	Commercial, Industrial Residential, Agricultural and Municipal Land Uses	Conduct inspections of inventoried existing development (including residential and agricultural land uses) to ensure BMPs are being implemented to reduce the potential of HPWQC and PWQP loading.	✓	✓	✓	✓		✓	✓	Continuous	
Enforcement (Prov E.6)												
1	County of Riverside	Existing Development	Enforce escalating legal authority established for all inventoried existing development, including residential and agricultural, to conserve water and eliminate dry weather flows. Verbal warnings shall be tracked along with written escalating enforcement.	✓	✓	✓	✓	✓	✓	✓	Continuous	
2	County of Riverside	New and Redevelopment of all Land Uses	Impose legal authority to ensure all development and redevelopment projects (with emphasis on residential, park and agricultural projects) are in compliance with all post construction requirements specifically as they pertain to erosion and dry weather flow prohibitions.	✓	✓	✓	✓	✓	✓	✓	Continuous	
3	County of Riverside	Illicit Discharge Detection and Elimination	Implement escalating enforcement responses to compel compliance with statutes, ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, and existing development in the Enforcement Response Plan. Escalating enforcement strategies will initially start with education and verbal warnings and escalate to cease and	✓	✓	✓	✓	✓	✓	✓	Upon WQIP approval	Evaluate current escalating enforcement strategies and refine to specifically address the elimination of nutrient discharges and priority water quality pollutants (i.e., bacteria, metals, sediment and trash).

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
			desist orders to taking legal actions as necessary. All enforcement actions shall be tracked in a database.									
4	County of Riverside	Unpermitted Agricultural Operations	Report suspected agriculture operation "non-filers" to the Regional Board promptly. Maintain database of reported "non-filers".	✓	✓	✓	✓	✓	✓	✓	Continuous	Observations by field staff should report incidents to Code Enforcement for tracking purposes and the County NPDES Administrator for reporting to the Regional Board.
Public Education (Prov E.7)												
1	County of Riverside	Municipal Parks	Implement pet waste management outreach in County Parks for resident pet owners.	✓	✓		✓	✓		✓	Continuous	
2	County of Riverside	Residential/ Commercial/ Municipal	Implement a public education and participation program to promote and encourage development of programs, management practices and behaviors that reduce the discharge of HPWQC and other PWQPs (specifically for Residential and Agricultural land uses).	✓	✓	✓	✓	✓	✓	✓	Continuous	Coordinate efforts with RCFC&WCD, County Departments and partnering agencies such as Water and School Districts.
3	County of Riverside	Residential/ Commercial/ Municipal	Stock public County counters at Riverside County offices with Pollution Prevention Public Education brochures. Brochures should highlight the importance of proper fertilizer use/application and over irrigation. Other brochures should include emphasis on proper septic maintenance and other good practices to prevent nutrient and other PWQP loading to the MS4 and receiving waters, Provide brochures to other agencies for their public counters as well (e.g., School Administration Buildings).	✓	✓	✓	✓	✓	✓	✓	Continuous	

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
4	County of Riverside	Residential/ Commercial/ Municipal	Facilitate public reporting, through outreach and public education, of Illicit Connections and Illicit Discharges, including over-irrigation.	✓	✓	✓	✓	✓	✓	✓	Continuous	Evaluate current reporting mechanisms including social media, hotlines, and websites with this strategy. Implement additional outreach efforts in Target Areas if current Jurisdictional Strategies under perform. Measure effectiveness through Outfall discharge monitoring results. Coordinate public education outreach efforts with the Riverside County Flood Control and Water Conservation District (RCFC&WCD) Public Education Unit for support. Funding is provided through the Implementation Agreement between the County and RCFC&WCD. Implementation schedule will coincide with RCFC& WCD outreach efforts for the current fiscal year.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
Optional Jurisdictional Strategies												
												Triggers:
1	Warm Springs Creek/ County of Riverside	Rural Residential/Agricultural Land Uses	Construct and manage the Integrated Mitigated Project This project will result in the creation of over 1,500 linear feet of new intermittent channel and seasonal wetlands. The 75-acre site is located south of Scott Road and west of Briggs road in the County of Riverside. The project will preserve, restore and enhance the existing un-named creek (which is tributary to Warm Springs Creek), ephemeral drainages, and associated wetland habitats. This project provided the required 2.3 acres mitigation for 3 capital projects, but is planned to have approximately 71.6 acres of surplus mitigation in the form of Habitat Enhancement, Created Habitat, Preserved Habitat or Restored Habitat for this un-named creek. In total the project is planned to install approximately 2,800 plants, including Oak trees, Sycamore riparian, Southern Willow Scrub, existing channel, and wetland species. Storm water run-on containing Nutrients and other PWQPs would be treated through infiltration and biofiltration.	✓	✓	✓	✓	✓		✓	Construction to begin in FY18/19 if all funding is secured	Construction contingent on: (1) Completing utility installation (currently in progress) (2) when all of the necessary financial resources have been secured. This strategies is placed as optional mostly due to funding. The project is partially funded with CFD funds, with the remainder is yet to be determined. The overall project budget is approximately $2M. At the time of the B.3 submittal, the plan is to bid the project by 2018. If the jurisdictional strategies fail, the excess mitigation may be used in an overall strategy to add to meet targets and goals.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
2	County of Riverside	Residential/ Commercial	Promote Incentive Partnership Programs: Live Turf Replacement & Outdoor Water Efficiency. Promote Incentive Programs with Water Agencies for BMP Retrofits.	✓	✓	✓	✓		✓	✓	See Implementation Notes	Triggers: Implementation of this strategy will be triggered if (1) failure to meet any goal pathways and (2) it has been determined by the County of Riverside through adaptive management that implementation is necessary; (3) it is determined that there would be an adequate demand for such a program with surveys or other methods; (4) other optional strategies are not be implemented or being assessed; and (5) all of the necessary resources have been secured.
3	County of Riverside and other Copermittees	Septic Systems	Implement a Partnering Rebate Program for septic system maintenance, with a focus in Target Areas.	✓	✓	✓	✓		✓	✓	See Implementation Notes	Triggers: Implementation of this strategy will be triggered if (1) failure to meet any goal pathways and (2) it has been determined by the County of Riverside through adaptive management that implementation is necessary; (3) other optional strategies are not be implemented or being assessed; and (4) all of the necessary resources have been secured. Gas tax can be used for work in the road right of way for public regulatory compliance. However, other funding (not general funds) will need to be secured specifically for this strategy. At this time no funding source currently exist, and enforcement procedures are used to address failing septic systems.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
4	County of Riverside	Sewer Infrastructure	Implement a Partnering Program with Sewering Agencies (note: County of Riverside does not provide sewer system services) to identify where sewer and storm water infrastructure are in close proximity and subsequently, confirm the absence of flow at nearby major outfall during dry weather for high risk areas.	✓	✓		✓		✓	✓		Triggers: Implementation of this strategy will be triggered if (1) failure to meet any goal pathways and (2) it has been determined by the County of Riverside through adaptive management that implementation is necessary; (3) obtain full cooperation and continued coordination from the applicable sewering agency; (4) other optional strategies are not be implemented or being assessed; and (5) all of the necessary resources have been secured.
5	County of Riverside	Onsite Wastewater Treatment System/ Sanitary Sewer Overflow	Implement a program for on-site wastewater treatment (septic) systems. May include mapping and risk assessment, inspection, or maintenance practices.	✓	✓				✓	✓	See Implementation Notes	Triggers: Implementation of this strategy will be triggered if (1) failure to meet any goal pathways and (2) it has been determined by the County of Riverside through adaptive management that implementation is necessary; and (3) septic systems have been determined to be a pollutant sources to the MS4; (4) other optional strategies are not be implemented or being assessed; and (5) all of the necessary resources have been secured, including obtaining non-Gas Tax or General Fund revenue sources.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
6	County of Riverside	Existing Development	Provide outreach presentations to elementary, middle, and high school students.	✓	✓	✓	✓	✓	✓	✓	See Implementation Notes	Triggers: Implementation of this strategy will be triggered if (1) failure to meet any goal pathways and (2) it has been determined by the County of Riverside through adaptive management that implementation is necessary; and (3) septic systems have been determined to be a pollutant sources to the MS4; (4) other optional strategies are not be implemented or being assessed; and (5) all of the necessary resources have been secured, including scheduling with the school district, obtaining targeted educational material from Principal Permittee for younger audiences, and obtaining the appropriate revenue sources.
7	County of Riverside/ Development Community	New and Redevelopment of all Land Uses	Hold external land development workshops targeting the development community (developers and their engineers).	✓	✓	✓	✓	✓	✓	✓	See Implementation Notes	Triggers: Implementation of this strategy will be triggered if (1) failure to meet any goal pathways and (2) it has been determined by the County of Riverside through adaptive management that implementation is necessary; (3) obtaining positive interest from the targeted audience; (4) other optional strategies are not be implemented or being assessed; and (5) all of the necessary resources have been secured, including obtaining the appropriate revenue sources.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
8	County of Riverside (Rural Areas)	Agricultural/ Equestrian/Livestock Land Uses	Implement outreach program for land owners of equestrian/livestock, and other agricultural operations.	✓	✓		✓	✓		✓	If Nutrient Reduction Goals are not met within a Permit Term, implement this strategy within 1 year of subsequent Permit Term. See Implementation Notes for additional Triggers.	Triggers: Implementation of this strategy will be triggered if (1) failure to meet any goal pathways and (2) it has been determined by the County of Riverside through adaptive management that implementation is necessary; (3) obtaining positive interest from the targeted audience; (4) other optional strategies are not being implemented or being assessed; and (5) all of the necessary resources have been secured, including obtaining the appropriate revenue sources.
9	County of Riverside	Commercial, Industrial and Residential Tracts with WQMPs, Municipal	Develop inspection data tracking through GIS applications.	✓	✓	✓	✓	✓		✓	See Implementation Notes	Triggers: Implementation of this strategy will be triggered if (1) failure to meet any goal pathways and (2) it has been determined by the County of Riverside through adaptive management that implementation is necessary; (3) all of the necessary resources have been secured, including obtaining the appropriate revenue sources.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
10	County of Riverside and Water Agencies/Districts	Commercial, Industrial and Residential	Promote/Partner incentive programs for BMP retrofits (e.g. water smart irrigation controllers, turf replacements programs, residential landscape evaluation program).	✓	✓	✓	✓	✓	✓	✓		Triggers:
											See Implementation Notes	Implementation of this strategy will be triggered if (1) failure to meet any goal pathways and (2) it has been determined by the County of Riverside through adaptive management that implementation is necessary; (3) obtaining positive interest from the targeted audience; (4) other optional strategies are not be implemented or being assessed; and (5) all of the necessary resources have been secured, including obtaining the appropriate revenue sources.
11	County of Riverside	Municipal Park Areas	Implement a turf replacement program in County Parks.		✓		✓	✓	✓	✓		Triggers:
											See Implementation Notes	Implementation of this strategy will be triggered if (1) failure to meet any goal pathways and (2) it has been determined by the County of Riverside through adaptive management that implementation is necessary; (3) obtaining positive interest from the targeted audience; (4) other optional strategies are not be implemented or being assessed; and (5) all of the necessary resources have been secured, including obtaining the appropriate revenue sources.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
12	County of Riverside /Water Districts/NGOs	Residential	Collaborate with partner agencies and groups to promote non-County sponsored incentive programs for BMP retrofits, for example, smart controllers, soil sensors, turf replacement, etc.	✓	✓	✓	✓	✓	✓	✓		Triggers:
											See Implementation Notes	Implementation of this strategy will be triggered if (1) failure to meet any goal pathways and (2) it has been determined by the County of Riverside through adaptive management that implementation is necessary; (3) obtaining positive interest from the targeted audience; (4) other optional strategies are not be implemented or being assessed; and (5) all of the necessary resources have been secured, including obtaining the appropriate revenue sources.
13	County of Riverside	Residential/ Commercial/ Industrial/Municipal	Outreach to large mobile landscaping service providers/vendors.	✓	✓	✓	✓	✓	✓	✓		Triggers:
											See Implementation Notes	Implementation of this strategy will be triggered if (1) failure to meet any goal pathways and (2) it has been determined by the County of Riverside through adaptive management that implementation is necessary; (3) obtaining positive interest from the targeted audience; (4) other optional strategies are not be implemented or being assessed; and (5) all of the necessary resources have been secured, including obtaining the appropriate revenue sources.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
WMA Strategies												
1	County of Riverside and Regional Jurisdictions	N/A	Coordinate with Integrated Regional Water Management (IRWM) regional water quality managers to identify and apply for grants related to water quality improvement projects (retrofits, stream rehabilitation, or other projects).	✓	✓	✓	✓	✓		✓		Triggers:
											Continuous	Interim goals are not met; progress towards numeric goals is not adequate; staff resources are identified and secured; adaptive management informs the RA's to implement. Resources required to implement strategy: Participation as a stakeholder in the IRWM Program as appropriate; Council approval of an IRWM proposed project; staffing necessary to implement any identified project.
2	County of Riverside and Regional Jurisdictions	N/A	Participate in Santa Margarita River Watershed Nutrient Initiative - Stakeholder Group to exchange information on successes on strategies. Implement or refine existing strategies to utilize other jurisdiction's strategical successes.		✓				✓	✓		Triggers:
											Continuous	Implementation may be triggered if (1) it has been determined by the County of Riverside through adaptive management that implementation is necessary; and (2) all of the necessary resources have been secured.
3		N/A										Triggers:

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Targeted Source Categories	Strategy	Priority Water Quality Pollutants (PWQP) Addressed						Implementation Frequency Schedule		Implementation Notes
				Bacteria	Eutrophic/ Nutrients (HPWQC) Dry Weather Flows	Metals	Sediment	Trash	Dry Weather Flows	FY 2018	Future Fiscal Year(s)	
	County of Riverside and Regional Jurisdictions		Partner/Implement Sustainable Landscapes Program with Water Agencies and Special Districts (e.g., Valley-Wide Recreation and Park Districts) to encourage landscape retrofits.	✓	✓		✓		✓	✓	Continuous	Implementation may be triggered if (1) it has been determined by the County of Riverside through adaptive management that implementation is necessary; and (2) all of the necessary resources have been secured.
4	County of Riverside and Regional Jurisdictions	N/A	Contingent on Regional Board approval of an implementable process, facilitate alternative compliance projects, for new development that are focused on restoring or creating beneficial uses.	✓	✓	✓	✓	✓	✓	✓		Triggers:
											Upon Regional Board Approval	Implementation may be triggered if (1) it has been determined by the County of Riverside through adaptive management that implementation is necessary; and (2) all of the necessary resources have been secured.
5	County of Riverside, Copermittees, Water Agencies/Districts	Residential, Commercial, Agricultural, and Industrial	Collaborate with watershed partners to develop consistent messaging to targeted audiences, such as residential, agricultural, commercial/industrial/residential land uses to conserve water and eliminate dry weather flows.	✓	✓	✓	✓	✓	✓	✓	Upon WQIP Approval	Review existing program and update as necessary to focus on Priority Water Quality Conditions (i.e., Eutrophication).

*NOTES: "Continuous" refers to a strategy that is already being implemented and will continue throughout Future Years.

Table 4-11. Jurisdictional Strategies Selected to Address Eutrophication Impacts in the Middle SMR Subwatershed – Riverside County Flood Control and Water Conservation District

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule		Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2018	Future Fiscal Years	
Illicit Discharge, Detection, and Elimination (IDDE) Program (Prov E.2)														
IDDE-1	Riverside County Flood Control and Water Conservation District	New Development, Residential, Commercial, Industrial	Promote a public reporting mechanism for incidental observations of IC/IDs.	Dry	X	X		X	X	X	X	X	Ongoing	**The District, as a Principal Permittee,** will continue operating a County-wide 1-800 hotline number to enable the public to report illegal dumping (including discharges from Industrial facilities, Commercial sites, and Construction projects), excess irrigation runoff, clogged storm drains, and faded or missing catch basin stencils. The hotline provides schedules for HHW and antifreeze, batteries, oil and paint clean-up locations and is capable of receiving reports in English and Spanish, 24 hours per day, seven days per week. IDDE is included in the JRMP template as part of each Copermittee's SOPs. The District will fund this program through the cooperative Implementation Agreement with the SMR Copermittees. T**he District, as a Copermittee,** will have a dedicated e-mail address/reporting link, located at http://rcflood.org/npdes/PollutionReporting.aspx, where the public can report any concerns, damage, or illegal dumping to storm drains, dams, basins, levees and/or channels. The District will fund this program through the Santa Margarita Benefit Assessment Fund.
IDDE-2	Riverside County Flood Control and Water Conservation District	Industrial, Residential, Commercial (incl. nurseries)	Train municipal field staff to identify and report ICIDs.	Dry	X	X		X		X	X	X	Ongoing	**The District, as a Principal Permittee,** will continue to provide Copermittees with annual training that focuses on IC/ID identification and reporting. These training courses have become routine SOPs in the JRMP and will be funded through the cooperative Implementation Agreement with the SMR Copermittees. T**he District, as a Copermittee,** will require its field inspection staff to attend this training. The District will fund this program through the District General Zone Fund.
IDDE-3	Riverside County Flood Control and Water Conservation District	Industrial, Residential, Commercial	Implement a District right-of-way inspection program to identify and report Illicit Connections and Discharges.	Dry	X	X		X		X	X	X	Ongoing	**The District, as a Copermittee,** will ensure that its field crews and field contractors are trained to identify, report and initiate elimination of ICIDs within District right-of-ways. The District will fund this program through the District General Zone Fund.
IDDE-4	Riverside County Flood Control and Water Conservation District	Open Spaces	Develop response procedures for homeless issue complaints to prevent or reduce trash and debris from entering receiving waters.	Dry	X	X	X	X	X	X	X	X	Ongoing	**The District, as a Principal Permittee,** will develop response procedures for homeless issue complaints to prevent or reduce trash and debris from entering receiving waters. These procedures will include coordination with the Sheriff's Department and other agencies for further investigation and clean-up. The District will fund this program through the cooperative Implementation Agreement with the SMR Copermittees. **The District, as a Copermittee,** will implement these procedures to remove the trash and debris associated with

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule		Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2018	Future Fiscal Years	
														homeless camps from waterways. The District will fund this program through the District General Zone Fund.
IDDE-5	Riverside County Flood Control and Water Conservation District	Existing Development	Identify areas with excessive water use	Dry	X	X		X	X	X	X	X	As needed	**The District, as a Copermittee,** will collaborate with water suppliers to evaluate water usage data to identify areas with excessive water use; such areas are expected to produce proportionately greater non-stormwater runoff so would be targeted for IDDE inspection. The District will fund this program through the Santa Margarita Benefits Assessment fund with in-kind services from water supply agencies.
IDDE-6	Riverside County Flood Control and Water Conservation District	Other Point and Non-Point Sources	Assessment of Permitted flows	Dry	X	X				X		X	Complete by 2023	**The District, as a Principal Permittee**, will conduct a study to evaluate the source contributions of dry weather flow and nutrient loading from natural and permitted flows. The project will include: permitted discharge & purple pipe inventory; natural sources inventory (rising groundwater, springs, etc.); assessment of flows covered by de-minimis permits; and flow characterization. The products will include flow and load estimates, a map of these sources, and recommendations for management approaches. The District will fund this program through the cooperative Implementation Agreement with the SMR Copermittees and seek assistance and in-kind services from water agencies and other SMR stakeholders.
Development Planning (Prov E.3)														
DEV-1	Riverside County Flood Control and Water Conservation District	New Development, Redevelopment, Residential	Implement Updated BMP Design Manual.	Both	X	X	X	X	X	X	X	X	Ongoing	**The District as a Copermittee** will review WQMPs for conformance with the BMP Design Manual as requested by County of Riverside staff, where there is flood plain encroachment and for projects requiring an encroachment permit from the District. In addition, the District as Copermittee will evaluate its capital improvement projects to determine Priority Development Project (PDP) criteria applicability and will prepare Project Water Quality Management Plans in conformance with the BMP Design Manual for projects meeting PDP criteria. The District will fund this program through pan check review fees and through the District General Zone Fund.
DEV-2	Riverside County Flood Control and Water Conservation District	New Development, Redevelopment, Residential	Update the BMP specifications (Soil mix, plant types, configuration) in the BMP Design Manual to enhance retention of nutrients.	Both	X							X	Ongoing	**The District, as Principal Permittee,** is using its LID Testing and Demonstration Facility to monitor and study the most recent approaches and techniques for biofiltration systems. These efforts include evaluating different soil media, plant palettes, and system configurations to optimize nutrient retention. This research will inform development of improved designs for biofiltration systems for nutrient retention and the District will ensure that the BMP Design Manual is revised to incorporate recommendations arising from this research. The District will fund this program through the cooperative Implementation Agreement with the SMR Copermittees.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule		Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2018	Future Fiscal Years	
DEV-3	Riverside County Flood Control and Water Conservation District	New Development, Redevelopment, Residential	Update the BMP Design Manual with landscape design and maintenance guidance	Both	X	X		X	X	X	X	X	Ongoing	**The District, as Principal Permittee**, will develop improved guidance for the design, implementation, and maintenance of landscaping for development projects. The guidance will focus on reducing the use of fertilizers, selection of plants, and outline maintenance procedures to prevent non-stormwater flows and improve management and containment of landscape clippings. The BMP Design Manual will be updated with this guidance.
DEV-4	Riverside County Flood Control and Water Conservation District	New Development, Redevelopment, Residential	Train staff on Updated BMP Design Manual.	Both	X	X	X	X	X	X	X	X	Annually	**The District, as a Principal Permittee,** will revise its training module to include the updates to the BMP Design Manual and deliver the module to the Copermittees. **The District, as Copermittee**, will ensure that its staff attends this training. The District will fund this program through the cooperative Implementation Agreement with the SMR Copermittees.
Construction Management (Prov E.4)														
CON-1	Riverside County Flood Control and Water Conservation District	New Development, Residential, Commercial, Industrial	Train staff on implementation of BMPs that reduce the potential of HPWQC and PWQP loading, and are site specific and seasonally appropriate to the construction phase, year round.	Both	X	X		X	X	X	X	X	Annually	**The District, as a Principal Permittee**, will continue providing annual training to enable Copermittees to effect proper implementation of year-round site-specific/phase-specific construction BMPs, CGP requirements, and SWPPPs at municipal construction sites. The District will fund this program through the cooperative Implementation Agreement with the SMR Copermittees. **The District, as a Copermittee,** will ensure that its staff attend and apply this training to the preparation and oversight of SWPPPs prepared for District projects. The District will fund this program through the District General Zone Fund.
CON-2	Riverside County Flood Control and Water Conservation District	New Development, Residential, Commercial, Industrial	Require preparation and implementation of SWPPPs	Both	X	X	X	X	X	X	X	X	Annually	**The District, as Copermittee,** will review SWPPPs and inspect its construction sites for conformance with the Stormwater and Non-Stormwater Pollution Control provisions of its standard specifications and contract documents.
Existing Development Management (Prov E.5)														
ED-1	Riverside County Flood Control and Water Conservation District	Municipal Facilities	Inspect and maintain flood control facilities.	Both	X	X	X		X	X	X	X	Ongoing	**The District, as a Copermittee**, will continue maintaining its facilities by removing debris and excess sediment, repairing eroded areas, tracking slopes, maintaining vegetated areas, rehabilitating and/or replacing structural rip-rap, repairing grout, removing and replacing concrete channel linings, repairing washouts, etc. The District will fund this program through the District General Zone Fund.
ED-2	Riverside County Flood Control and Water Conservation District	Existing Development, parks and recreation, orchards/vineyards/nurseries, horse ranches/equestrian, other agriculture, open space	Inspect District outfalls and coordinate abatement activities with affected jurisdictions.	Both	X	X		X					Annually	**The District, as a Copermittee,** will inspect all of its outfalls twice per year and work with affected jurisdictions to provide outreach materials to the general public to abate dry weather flows. The District will fund this program through the Santa Margarita Benefit Assessment Fund.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule		Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2018	Future Fiscal Years	
ED-3	Riverside County Flood Control and Water Conservation District	Existing Development	Provide funding for Riverside County Fire Department HAZMAT Response Program.	Both	X	X	X	X		X	X	X	Annually	**The District, as a Principal Permittee**, will provide funding ($1,825,000 over period FY17/18 to FY21/22) to Riverside County Fire Department for watershed-wide hazardous-material incident response and clean-up.
Enforcement Response Plans (Prov E.6)														
ERP-1	Riverside County Flood Control and Water Conservation District	New Development, Residential, Commercial, Industrial, parks and recreation, orchards/vineyards/nurseries, horse ranches/equestrian, other agriculture, open space	Require the implementation of the ERP to ensure proper use of BMPs to prevent or reduce the discharge of pollutants into MS4 networks.	Both	X	X	X	X	X	X	X	X	Ongoing	**The District, as a Principal Permittee,** will provide training to the Copermittees on implementation of the ERP during existing development inspections. Funding will be provided through the cooperative Implementation Agreement with the SMR Copermittees and the use of the District General Zone Fund. **The District, as a Copermittee,** will ensure that its inspection staff attends and applies ERP training to investigations arising from IDIC notifications.
ERP-2	Riverside County Flood Control and Water Conservation District	Construction Activities	Require the implementation of the ERP to ensure that private construction activities comply with the Construction General Permit and Copermittees' Stormwater Ordinances.	Both	X	X	X	X	X	X	X	X	Ongoing	**The District, as a Principal Permittee,** will provide training to the Copermittees on proper implementation of the ERP during construction site inspections. Funding will be provided through the cooperative Implementation Agreement with the SMR Copermittees and the use of the District General Zone Fund. **The District as a Copermittee** will ensure that its inspection staff attends and applies ERP training to oversight of District construction activities. The District will fund this program through the District General Zone Fund.
Public Education and Participation (Prov E.7)														
PUB-1	Riverside County Flood Control and Water Conservation District	Industrial, Commercial, Residential	Collaborate with watershed partners to develop consistent messaging to targeted audiences, such as commercial residents to conserve water and reduce dry weather flows.	Both	X	X	X	X	X	X	X	X	Ongoing	**The District, as a Principal Permittee and a Copermittee,** will collaborate with Copermittees and watershed partners to develop and deliver a comprehensive education and outreach program that will enable consistent messaging to be delivered to targeted audiences and encouraging practices that conserve water and eliminate excess irrigation runoff. The District will fund this program through the cooperative Implementation Agreement with the SMR Copermittees.
PUB-2	Riverside County Flood Control and Water Conservation District	Existing Development	Develop and provide outreach material to mobile landscape service providers that focuses on runoff and nutrient reduction.	Both	X		X		X	X		X	Ongoing	**The District, as a Principal Permittee and a Copermittee,** will develop and provide educational materials and outreach, incorporating technical content developed under PUB-1, to landscaping service providers. The materials will focus on preventing irrigation runoff, minimizing fertilizer and pesticide use, and proper containment and disposal of material. The District will fund this program through the cooperative Implementation Agreement with the SMR Copermittees.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule		Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2018	Future Fiscal Years	
PUB-3	Riverside County Flood Control and Water Conservation District	Residential	Provide outreach presentations to elementary, middle, and high school students to ensure that environmental protection is addressed early-on during the academic process.	Both	X	X		X	X	X		X	Ongoing	**The District, as a Principal Permittee and a Copermittee,** will provide educational materials, incorporating informational content developed under PUB-1, to Homeowner Associations. The District will fund this program through the cooperative Implementation Agreement with the SMR Copermittees.
PUB-4	Riverside County Flood Control and Water Conservation District	Existing Development, parks and recreation, orchards/vineyards/nurseries, horse ranches/equestrian, other agriculture, open space	Enhanced Jurisdictional: Coordinate/develop outreach materials in support of Copermittee enhanced inspection, outreach & enforcement programs	Both	X	X		X	X	X	X	X	Ongoing	**The District, as a Principal Permittee and a Copermittee,** will coordinate the development and distribution of an informational brochure for nurseries, vineyards, and horse ranches that focus on BMPs that reduce nutrients in runoff. The District will fund this program through the cooperative Implementation Agreement with the SMR Copermittees.
PUB-5	Riverside County Flood Control and Water Conservation District	Existing Development, parks and recreation, orchards/vineyards/nurseries, horse ranches/equestrian, other agriculture, open space	**Enhanced Jurisdictional:** Develop a webpage to ensure Copermittees and the general public have access to the latest NPDES information.	Both	X				X	X	X	X	Ongoing	**The District, as a Principal Permittee and a Copermittee**, will further develop a website intended to encourage community stewardship of the Santa Margarita River. The District will fund this program using NPDES Benefit Assessment funds.
Optional Jurisdictional Strategies and Schedule														
OPT-1	Riverside County Flood Control and Water Conservation District	New Development, Residential, Commercial, Industrial	Perform infiltration-testing at District basins and outfalls to collect data to assess the feasibility of regional recharge facilities or individual infiltration BMPs.	Both	X	X	X					X	Ongoing	**The District, as a Copermittee,** will evaluate District basins to determine opportunities for managing these facilities to optimize infiltration. Enhancing infiltration rates within existing infrastructure may increase wet and dry weather flow capture thereby reducing pollutant loading. Revised basin management practices will be implemented starting in 2021 as determined by need through the adaptive management process to effect additional load reductions. The District will fund this program through the District General Zone Fund.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule		Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2018	Future Fiscal Years	
OPT-2	Riverside County Flood Control and Water Conservation District	New Development, Residential, Commercial, Industrial	Partner with community groups to engage the public in promoting educational programs and community cleanups.	Both	X	X		X	X				Ongoing	**The District, as a Copermittee,** will partner with community groups to further enable the public to participate in channel cleanups. Clean-ups will remove anthropogenic bio-degradable debris that can contribute to nutrient loading. The annual Santa Ana River clean-up event is a model. The District will fund this program through the Santa Margarita Benefit Assessment Fund.
OPT-3	Riverside County Flood Control and Water Conservation District	New Development, Residential, Commercial, Industrial	Evaluate the suitability of regional basins.	Both	X	X						X	Ongoing	**The District, as a Copermittee,** will incorporate water quality features into a planned regional detention basin upstream of Interstate15 within the City of Wildomar. The District will fund this program through the District General Zone Fund.
Optional WMA Strategies and Schedule														
WMA-1	Upper and Middle Watershed Jurisdictions	IDDE	Partner with Water District(s) on pilot projects to abate dry weather flows.		X	X		X					As needed	**The District, as a Principal Permittee,** will screen the watershed's MS4 infrastructure for opportunities to construct dry weather flow diversions to the sanitary sewer for outfalls where persistent dry weather flows are not being abated by non-structural control strategies. The District will fund this program through the Santa Margarita Benefit Assessment Fund.
WMA-2	Upper and Middle Watershed Jurisdictions	IDDE	Coordinate incentive programs for reducing outdoor water use with Water Districts		X	X				X	X		As needed	**The District, as a Principal Permittee,** will partner with Water Districts on grant funding opportunities that encourage low water landscaping, use of rain barrels, etc. The District will fund this program through the cooperative Implementation Agreement with the SMR Copermittees.
WMA-3	Upper and Middle Watershed Jurisdictions	New Development	Update WMAA.		X		X			X	X		As needed	**The District, as a Principal Permittee,** will prepare an updated WMAA projects created with reference Integrated Water Resource Manageme Conservation Plan. The District will fund the WMAA update through the Copermittees unless grant opportunities can be located.
WMA-4	Upper and Middle Watershed Jurisdictions	New Development	Update Water Quality Equivalency Calculations as part of the Alternative Compliance program.		X	X	X	X		X	X		As needed	**The District, as a Principal Permittee,** will update water quality equivalency calculations as part of the regional criteria for alternative compliance. The District will fund this effort through the cooperative Implementation Agreement with the SMR Copermittees.
WMA-5	Upper and Middle Watershed Jurisdictions	New Development	Submit Grant Applications to support the development and/or implementation of the WMAA and Alternative Compliance Program.		X	X	X	X		X	X		As needed	**The District, as a Principal Permittee,** will search for applicable grant opportunities and partnerships with Copermittees, stakeholder groups, State and Federal agencies, non-profit organizations, etc. to develop and/or implement the WMAA and Alternative Compliance program. The District will fund the development of the WMAA through the cooperative Implementation Agreement with the SMR Copermittees.
WMA-6	Upper Watershed Jurisdictions	Various Point and Non-Point Sources	Develop a Stormwater Resources Plan.		X	X	X			X	X		As needed	**The District, as a Principal Permittee,** will seek partnerships with Water Districts to develop a Stormwater Resources Plan that will identify and select, through a systematic process of prioritization, candidate projects for funding consideration. The District will seek grant funding opportunities to assist Water Districts in funding this effort.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule		Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Food Supply	FY2018	Future Fiscal Years	
WMA-7	Upper and Middle Watershed Jurisdictions	Various Point and Non-Point Sources	Coordinate with the SMR Nutrient Initiative Group to share watershed-related information.		X								As needed	**The District, as a Principal Permittee,** will continue providing support for the analysis of eutrophication and nutrient loading in the upper Santa Margarita River and tributaries. The District will fund this support through the cooperative Implementation Agreement with the SMR Copermittees.
WMA-8	Upper and Middle Watershed Jurisdictions	IDDE and Various point and Non-Point Sources	Coordinate with the SMR IRWM group to share watershed-related information.		X	X		X		X	X		As needed	**The District, as a Principal Permittee,** will seek partnerships with Water Districts to manage water resources, turf removal programs, landscape water reduction, use of recycled water, BMP implementation in Ag and equestrian land uses, etc. The District will seek grant funding opportunities to assist Water Districts in funding these programs.
WMA-9	SMR	Various Point and Non-Point Sources	Coordinate with the Consultation committee to provide updates and share watershed-related information.		X	X		X	X	X	X		As needed	**The District, as a Principal Permittee,** will seek partnerships with Water Districts, stakeholder groups, non-profit organizations, etc. to discuss the status of the health of the watershed in efforts to identify projects to address common issues.

4.2.1.3 Optional Jurisdictional

Optional jurisdictional strategies include those that Copermittees and the City of Menifee may implement to achieve interim and final numeric goals. As part of the five-year assessment process, implementation of strategies will be evaluated against progress towards goals. Where interim goals are met and the current strategies and schedules are determined to be adequate to achieve the subsequent interim or final goal, Copermittees and the City of Menifee may adjust current strategies. Where interim goals are not achieved, and/or it is determined that the current strategies, even if implemented on accelerated schedules, would not achieve future interim or final goals, optional jurisdictional strategies may be triggered and implemented as resources allow. Implementation is contingent on the time needed to assemble resources and the availability of funding. The process for identifying optional jurisdictional strategies is summarized in **Figure 4-11**. Optional strategies for each Copermittee and the City of Menifee are detailed in the jurisdictional strategies tables above. The optional jurisdictional strategies include optional programs, retrofits, and stream rehabilitation programs per Permit Provision B.3.b.

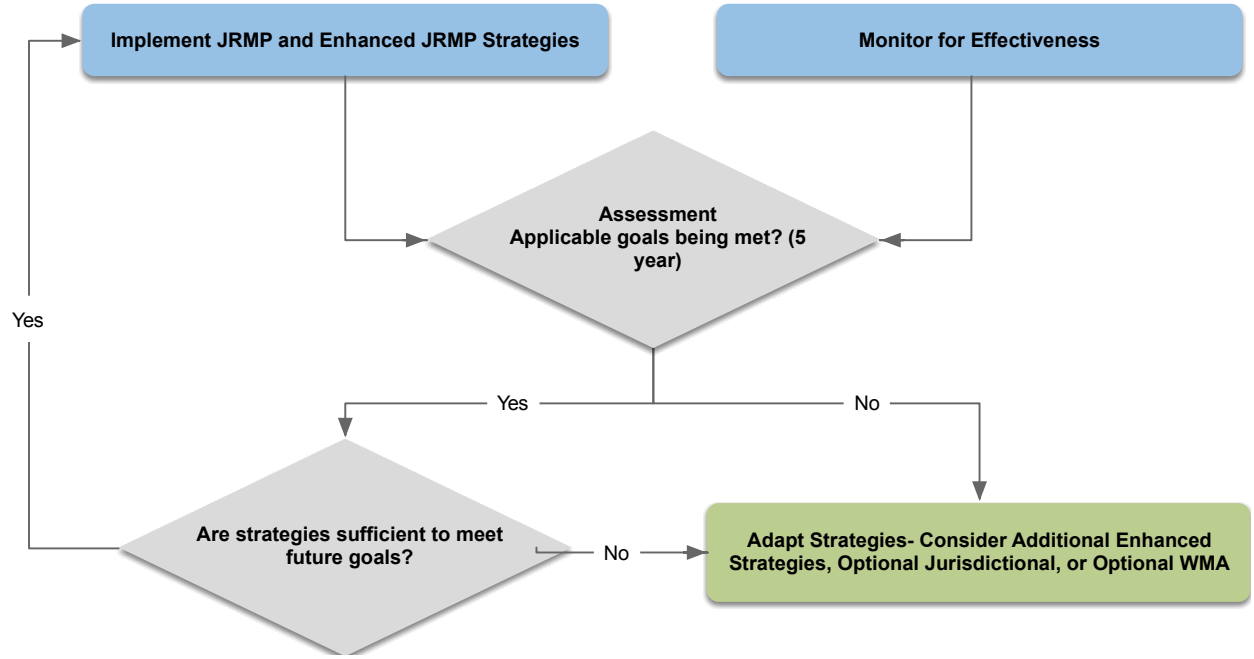

Figure 4-11. Adaptive Management Process to Identify Additional Strategies

4.2.1.3.1 Enhanced Street Sweeping

As described in the Jurisdictional Strategies, street sweeping can be an effective strategy to mediate pollutants that are transported by sediment or leaf debris, including nutrients and other pollutants (e.g. metals, oil and grease, bacteria, and trash), into the MS4s. Street sweeping frequencies and routes could be targeted to more effectively remove debris from problem areas identified by the Copermittees and the City of Menifee.

4.2.1.3.2 Coordination with Water Districts

The Copermittees and the City of Menifee could coordinate with water districts to identify areas with high water usage during dry months, and, thereby, pinpoint and address potential sources of dry weather flows. The coordination could include community surveys and enforcement efforts for over-irrigation, and incentive programs to encourage proper irrigation practices.

4.2.1.3.3 Capital Improvement Program Projects

Capital Improvement Program (CIP) projects could include structural BMPs that treat and/or reduce dry weather and stormwater runoff. These type of BMPs are designed to treat pollutants based on site-specific conditions. Typically, the total cost of structural BMPs tend to be higher than non-structural BMPs, as installation and maintenance is required. Furthermore, extensive studies are needed to select appropriate devices that will treat the desired pollutants at each site. The installation of structural BMPs may be more cost-effective if these are considered in initial planning phases for specific projects. These projects could provide a multi-pollutant benefit in reducing runoff.

4.2.1.3.4 Dry Weather Treatment

Dry weather retrofits (and infiltration or treatment) could be an effective strategy to reduce dry weather flows and reduce multiple pollutants. A dry weather retrofit may include the reconfiguration of the outlets of existing flood control basins to allow more time for evapotranspiration. This could be particularly effective in eliminating non-stormwater discharges to receiving waters. Infiltration BMPs may include infiltration basins, trenches, and galleries, bioretention systems, dry wells, hybrid bioretention/dry wells, or permeable pavements. Infiltration BMPs could be considered in areas with appropriate soils that promote infiltration and where groundwater augmentation is feasible (i.e., stormwater quality would not affect groundwater basin).

The Copermittees and the City of Menifee have reason to question the feasibility of infiltration (independent of a flood control function) in large portions of the Middle SMR Subwatershed that are served by MS4 facilities. Investigations and discussions with stakeholders during this planning process revealed three concerns:

1. First, the condition of the groundwater below most of the MS4 facilities is sensitive. There are two aquifers, one on top of the other, separated by a leaky clay layer. The aquifer on top is of poor quality, while the deeper aquifer is of better quality and is the one used for water supply. There is concern that if the surface conditions are changed with infiltration basins, the surface water will enter the top aquifer and force poor quality water from it to enter the deeper aquifer and, thereby, jeopardize drinking water supplies.

2. Second, infiltration rates are often poor to non-existent due to high groundwater conditions. The RCFCWCD discovered this as a result of infiltration tests completed as it investigated the feasibility of potential infiltration basin sites.
3. Third, there is a concern for water rights. Surface water in the SMR WMA has been adjudicated. Camp Pendleton is downstream, and has a claim on surface flows generated in the Middle SMR Subwatershed. If surface flows from the Middle SMR Subwatershed do not exceed certain volumes, they must be replaced, usually with much more expensive Colorado River water. Thus, surface flows diverted to groundwater would have to be replaced, at a high cost, to satisfy the claim.

Taken together, these concerns may be difficult to overcome. They may effectively prohibit the selection of infiltration as an optional strategy in many areas of the Middle SMR Subwatershed.

4.2.2 Strategies to Address Eutrophication Impacts and Nutrients in the Lower SMR Subwatershed

The Permit establishes that WQIP strategies should be identified on the basis of their likelihood to "effectively prohibit non-storm water discharges to the MS4, reduce pollutants in storm water discharges from the MS4 to the MEP, protect the beneficial uses of receiving water from MS4 discharges, and/or achieve the interim and final numeric goals identified under Provision B.3.a."

Four primary jurisdictional strategy programs are required under the 2013 Permit, each requiring its own inventory of potential pollutant sources. These include:

1. Illicit Discharge Detection and Elimination (MS4 outfall inventory);
2. Development Planning (Priority development project [PDP] and BMP inventory);
3. Construction Management (Construction site inventory); and
4. Existing Development Management (Industrial, Commercial, Municipal, and Residential inventories).

San Diego County has developed inventories for each of these categories. Known and suspected sources contributing to nutrient loading are discussed in detail in **Chapter 2**. These known and suspected sources include persistently flowing outfalls and specific land use types. Modeling completed for the SMR identified irrigated agriculture, orchards, vineyards and nurseries, open scrublands and grasslands, and residential land uses as the largest contributors of total nitrogen load. Total phosphorus loading is being contributed by roads, orchards, vineyards and nurseries, open scrublands and grasslands, and residential land uses. Jurisdictional strategies are targeted towards reducing dry weather flow and addressing the types of land use sources that are within the MS4 drainage area.

Additional optional strategies have also been identified. These optional strategies are currently being implemented, are planned for implementation, or may be triggered for implementation in the future to address the HPWQC.

Strategies to address nutrients in Rainbow Creek and eutrophic conditions in the SMR Estuary were chosen on the basis of their expected effectiveness in reducing pollutant sources and their suitability and potential to be implemented in order to achieve required goals. Non-structural strategies represent the first line of defense for management of stormwater pollutants. These institutional programs tend to be the most cost-effective options for water quality improvement because they focus on controlling the sources of pollution throughout the landscape before

pollutants can be washed downstream by stormwater runoff. During development of previous WQIPs throughout the San Diego Region (San Diego Regional Water Quality Control Board 2016b), maintenance and enhancement of non-structural strategies has been acknowledged by the Regional Water Board to reduce pollutant loads by approximately 10%.

Schedules for strategy implementation reflect the time necessary to fully fund, develop, initiate, and complete the chosen strategies. Strategies with relatively high benefit outcomes and low resource requirements are scheduled for earlier implementation. Strategies planned for later years may have implementation requirements that depend on the outcomes of earlier strategies, or might have significant funding needs.

While the chosen strategies focus on nutrients, these strategies address multiple pollutant sources and constituents as shown in each of the jurisdictional strategy tables above. Optional strategies are also presented in the jurisdictional strategy tables above. Optional strategies may be triggered on the basis of a set of given conditions, such as necessity or as resources are available. The strategies and schedules are subject to change, and are contingent upon programmatic requirements and funding availability. They will be modified through the adaptive management process as needed.

4.2.2.1 Modeling of Structural Strategies for Rainbow Creek

To comply with the Nutrient TMDL in Rainbow Creek as required by Attachment E.3, Table 3.3, of the Permit, the County of San Diego completed a modeling effort to identify the most effective structural strategies for reducing nutrient loading. The purpose of the modeling is to provide reasonable assurance that a specific set of actions will result in sufficient reduction in nutrients to meet compliance with the Final Effluent Limitations assigned to the County of San Diego in Attachment E.3.b.2(b)(ii). To ensure consistency with modeling efforts throughout the watershed, the Rainbow Creek modeling effort built upon modeling completed for the SMRNIG investigation for the SMR Estuary and river (Sutula et al, 2016). That Hydrological Simulation Program FORTRAN (HSPF) watershed model was recently updated and the details can be found in the updated allocation memorandum (Tetra Tech, May 2016) and in Appendix 4A. The updated model improved the representation of land uses within San Diego County and provided additional hydrological refinements to improve the model simulation results for the Rainbow Creek watershed. This updated model was then used to simulate potential structural strategies to reduce nutrients in Rainbow Creek.

The modeling results demonstrated that, given the constraints and conditions of the Rainbow Creek watershed, biofiltration that is designed to provide advanced nutrient treatment is the most appropriate strategy to address wet weather discharges from outfalls to Rainbow Creek. The flat topography in this specific part of the watershed combined with a shallow groundwater level is a constraint for the design of structural BMPs. Wetland channels are recommended and can in some cases be sited in the public right-of-way to intercept stormwater and dry weather runoff. Stream restoration can also be an effective strategy to help restore beneficial uses to degraded creeks and enhance nutrient capture and assimilation. Typical stream restoration projects include reshaping of the channel, installation of features to enhance fluvial processes, and replanting of riparian vegetation.

The County of San Diego proposes to implement structural strategies to address wet weather outfall discharges into Rainbow Creek. Work on the siting and design of these structural BMPs is underway. Funding has been secured through Fiscal Year 19-20 to select sites for structural BMP

installation and to move forward with the implementation of BMPs as soon as possible. Currently, the structural BMPs in the Rainbow Creek watershed are being planned to specifically target areas with the highest observed loading of nutrients. The model shows that 6 of the 19 outfalls in the Rainbow Creek subwatershed account for 77% of the total nutrient loading coming from County MS4. Focusing the structural BMPs (nutrient-sensitive biofiltration, wetland channels, or an equivalent approach) to reduce loading at these sites is being analyzed by the engineering and design team. The ongoing work includes conducting a constraints analysis and preparing preliminary engineering designs which will be used to evaluate whether this is the most effective and efficient approach to reducing nutrient loading in the watershed during wet weather. During the design phase, alternate BMPs than the ones listed here may be selected so long as they provide the equivalent level of nutrient load reduction. The level of flow treated for each individual BMP will also be determined and targeted to achieve the appropriate load reductions during the design phase.

The strategies, as determined by reasonable assurance compliance modeling, that are proposed for implementation in order to meet the Rainbow Creek Nutrient TMDL are summarized in **Table 4-12**. Additional details on the modeling techniques and results can be found in Appendix 4A. As required by Permit Provision B.3, this modeling effort provides reasonable assurance that implementation of these proposed structural strategies or equivalent structural strategies will achieve compliance with the Final Effluent Limitations assigned to the County of San Diego.

The County of San Diego's five-year budget forecast identifies the need for funding to continue for the structural strategies in Rainbow Creek watershed and it is expected that funds will be available for this work, since achieving compliance with the Nutrient TMDL is a priority for the County of San Diego. However, it should be noted that the Watershed Protection Program of San Diego County is currently a General Fund program and thus funding must be secured on an annual basis. Progress and status of implementation of the structural BMPs in the Rainbow Creek watershed will be updated annually as part of the Watershed annual reports.

The County of San Diego has already begun the design phase for wetland channels to capture runoff from approximately 200 acres of the southern portion of Rainbow Valley, as shown in Figure 4-12. This includes runoff from several of the large nurseries in the valley and treats the drainage areas associated with HST-01 and SMG-089. The proposed channel wetlands plan to include segments of channel along 5th Street and Huffstatler Street north of 5th Street. The design will reconfigure the existing channels and include a gravel substrate topped by soil media and vegetation creating a subsurface flow wetland which will maximize nutrient reduction through biological uptake, microbial interactions, and anaerobic zone for denitrification. The finalized designs for this structural BMP are scheduled to be completed by June 2019, with a construction bid package awarded in late 2019. The County is working towards installing the remaining structural BMPs in a timely manner so that monitoring results can demonstrate compliance with the Rainbow Creek TMDL prior to the December 31, 2021 deadline.

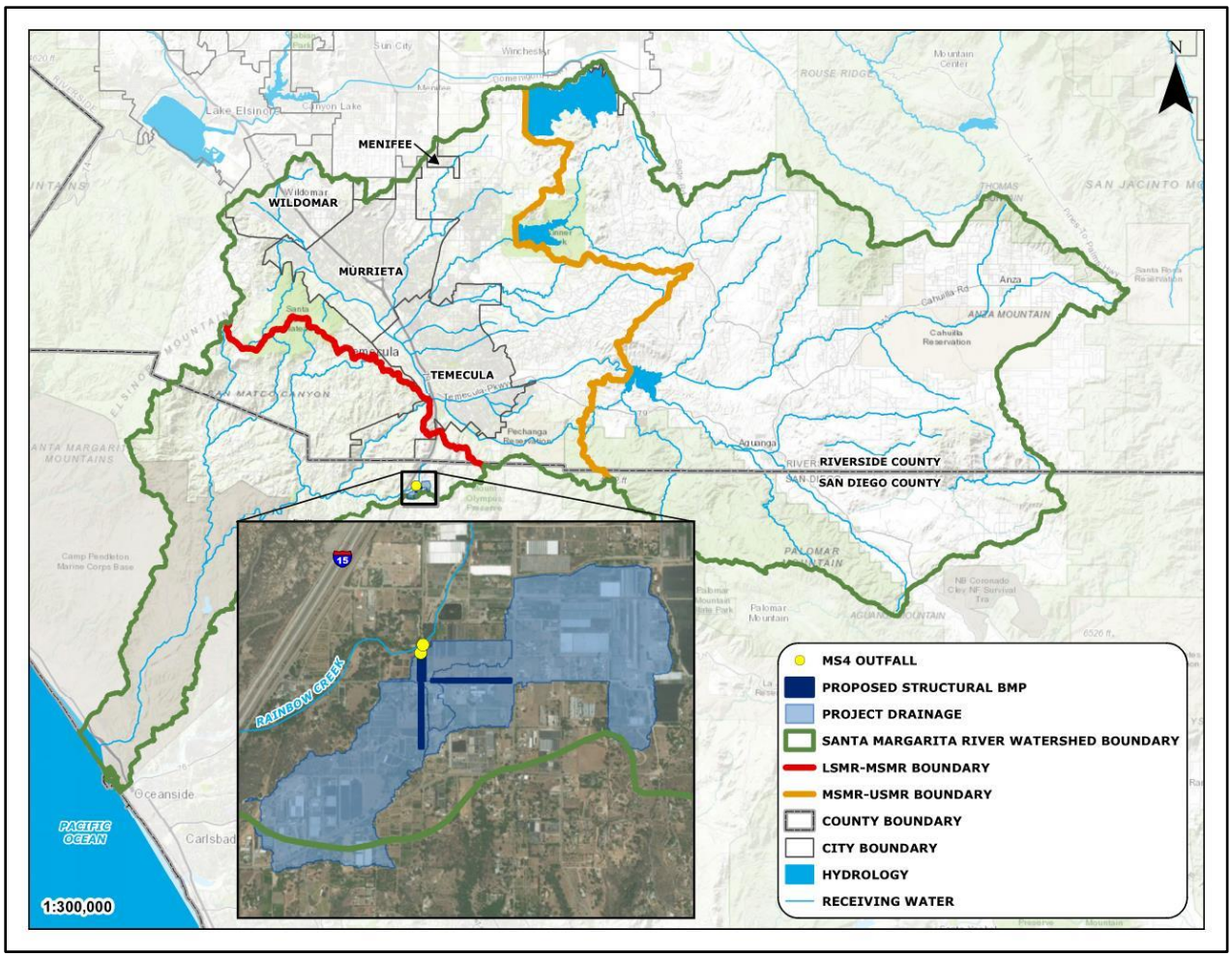

Figure 4-12. Proposed Structural BMP Currently in Design Phase in Rainbow Valley

Table 4-12. Proposed Structural Strategies to Meet Compliance with Rainbow Creek Nutrient TMDL

Strategy	Units	Quantity[1]	Scheduled Compliance
Nutrient-Sensitive Biofiltration (Based on six priority outfalls) or equivalent	acres	0.21	12/31/2021
Wetland Channels (Based on six priority outfalls) or equivalent	acres	0.39	12/31/2021
Stream Restoration and Channel Improvements or equivalent (Public-Private Partnerships)	linear feet	2,143 [2]	12/31/2021

1. Note that quantities are based on planning-level, desktop analyses. Actual quantities will vary during implementation on the basis of site-specific designs, conditions, and constraints.
2. Sized based on rate of 0.075 lbs/ft/yr removed of TN (Chesapeake Stormwater Network and Center for Watershed Protection, 2014).

4.2.2.2 Jurisdictional Strategies

The Copermittees have identified jurisdictional strategies that will be implemented as part of their JRMPs. Achievement of water quality benefits will ultimately be measured against the interim and final numeric goals as discussed in **Section 3.3.1**. The key sources for the County of San Diego and the relative loading of nutrients from those sources to the County's MS4s provide the foundation for strategy selection. The priority sources and relative nutrient loading are summarized for the County of San Diego in **Table 4-13**.

Table 4-13. Summary of Key Sources of Nutrients for the County of San Diego

Key Sources	Total Nitrogen[1]	Total Phosphorus[1]
Orchards, Vineyards, Nurseries	56.60%	53.40%
Residential Areas/Activities	20.90%	23.30%
Other Agriculture	5.00%	4.50%

1. As a percentage of the total loading to the Copermittee's MS4.

The jurisdictional strategies can be categorized into three types:

1. Strategies building on the required JRMP elements in Provision E of the Permit. These include the JRMP requirements as well as modifications and enhancements within existing programs to provide a more focused approach, specifically addressing nutrients;
2. Optional jurisdictional strategies that may be implemented to achieve the interim and final goals; and
3. Coordinated strategies involving collaboration amongst multiple agencies within the WMA working towards common goals.

Under the Permit, strategies are required to be identified for the following six components. The required components are:

1. Illicit Discharge Detection and Elimination (MS4 outfall inventory) [Provisions D.2 and E.2];
2. Development Planning (PDP and BMP inventory) [Provision E.3];

3. Construction Management (Construction site inventory) [Provision E.4];
4. Existing Development Management (Industrial, Commercial, Municipal, and Residential inventories) [Provision E.5];
5. Enforcement Response Plans [Provision E.6]; and
6. Public Education and Participation [Provision E.7].

Table 4-14 presents the jurisdictional strategies planned for implementation to address nutrients in the Lower SMR Subwatershed.

Table 4-14. Jurisdictional Strategies for the Lower SMR Subwatershed

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Illicit Discharge, Detection, and Elimination (IDDE) Program (Prov E.2)															
IDDE-1	County of San Diego	Industrial, Residential, Commercial	Maintain storm water conveyance system map to facilitate Illicit Discharge, Detection, and Elimination program.	Dry	X	X		X		X	X	X	X	Ongoing	Ongoing updates to mapping as needed.
IDDE-2	County of San Diego	Industrial, Residential, Commercial (incl. nurseries),	Utilize municipal personnel and contractors to identify and report Illicit Connections and Discharges.	Dry	X	X		X		X	X	X	X	Ongoing	Annual stormwater training for municipal personnel and contractors as needed.
IDDE-3	County of San Diego	Industrial, Residential, Commercial	Updated focused training for County field staff.	Dry	X	X		X	X	X	X	X	X	Annually	Training is updated and will be administered as needed.
IDDE-4	County of San Diego	Onsite Wastewater Treatment Systems	Address septic system failures where observed.	Dry	X	X		X	X	X	X	X	X	Ongoing	Per the LAMP policy, DEH will respond to septic system failures as appropriate.
IDDE-5	County of San Diego	Industrial, Residential, Commercial	Facilitate public reporting of Illicit Connections and Illicit Discharges via email.	Dry	X	X		X	X	X	X	X	X	Ongoing	A bilingual hotline, dedicated e-mail address, and multiple online reporting tools will continue to be supported.
IDDE-6	County of San Diego	Industrial, Residential, Commercial	Bilingual hotline (I Love a Clean San Diego) to provide better customer service.	Dry	X	X		X	X	X	X	X	X	Ongoing	The I Love A Clean San Diego hotline will continue to be supported.
IDDE-7	County of San Diego	Industrial, Residential, Commercial	Implement practices and procedures to address spills with the potential to enter the storm drain system.	Dry	X	X		X		X	X	X	X	Ongoing	A NOV will be issued by DEH when appropriate per the LAMP policy. Prompt follow up and mitigation is implemented.
IDDE-8	County of San Diego	Sanitary Sewer Overflow	Coordinate spill response with responsible sanitary sewer agencies.	Dry	X	X		X		X	X	X	X	Ongoing	Implement plan to inform the public of risks associated with sewer spills, conducting sampling, reporting, posting signs, etc.
IDDE-9	County of San Diego	Industrial, Residential, Commercial	Utilize municipal personnel and Contractors to monitor storm water outfalls for discharges of potential Illicit Connections and Illicit Discharges.	Dry	X	X	X	X	X	X	X	X	X	Ongoing	This is part of our IDDE program.
IDDE-10	County of San Diego	Industrial, Residential, Commercial	Develop and implement a strategy for investigating and addressing Illicit Connections and Illicit Discharges.	Dry	X	X		X		X	X	X	X	Ongoing	This is part of our IDDE program
IDDE-11	County of San Diego	Open Spaces	Refer homeless issue complaints to Sheriff or appropriate jurisdictions.	Dry	X	X	X	X		X	X	X	X	Ongoing	This is part of our IDDE program
Development Planning (Prov E.3)															
DEV-1	County of San Diego	New and Redevelopment	Priority Development Projects (PDPs): In addition to requirement for all development projects, implement or require implementation of onsite structural BMPs to control pollutants and manage hydromodification for PDPs.	Both	X	X	X	X		X	X	X	X	Ongoing	The County BMP Design Manual requires all PDPs to implement PC and HMP BMPs. These requirements are captured in the WPO and County's BMP DM.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
DEV-2	County of San Diego	New and Redevelopment	Update BMP Design Manual procedures to specify storm water requirements applicable to development and redevelopment projects, identify and design appropriate BMPs, establish maintenance criteria, and establish where implemented alternative compliance options.	Both	X	X	X	X	X	X	X	X	X	Ongoing	Updated to reflect the Regional Model BMP DM with additional changes to incorporate County implementation practices.
DEV-3	County of San Diego	New and Redevelopment	Conduct internal (staff) training on the updated BMP Manual.	Both	X	X	X	X		X	X	X	X	Ongoing	Initial training was provided and will be continued as needed.
DEV-4	County of San Diego	New and Redevelopment	Impose legal authority to ensure all development and redevelopment projects are in compliance with all post construction requirements.	Both	X	X	X	X	X	X	X	X	X	Ongoing	The Watershed Protection Ordinance was updated in FY16 to include modifications necessary as the result of the updated permit and the inclusion of applicant-implement offsite alternative compliance.
DEV-5	County of San Diego	New and Redevelopment	Update County codes, ordinances, and storm water design standards consistent with the permit and the updated BMP Manual.	Both	X	X		X		X	X	X	X	One time	The Watershed Protection Ordinance was updated in FY16 to include modifications necessary as the result of the updated permit and the inclusion of applicant-implement offsite alternative compliance.
Construction Management (Prov E.4)															
CON-1	County of San Diego	Construction Waste Management	Require implementation of BMPs that are site specific, seasonally appropriate and appropriate to the construction phase, year round.	Both	X		X	X	X	X	X	X	X	As necessary	Every project requires implementation of site specific construction BMPs, seasonably appropriate and appropriate to the construction phase.
CON-2	County of San Diego	Construction Waste Management	Impose legal authority to ensure inventoried construction projects are in compliance with all requirements.	Both	X	X	X	X	X	X	X	X	X	As necessary	The Watershed Protection Ordinance is the current legal authority to insure inventoried construction projects are in compliance with all requirements.
CON-3	County of San Diego	Construction Waste Management	Provide internal staff training related to construction storm water management.	Both	X	X	X	X	X	X	X	X	X	Annually	Training will be administered as needed.
Existing Development Management (Prov E.5)															
ED-1	County of San Diego	Industrial, Commercial, Municipal, Residential	Maintain and update a watershed-based inventory of existing development (i.e. commercial, industrial, municipal and residential areas).	Both	X	X	X	X		X		X	X	Ongoing	Inventory for these items is tracked in an electronic database.
ED-2	County of San Diego	Industrial, Commercial, Municipal, Residential	Improve the tracking of watershed based inventories via consolidated database.	Both	X	X	X	X	X	X		X	X	Ongoing	Inventory for these items is tracked in an electronic database.
ED-3	County of San Diego	Industrial, Commercial, Municipal, Residential	Designate a minimum set of BMPs required for all existing development inventories, including special event venues. The designated minimum BMPs must be specific to facility or area types and pollutant generating activities, as appropriate.	Both	X	X	X	X	X	X		X	X	Annually	The JRMP establishes minimum BMPs for all land use types.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
ED-4	County of San Diego	Municipal	Pet waste management and outreach in County Parks.	Both	X	X				X		X	X	Ongoing	Determine if pet waste is currently addressed in County Parks in this area and increase outreach if needed.
ED-5	County of San Diego	Municipal	Implement a schedule or operation and maintenance activities for the storm water conveyance system and related structures.	Both	X	X		X		X		X	X	Ongoing	Stormwater conveyance system maintenance is referred to appropriate departments when needed.
ED-6	County of San Diego	Streets	Implement a schedule of operation and maintenance for County paved and unpaved roads.	Both	X	X		X		X		X	X	Ongoing	County Road Crews employ a schedule for maintenance of County Roads.
ED-7	County of San Diego	Residential	Promote and encourage implementation of designated BMPs in residential areas.	Both	X	X				X		X	X	Ongoing	The County will support and promote efforts of partner agencies that provide incentive programs.
ED-8	County of San Diego	Industrial, Commercial, Municipal, Residential	Conduct inspections of inventoried existing development to ensure compliance.	Both	X	X		X		X		X	X	Ongoing	Inspections are completed on an ongoing basis as described in the JRMP and in compliance with the Permit. Twenty percent of the inventory will be inspected per year, all within 5 years.
ED-9	County of San Diego	Residential	Conduct focused residential inspections based on strategic assessments.	Both	X	X		X		X	X	X	X	Ongoing	Residential areas that are identified as contributing to nutrient loading will be selected for additional outreach and/or inspection programs. Twenty percent of the inventory will be inspected per year, all within 5 years.
ED-10	County of San Diego	Residential	Develop a residential inspections tracking program via mobile platform - miles, violations, etc.	Both	X	X		X		X		X	X	Ongoing	Residential inspections are tracking in the electronic database.
ED-11	County of San Diego	Industrial, Commercial, Municipal, Residential	Improve inspections data tracking through mobile phone applications.	Both	X	X		X		X		X	X	Ongoing	Mobile phone applications that synch to the inspections tracking system are currently in development.
ED-12	County of San Diego	Industrial, Commercial, Municipal, Residential	Enforce legal authority established for all inventoried existing development to achieve compliance.	Both	X	X		X	X	X	X	X	X	Ongoing	Legal authority will be enforced as outlined in the JRMP.
ED-13	County of San Diego and Regional Jurisdictions	Residential	Promote incentive program for BMP retrofits (e.g. water smart irrigation controllers, turf replacements programs, residential landscape evaluation program).	Both	X	X		X		X		X	X	Ongoing	The County will collaborate with and promote the efforts of partner agencies incentive programs.
ED-14	County of San Diego	Municipal	Turf replacement in Rainbow Park.	Both	X	X	X	X		X		X	X	Ongoing	The plans for this replacement are complete and work should be starting this Fiscal Year.
ED-15	County of San Diego	Equestrian Land Uses	Promote the implementation of equestrian BMPs and distribute outreach material.	Both	X	X				X	X	X	X	Ongoing	Outreach materials have been developed; identify any areas where they can be distributed.

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
Public Education and Participation (Prov E.7)															
PUB-1	County of San Diego	Industrial, Commercial, Residential	Implement a public education and participation program to promote and encourage development of programs, management practices and behaviors that reduce the discharge of pollutants in storm water prioritized by high risk behaviors, pollutants of concern, and target audiences.	Both	X	X		X	X	X		X	X	Ongoing	The County completes numerous education and public participation programs for a diverse target audiences. See JRMP.
PUB-2	County of San Diego	Residential	Educational Workshops on Integrated Pest Management, manure management and others as needed.	Both	X	X			X	X	X	X	X	Ongoing	The County completes numerous education and public participation programs for diverse target audiences. See JRMP.
PUB-3	County of San Diego	Industrial, Commercial, Residential	Collaborate with watershed partners to develop consistent messaging to targeted audiences, such as commercial residents to conserve water and reduce dry weather flows.	Both	X	X	X	X	X	X	X	X	X	Ongoing	The County completes numerous education and public participation programs for diverse target audiences. See JRMP.
PUB-4	County of San Diego	Residential, Commercial	Outreach to mobile landscaping service providers.	Both	X		X		X	X		X	X	Ongoing	Educational materials and outreach will be distributed to landscaping service providers as needed and appropriate.
PUB-5	County of San Diego	Residential	Give outreach presentations to elementary, middle, and high school students.	Both	X	X		X	X	X		X	X	Ongoing	The County completes numerous education and public participation programs for diverse target audiences. See JRMP.
Optional Jurisdictional Strategies and Schedule															
OPT-1	County of San Diego	Sewer Infrastructure	Divert persistent dry weather flows from storm drains to sewer.	Dry	X	X				X	X			Once triggered, 2-3 years	Triggers: Implementation of this strategy may be triggered if (1) an interim goal has not been met; and (2) it has been determined by the County of San Diego through adaptive management that implementation is necessary; and (3) permission is granted from sewer agency; and (4) ground water or permitted discharges have been ruled out; and (5) all of the necessary resources have been secured. Resources include: Staff availability, Grant funding or alternative source, Contractor funding, Engineering design, Environmental review, Permits, Ongoing funding for operation/maintenance

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
OPT-2	County of San Diego and Partners	Residential, Commercial	Promote Incentive Programs: Rain Barrel, Live Turf Replacement & Outdoor Water Efficiency. Promote Incentive Programs for BMP Retrofits.	Both	X	X		X	X	X	X			Continuous, as resources allow	Triggers: Implementation of this strategy may be triggered if (1) an interim goal has not been met; and (2) it has been determined by the County of San Diego through adaptive management that implementation is necessary; and (3) pilot program success; and (4) all of the necessary resources have been secured. Resources include: Staff availability, Grant funding or alternative source, Incentive items, Establishment of partnerships
OPT-3	County of San Diego	Onsite Wastewater Treatment Systems	Implement a program that provides rebates or incentives for pumping onsite wastewater treatment systems.	Both	X	X				X	X			Once triggered, Pilot program 1 -2 years, as needed thereafter	Triggers: Implementation of this strategy may be triggered if (1) an interim goal has not been met; and (2) it has been determined by the County of San Diego through adaptive management that implementation is necessary; and (3) pilot programs have demonstrated success; and (4) all of the necessary resources have been secured. Resources include: Staff availability, Grant funding or alternative source, Contractor funding, Partnerships, Incentive items
OPT-4	County of San Diego	Municipal Areas	Implement a Green Streets Retrofits Program.	Both	X	X		X	X	X	X			Once triggered, 3-7 years per project; ongoing operation & maintenance thereafter	Triggers: Implementation of this strategy may be triggered on a project-by-project basis if (1) a specified interim goal has not been met; and (2) it has been determined by the County of San Diego through adaptive management that implementation is necessary; and (3) pilot program success; and (4) all of the necessary resources have been secured. Resources include: Staff availability, Grant funding or alternative source, Contractor funding, Engineering or landscaping design, Permits, Environmental review, Right of way acquisition, Ongoing funding for operation/maintenance
OPT-5	County of San Diego	Open Spaces	Flood Control Channel Rehabilitation Projects (e.g., removal of impervious lining in flood control channel and replacement with earthen or vegetated surface).	Both	X		X	X		X	X			Once triggered, 4-7 years per project; ongoing operation & maintenance thereafter	Triggers: Implementation of this strategy may be triggered if (1) an interim goal has not been met; and (2) it has been determined by the County of San Diego through adaptive management that implementation is necessary; and (3) engineering design, monitoring, and outreach plans are approved; and (4) all of the necessary resources have been secured. Resources include: Staff availability, Grant funding or alternative source, Contractor funding, Partnerships, Engineering design, Permits, Environmental review, Right of way acquisition (if needed), Ongoing funding for operation/maintenance

Strategy Number	Geographic Extent/ Jurisdiction/ Collaboration	Sources Addressed	Strategy	Dry Weather/ Wet Weather/ Both	HPWQC	PWQCs						Implementation Schedule			Implementation Approach/Notes
					Eutrophication/ Nutrients	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	FY2017	FY2018	Future Fiscal Years	
OPT-6	County of San Diego and Regional Partners	Municipal Areas	Identify candidate areas of existing development for stream, channel, and/or habitat rehabilitation projects and facilitate implementation of such projects.	Both	X		X	X		X	X			Once triggered, 4-7 years per project; ongoing operation & maintenance thereafter	Triggers: Implementation of this strategy may be triggered if (1) an interim goal has not been met; and (2) it has been determined by the County of San Diego through adaptive management that implementation is necessary; and (3) all of the necessary resources have been secured. Resources include: Staff availability, Grant funding or alternative source, Contractor funding, Partnerships, restoration/rehabilitation designs approved, Environmental permits issued, CEQA/NEPA environmental review, and Ongoing funding for maintenance and monitoring.

The subsections below highlight some of the jurisdictional strategies, listed in **Table 4-14**.

4.2.2.2.1 Illicit Discharge Detection and Elimination [Permit Provisions D.2 and E.2]

4.2.2.2.1.1 Address Impacts of Sewers and Septic Systems

Sanitary sewer overflows (SSOs) are typically episodic events but can contribute to nutrient loads if they are not addressed promptly. Although overflows can happen during wet weather, they typically occur most often during dry weather. SSOs may occur from private sewer laterals and from the publicly owned sanitary system when blockages occur due to roots, grease, or other debris.

In addition to SSOs, faulty septic or Onsite Wastewater Treatment Systems (OWTS) can be a source of nutrients in this watershed area. The Local Agency Management Program (LAMP) describes San Diego County procedures for OWTS requiring corrective action. Within 24 hours of a complaint or other notification of a failing OWTS, the San Diego County Department of Environmental Health (DEH) will complete an investigation to determine the validity of the complaint. The LAMP provides DEH with the authority to require action to repair any OWTS within a reasonable time frame. If corrective action is not completed, enforcement will escalate, which may include condemnation of the structure.

4.2.2.2.1.2 Inspections and Enforcement of Illicit Discharges and Connections

Many types of illegal discharges contribute to nutrient loading in stormwater discharge and receiving waters. Illegal connections that convey these discharges are equally problematic. These challenges are typically associated with dry weather, transient in nature, and have been a focal point for the Copermittees' stormwater programs for many years. Full scale elimination of illegal discharges is challenging and requires a societal change in the way water is managed.

The County of San Diego will implement an active field program to better locate and abate illicit dry weather discharges. Potential dry weather discharges will be evaluated through inspections of MS4 outfalls discharging to receiving waters. Staff will spend time present in unincorporated communities identifying nuisance anthropogenic flows and addressing them through appropriate education and enforcement strategies. County of San Diego staff members have been trained to identify and report illicit discharges and illegal connections during required annual storm water training; this training has been updated to reflect recent Permit changes.

4.2.2.2.2 Development Planning [Permit Provision E.3]

4.2.2.2.2.1 Equine Facility BMPs, Manure Management, and Equine BMP Manual Updates

The Lower SMR Subwatershed contains a significant amount of rural residential land uses, where lots tend to be larger and domestic livestock are more common. Several programs are implemented that address domestic animals as sources of nutrients.

If not applied properly, manure can be a significant source of nutrient loading when used as fertilizer. Manure re-use is addressed through several existing programs, in conjunction with existing development requirements. Examples include:

- Composting areas must be located in a fashion so as to prevent runoff to the MS4 or receiving waters.

- Existing development inspections programs provide oversight, outreach, and enforcement where necessary to ensure proper storage and re-use of manure.
- IDDE, monitoring, and source tracking programs are in place to detect discharges and identify sources where manure re-use may be contributing to water quality problems related to nutrient loading.

An effective source control program promotes an inventory and frequent inspection of horse ranches, livestock areas, kennels and other pet service areas. Community outreach tools include education materials that stress manure and wash water management, directing drainage away from and/or around exposed stalls, horse health, and WMA awareness. These BMPs address both commercial and private facilities.

The County of San Diego Equine Best Management Practices Manual has been developed as a resource for horse owners and facilities to manage stormwater runoff. This manual contains helpful information for manure management, dirt access roads and trails, arenas and paddocks, stockpiles, horse wash rack drains, vehicle maintenance, housekeeping, site design, exclusionary fencing, pest management, training and education.

4.2.2.2.2.2 BMP Design Manual Updates and Training

The BMP Design Manual requirements apply to residential, commercial, industrial, educational, and transportation land uses. The Manual guides applicants through the design and submittal process to ensure the necessary stormwater features are being implemented. Project designs must show runoff being infiltrated or else treated by structural BMPs, such as bioretention facilities, planter boxes, filters, settling ponds, or constructed wetlands.

The BMP Design Manual for new development and redevelopment was updated in FY16 and training was provided to County of San Diego staff, followed by the development industry. One-time land development workshops were held to educate the development community on updated requirements, particularly as they pertain to priority sources of bacteria, nutrients, and other pollutants, such as residential areas and commercial areas including nurseries and eating/drinking establishments.

4.2.2.2.3 Construction Management [Permit Provision E.4]

Although development in this region of the watershed is limited, construction sites have the potential to contribute to nutrient loading primarily through ineffective erosion control that can lead to phosphorus-borne sediment entering the receiving water.

The agencies have been implementing construction stormwater programs for several Permit terms. Over this time, agency staff and the construction community have become well trained in construction stormwater management. Additional oversight is required per the State Construction General Permit (Order 2009-0009-DWQ) for sites greater than one acre. With this amount of focus, the limited sources of nutrients related to construction are well addressed via the existing Permit requirements. For this reason, the agencies will focus on the baseline programs as required under the Permit.

For active construction areas, the County routine enforcement measures include Administrative

Warnings and Notices of Violation. Public works projects use construction plans, specifications, and Stormwater Pollution Prevention Plans to effectively eliminate or control pollutant discharge

through stormwater. Adherence with contract provisions is confirmed by inspection staff and enforced using standard payment provisions, liquidated damage clauses, and other means.

4.2.2.2.4 Existing Development Management [Permit Provision E.5]

The Existing Development Management Program addresses a variety of sources including commercial/industrial, residential, and municipal areas and activities. The County of San Diego has an inspection program that addresses each of these sources. Due to the prevalence of rural residential land in this area, jurisdictional strategies will focus on residential inspections to help reduce irrigation runoff and nutrient loading to the receiving water.

4.2.2.2.4.1 Residential Inspections

The "education first" approach is a key component in the County's routine enforcement process within existing residential areas. County staff are also required to inspect structural BMPs and respond to complaints regarding structural BMP performance. Advisory letters, verbal warnings, CARs, and Clean-up and Abatement Notices (through which the County cleans or repairs the structural BMP and then charges the responsible party) are all routinely used as follow up measures, if necessary. As field staff conduct investigations, they maintain records and a database of relevant information for each incident. This information is entered into a database that is used for annual reports submitted to the Regional Water Board.

Educational outreach by the County is developed and implemented based on the following four objectives:

1. Teaching basic awareness;
2. Adapting education to specific target audiences;
3. Clearly describing specific responsibilities under the Watershed Protection Ordinance; and,
4. Providing instruction to successfully implement BMPs, with an emphasis on pollution prevention.

For the residential and general public audiences, the County's educational outreach program, as described in the JRMP, utilizes a multi-media approach. Media types may include print materials, television, radio, websites, billboards, and promotional items. Through joining efforts with the County Water Authority, the County of San Diego has been and continues to work to collaborate on efforts to reduce water use and over-irrigation. Messages and promotional materials have been tailored to promote the use of native or drought-tolerant plants.

Irrigation runoff reduction programs can also be integrated with BMPs that encourage landscaping and gardening practices that reduce the load of fertilizers and chemicals that enter in stormwater, such as integrated pest management, reduction of fertilizer and pesticide use, xeriscaping and turf conversion.

4.2.2.2.4.2 Turf Replacement at Rainbow Park

To reduce irrigation runoff and other dry weather pollutant generating activities from County Parks, the County of San Diego is replacing 95,000 square feet of existing lawn in Rainbow Park with synthetic turf and a sand infill drainage system. This retrofit will begin in 2017, with construction estimated to be completed in 2018.

4.2.2.2.4.3 Rainbow Creek Nutrient Reduction and Management Plan

The Rainbow Creek Nutrient Reduction and Management Plan (NRMP), required by Section B.2 of the Permit, was completed in 2016 and outlines several waste control and cleaning practices for County-responsible sources. Management practices for irrigation, nutrient control, and erosion and runoff are recommended for agricultural operations. The County of San Diego's Department of Agriculture, Weights, and Measures (AWM) is authorized to inspect commercial nurseries and greenhouse facilities and conduct follow up inspections if deficiencies are found.

AWM's inspection frequencies are prioritized based on the facility's assigned threat to water quality, as determined using the methodologies outlined in the County's JRMP, Section 5.2.4. AWM annually inspects all facilities that have been designated as a high threat to water quality. The goal for each inspection is to ensure compliance with the County's Watershed Protection Ordinance. For locations where non-compliance is observed at the time of the inspection, AWM follows the Enforcement Response Plan as described in the JRMP, Section 9.0 and in Section 4.2.2.2.5 below. Consistent with the education first approach taken across the stormwater program, AWM often provides contact information for various organizations that can provide assistance with BMP implementation at agricultural operations, such as Mission Resource Conservation District, Natural Resource Conservation Service and University of California Cooperative Extension Office.

4.2.2.2.4.4 Sustainable Landscapes Retrofit Program

The Sustainable Landscapes Retrofit Program is designed to encourage landscape retrofits to reduce the amount of potable water applied to urban landscapes and minimize pollutant infiltration to local waterbodies. Through an Integrated Regional Water Management Program (IRWMP) grant awarded using state of California Proposition 84 funds, the County of San Diego in concert with other agency and non-government partners is also developing a Sustainable Landscapes Retrofit Program. The Sustainable Landscapes Retrofit Program consists of an integrated set of landscaping practices, including stormwater capture and use, LID and potable water conservation that will help property owners retrofit their high water-use landscaping for more sustainable ones. The program targets residential-scale urban landscapes, and is a collaborative effort among three public agencies. Multipollutant benefits of the program include reduction in nutrients and bacteria from residential areas, nurseries, and greenhouses. The program leads to benefits to water quality improvement and reduced cost for the Copermittees. Reductions in cost are realized from reductions in water use, green waste, labor, fertilizers, pesticides, and carbon dioxide emissions. Target areas include municipal fixed facilities; industrial and commercial facilities; construction sites; residential; general public; land development and redevelopment; streets and parking facilities.

4.2.2.2.4.5 Designate a Minimum Set of BMPs Required for Existing Development Inventories

The County of San Diego has established a set of minimum BMPs to support their jurisdictional strategy implementation. These BMPs are presented in **Table 4-15**.

4.2.2.2.5 Enforcement Response Plans [Permit Provision E.6]

As described in the County of San Diego's Enforcement Response Plan (ERP), a wide range of enforcement 'tools' can be implemented to abate illicit discharges and facilitate compliance.

The primary objective of the ERP is to promote voluntary compliance with applicable ordinances and the NPDES permit provisions. In cases of non-compliance, the ERP provides County staff with several enforcement tools to ensure a return to compliance in a timely manner while following due process. While emphasizing education as the primary means of achieving compliance, the County also has the necessary authority and procedures in place to investigate and enforce in cases of continued non-compliance. In the event that a violation or potential violation may endanger health or the environment, the County may forego the "education first" approach and proceed immediately to more stringent enforcement measures.

4.2.2.2.6 Public Education and Participation [Permit Provision E.7]

Education and outreach programs are implemented to provide the public with resources and incentives to accomplish projects and practices that protect and improve water quality throughout the WMA. The County of San Diego provides manuals for landscaping and BMP design that, if implemented, reduce dry weather flows to the MS4 and ultimately to receiving waters. These manuals include the LID Handbook, the Standard Urban Stormwater Mitigation Plan (SUSMP) (County of San Diego, 2012), the Hydromodification Management Plan (HMP) (County of San Diego, 2011), and the BMP Design Manual (County of San Diego, 2016).

Materials for education and outreach have been developed to focus on prevention of discharges to the MS4 and reduction of pollutants reaching receiving waters. Specific handouts have been created related to over-irrigation that may be distributed to property owners in the WMA. Additionally, promotional items are often distributed and may include pens, pencils, magnets, and rulers, as well as more behavior-specific items including packages of California poppy seeds to promote the use of native or low maintenance plants. All items contain stormwater messages and the County of San Diego Stormwater Hotline and Project Clean Water website. Outreach materials are distributed by County staff during community events, displayed in kiosks at appropriate locations, and supplied to partner organizations to distribute at their facilities.

The County will continue to sponsor workshops for specific target audiences and pollutants of concern, including some that address nutrients such as manure management and composting for horse owners and animal facilities; integrated pest management and gardening workshops for residents interested in gardening and more sustainable landscape practices; and rain water harvesting classes to encourage rainfall capture from roofs for landscape use.

Table 4-15. Minimum BMPs Supporting Jurisdictional Strategy Implementation for the Lower SMR Subwatershed

Best Management Practice Watershed	Pollutant Sources								HPWQC
	Residential	Commercial	Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries	Horse Ranches	Other Agriculture	Open Space	Nutrients
1. Eliminate illicit connections to the municipal separate storm sewer system (MS4).	●	●	●	●	●	●	●		●
2. Eliminate illicit non-storm water discharges.	●	●	●	●	●	●	●	●	●
3. Properly dispose of process and wash water.	●	●	●	●	●	●	●		●
4. Properly dispose of vehicle and equipment wash water/eliminate the discharge of vehicle and equipment was water.	●	●	●	●	●	●	●		
5. Properly dispose of water from fire sprinkler maintenance activities	●	●	●	●	●	●	●		
6. Eliminate pumped groundwater, foundation and footing drain discharges.	●	●	●	●	●	●	●		●
7. Minimize rising groundwater, diverted stream flows, uncontaminated groundwater infiltration, springs, riparian habitat/wetland flows, potable water sources, and foundation/ footing drain discharges.	●	●	●	●	●	●	●	●	●
8. Protect unpaved areas, including landscaping, from erosion using vegetation or physical stabilization.	●	●	●	●	●	●	●	●	●
9. Regularly clean parking lots.	●	●	●	●	●	●	●		
10. Implement good housekeeping to keep site free of trash and debris.	●	●	●	●	●	●	●	●	●
11. Provide and maintain secondary containment to catch spills when storing potential liquid pollutants in outdoor areas.	●	●	●	●	●	●	●		●
12. Properly store and dispose of hazardous substances.	●	●	●	●	●	●	●		●
13. Cover, contain, and/or elevate materials stored outside that may become a source of pollutants in storm water or non-storm water.	●	●	●	●	●	●	●		●
14. Label containers to prevent mishandling of hazardous materials and other potential pollutants.	●	●	●	●	●	●	●		●

Best Management Practice Watershed	Pollutant Sources								HPWQC
	Residential	Commercial	Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries	Horse Ranches	Other Agriculture	Open Space	Nutrients
15. Develop a written plan that identifies appropriate BMPs, including spill response, and includes procedures for proper implementation.	●	●	●	●	●	●	●		●
16. Prevent or capture liquid leaks from vehicles and equipment.	●	●	●	●	●	●	●		
17. Maintain a readily accessible spill cleanup kit that is appropriate for the type of material stored.	●	●	●	●	●	●	●		●
18. Immediately clean up spills.	●	●	●	●	●	●	●		●
19. Temporarily protect MS4s from non-storm water discharges while conducting activities that have the potential to result in a discharge.	●	●	●	●	●	●	●	●	●
20. Implement a pollution prevention system for uncovered outdoor sources of pollutants.	●	●	●	●	●	●	●	●	●
21. Train appropriate employees on storm water pollution prevention.	●	●	●	●	●	●	●	●	●
22. Keep trash/waste storage areas free of exposed trash, sediment, and debris.	●	●	●	●	●	●	●	●	●
23. Protect waste storage areas from contact with storm water and non- storm water flows on to the property.		●	●	●	●	●	●	●	●
24. Eliminate irrigation runoff.	●	●	●	●	●	●	●		●
25. Eliminate nursery irrigation discharges.	●	●	●		●				●
26. Properly dispose of discharges from swimming pools, spas, fountains, reflective pools, ponds, and filter backwash.	●	●	●	●					●
27. Control air conditioning condensation discharges.	●	●	●	●	●	●			●
28. Eliminate floor mat cleaning discharges.	●	●	●	●					●
29. Regularly clean and maintain structural BMPs and LID installations to ensure proper performance.	●	●	●	●	●	●	●		●

Best Management Practice Watershed	Pollutant Sources								HPWQC
	Residential	Commercial	Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries	Horse Ranches	Other Agriculture	Open Space	Nutrients
30. Keep storm drain inlets and under drains free of sediment, trash, and debris.	●	●	●	●	●	●	●		●
31. Properly manage pesticides and fertilizers.	●	●	●	●	●	●	●		●
32. Implement controls to prevent pollution from exposed outdoor work areas.	●	●	●	●	●	●	●		●
33. Drain fluids from inoperable vehicles and store or dispose of appropriately.	●	●	●	●	●	●	●		
34. Provide pollution prevention signage for storm drains.	●	●	●	●	●	●	●		●
35. Properly store and dispose of green waste.	●	●	●	●	●	●	●		●
36. Manage animal waste and animal washing in a manner that prevents transport of wastes and wash water off-site.	●	●	●	●	●		●		●

4.2.2.3 Optional Strategies

Optional jurisdictional strategies include those that the Copermittees may implement if necessary to achieve interim and final numeric goals. Implementation of the optional strategies will be contingent on circumstances supported by the need for the additional effort, the cost/benefit as compared to other options and strategies, and the availability of funding. Optional jurisdictional strategies for the County of San Diego in the Lower SMR Subwatershed are listed above in **Table 4-14**. The subsections below summarize the optional strategies, or combinations of optional strategies.

4.2.2.3.1 Dry Weather Flow Diversion

Diverting persistent dry weather flows to sanitary sewers reduces nutrient loading to the receiving water. This strategy addresses nuisance dry weather flows from the MS4 and pollutants from roads, streets, and parking lots. Structural BMPs will also be implemented within the County of San Diego's jurisdiction. The County of San Diego will take into account the locations of existing structural controls when considering future implementation efforts and potential locations for structural controls.

Implementation of this strategy may be triggered if:

1. An interim goal has not been met;

2. It has been determined by the County of San Diego, through adaptive management, that implementation is necessary;
3. Permission is granted from wastewater collection agency;
4. Permitted discharges have been ruled out; and
5. All of the necessary resources have been secured. Resources include staff availability, grant funding or alternative source, contractor funding, engineering design, environmental review, permits, ongoing funding for operation/maintenance.

4.2.2.3.2 Promote Incentive Programs for BMP Retrofits

Another tactic for addressing the source of nutrient loading in this area is the increased promotion and support of incentives targeted to promote water conservation and landscape retrofits through partner agencies (including Metropolitan Water District, local water districts, and the San Diego County Water Authority). Examples of these incentive programs include payments for things such as turf replacement, sprinkler head nozzle replacements, smart irrigation controllers, rain barrels, etc. These incentive programs can be an important tool in creating change at the individual level and could be promoted until resources are depleted. Programs that support landscape retrofits will target sources of wet and dry weather flows that can mobilize nutrients, particularly those associated with residential areas as well as roads, streets, and parking. The Sustainable Landscapes Retrofit Program is also currently being implemented to encourage landscape retrofits at nurseries and greenhouses, as well as residential areas. The Sustainable Landscapes Retrofit Program is discussed in greater detail in **Section 4.2.2.2.4**.

Implementation of this strategy will be triggered if:

1. An interim goal has not been met;
2. It has been determined by the County of San Diego through adaptive management that implementation is necessary;
3. Pilot program success and;
4. All of the necessary resources have been secured. Resources include staff availability, grant funding or alternative funding source, incentive items, and establishment of partnerships.

4.2.2.3.3 Septic System Rebate Programs

Many properties in this area operate onsite wastewater treatment systems. Improperly maintained OWTS can be a source of nutrients. If funding were available, a Septic System Rebate Program could be implemented. This rebate program would be designed to target nutrient loading by promoting frequent inspection and pumping, which can prevent septic system failures. Additional resources to educate property owners of recommended maintenance activities and preventative measures, such as what not to put into the system and how to avoid overloading their residential septic systems, could be developed and made available. Rebates would be available on a first-come, first serve basis as funding allows.

Rebate and inspections programs as an optional jurisdictional strategy would be triggered if:

1. An interim goal has not been met;

2. It has been determined by the County of San Diego through adaptive management that implementation is necessary;
3. Pilot programs have demonstrated success; and
4. All of the necessary resources have been secured. Resources include staff availability, grant funding or alternative source, contractor funding, partnerships, and incentive items.

4.2.2.3.4 Green Streets Retrofit Program

The County of San Diego utilizes LID projects and green street designs to effectively reduce flows during storm events and to reduce nutrient concentrations by retrofitting impervious areas. Green infrastructure aims to incorporate elements found in natural areas into the road right-of-way to provide water quality and community benefits. Green streets, in particular, can consist of multiple BMP types implemented in a linear manner within the road right-of-way. Placing BMPs within the right-of-way provides an additional opportunity to treat urban storm water runoff, attenuate peak flow, and reduce discharge volume while improving community pride, land value, and habitat quality. Green streets also provide the added benefit of treating runoff from both the roadway and contributing parcel.

This strategy would be implemented if:

1. An interim goal has not been met;
2. It has been determined by the County of San Diego, through adaptive management, that implementation is necessary;
3. Pilot program success; and
4. All of the necessary resources have been secured. Resources include staff availability, grant funding or alternative funding source, contractor funding, engineering or landscaping design, permits, environmental review, right of way acquisition, and ongoing funding for operation/maintenance.

4.2.2.3.5 Flood Control Channel Rehabilitation Projects

Examples of potential rehabilitation projects include partial or total removal of impervious lining in the flood control channel and replacement with an earthen or vegetated surface. These projects can result in nutrient and sediment load reductions and restoration of aquatic habitat and vegetation. They may also provide educational opportunities and lead to greater public understanding of water quality protection and improvement actions. Rehabilitation projects are expected to address nutrient loading in receiving waters.

Implementation of this strategy may be triggered if:

1. An interim goal has not been met;
2. It has been determined by the County of San Diego, through adaptive management, that implementation is necessary;
3. Engineering design, monitoring, and outreach plans are approved; and
4. All of the necessary resources have been secured. Resources include staff availability, grant funding or alternative source, contractor funding, partnerships, restoration / right of way acquisition, California Environmental Quality Act (CEQA)/National Environmental Policy

Act (NEPA) environmental review, environmental permits issued, and ongoing funding for maintenance and monitoring.

4.2.2.3.6 Stream Restoration Projects

Increased runoff volumes and velocities from natural wet weather events and increased urban development can result in erosion of stream banks and channels and degrade or alter natural systems. Erosion can result in large quantities of sediment and sediment-bound pollutants such as phosphorus entering the water column and traveling downstream, where it can contribute to nutrient loading in the SMR Estuary. A stream restoration project could be designed to reduce nutrient loading and is expected to have supplemental reductions to bacteria and sediment.

The stream restoration remedy includes the following proposed options, as funds are available and pending approval of environmental documents, obtaining permits, and the feasibility of effectiveness:

- Widening or modifying the impaired creek channel to disperse and slow flow to increase residence time and nutrient uptake.
- Re-sloping streambanks to reduce erosion and Total Suspended Solids (TSS) and nutrient loading downstream.
- Streambank stabilization by revetments, log cribs, groins, or gabions reduce erosion and TSS and nutrient loading downstream.
- Floodplain restoration and reconnection with the stream course to increase retention time and groundwater recharge.
- Restored native basins to temporarily capture and reduce flow and promote nutrient uptake and groundwater recharge.
- Refurbishment of existing basins for desilting and groundwater recharge.
- Replacing invasive vegetation species with native vegetation that has increased nutrient uptake.

Implementation of this strategy may be triggered if:

1. An interim goal has not been met;
2. It has been determined by the County of San Diego, through adaptive management, that implementation is necessary; and
3. All of the necessary resources have been secured. Resources include staff availability, grant funding or alternative source, contractor funding, partnerships, approved restoration/rehabilitation designs, CEQA/NEPA environmental review, environmental permits issued, and ongoing funding for maintenance and monitoring.

4.2.3 Optional WMA Strategies

The Copermittees and the City of Menifee have identified multiple coordinated efforts (i.e., optional regional or multijurisdictional WMA strategies) to be implemented to address eutrophication impacts and nutrient loading within the SMR watershed. The optional WMA strategies differ from the optional jurisdictional strategies in that they are a coordinated effort

amongst two or more jurisdictions working collaboratively, at a regional, WMA, or multi-jurisdictional level within the SMR WMA towards common goals within the watershed. Collaboration potentially increases efficiency and effectiveness in addressing sources through economies of scale (e.g., watershed-wide outreach approaches or incentive programs to address over-irrigation, in-stream rehabilitation to reduce eutrophication within waterbodies). The coordinated efforts are summarized in **Table 4-16**.

As part of the five-year assessment process, implementation of strategies will be evaluated against progress to goals. Where interim goals are met and the current implementation approach is determined to be effective enough to achieve the next interim or final goal, Copermittees and the City of Menifee may adjust current strategies, but will likely not implement optional WMA strategies. Where interim goals are not achieved, and/or it is determined to be unlikely that current implementation levels will achieve future interim or final goals, optional WMA strategies may be triggered and implemented as resources allow. Implementation of the optional WMA strategies will be contingent on circumstances supported by the need for the additional effort, the expected efficiency and effectiveness of the strategy as compared to other options and strategies, and the availability of funding. The process to trigger the watershed strategies are specific to the individual WMA strategy, and are largely dependent on necessity and availability of funding. Each of the WMA strategies is included as an option moving forward for all jurisdictions; however, specific projects for implementation may only include a subset of the jurisdictions, depending on the applicability of the WMA strategy to the jurisdiction.

Table 4-16. Collaborative WMA Strategies for the SMR WMA

Optional WMA Strategy	Implementation Timeframe/ Schedule	RCFCWCD	County of Riverside	County of San Diego	City of Menifee	City of Murrieta	City of Temecula	City of Wildomar	Triggers	Resources	Pollutant Sources	HPWQC	Priority Water Quality Conditions						
												Eutrophication (Nutrients)	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	Industry
Incentive programs to reduce non-stormwater and stormwater runoff (e.g., drought tolerant landscaping, rain barrel program, turf replacement).	Implemented starting in the following fiscal year after triggered.	•	•	•	•	•	•	•	Implementation of this strategy may be triggered if (1) an interim goal has not been met; and (2) it has been determined through adaptive management that implementation is necessary and that this approach would help to address sources of nutrient loading; and (3) all the necessary resources have been secured.	(1) Willing partners (e.g., Water Districts, other municipalities); (2) funding necessary to contribute to a program; (3) if resources are unavailable, implementation would be contingent on receipt of grant funding	Sources within upstream catchment area (to be determined)	•	•	•	•	•	•	•	•
Regional dry weather inspector(s): Inspect areas watershed-wide for anthropogenic sources of dry weather flow, gather Permit-required information, conduct outfall screening, follow a developed SOP, and alert responsible Copermittee when issues are observed.	Implemented within two fiscal years after triggered.	•	•			•	•		Implementation of this strategy may be triggered if (1) an interim goal has not been met; and (2) it has been determined through adaptive management that implementation is necessary and that this approach would help to address sources of nutrient loading; and (3) all the necessary resources have been secured.	(1) Funding for one full time position within an agency in the watershed or contract supported by other Copermittees within the watershed (2) Each Copermittee would need available staff resources to respond to identified problems and proceed with enforcement as necessary	Dry weather flows from targeted areas	•	•	•	•	•	•	•	•
In-stream strategies, including watercourse rehabilitation to provide natural uptake of nutrients, increase shading, or modify physical factors to reduce algal growth.	Allow 2-5 years for design, permit, and construction once triggered.	•	•	•	•		•		Implementation of this strategy may be triggered if (1) an opportunity for a project is identified that would effectively address problems within the watershed; and (2) an interim goal has not been met; and (3) Copermittees with jurisdiction are willing participants in the project; and (4) all necessary resources and permits have been secured.	A stream restoration project would require the following resources: 1) Studies to identify suitable sites; 2) Evaluation of feasibility; 3) Engineering design plans; 4) Capital Improvement Program funding secured; 5) Land acquisition and/or private-public partnership agreements (as necessary); 5) Construction contract bid/award; 6) Project construction; 7) Adequate resources for operation and maintenance	Sources within upstream catchment area (to be determined)	•	•	•	•	•	•	•	•
Regional dry weather retrofits or incentives for retrofits for existing development to reduce/eliminate dry weather flows.	Allow 2-5 years for design, permit, and construction once triggered.	•	•				•		Implementation of this strategy may be triggered if (1) an interim goal has not been met; and (2) it has been determined through adaptive management that implementation is necessary; and (3) all the necessary resources have been secured.	Retrofit program would require the following resources: 1) In-field evaluation of suitable sites for infiltration or diversion to sanitary sewer; 2) Evaluation of feasibility; 3) Engineering design plans; 4) Capital Improvement Program funding secured; 5) Land acquisition and/or private-public partnership agreements (as necessary); 5) Construction contract bid/award; 6) Project construction; 7) Adequate resources for facility operation and maintenance	Dry weather flows from targeted areas	•	•	•	•	•	•	•	•

Optional WMA Strategy	Implementation Timeframe/ Schedule	RCFCWCD	County of Riverside	County of San Diego	City of Menifee	City of Murrieta	City of Temecula	City of Wildomar	Triggers	Resources	Pollutant Sources	HPWQC	Priority Water Quality Conditions						
												Eutrophication utrients)	Recreation	Physical Habitat	Toxicity	Nuisance (Trash)	Water Supply	Agricultural Supply	Industry
Coordinate with Integrated Regional Water Management (IRWM) regional water managers to plan for and implement water quality improvement projects (retrofits, stream rehabilitation, or other projects) that will address nutrients and/or dry weather flows.	As triggered	•		•					Participation as stakeholder in IRWM program will occur, as needed and if funded, to promote applicable project adoption in the SMR WMA.	Individual projects and further participation in grant funding offered through IRWM assessed on case-by-case basis.	Sources within upstream catchment area (to be determined)	•	•	•	•	•	•	•	•
Participate in Santa Margarita River Watershed Nutrient Initiative - Stakeholder Group as a collaborative effort to reduce nutrients and dry weather flows.	Ongoing	•	•	•		•	•	•	Ongoing participation. This work is a follow-on effort to the 2006 San Diego Lagoons Investigative Order (R9-2006-0076; Lagoon Order) and subsequent work plan developed jointly by the Regional Water Board and WMA stakeholders.	Funding for staff support within an agency or contract supported by other Copermittees within the watershed	Sources within upstream catchment area (to be determined)	•							

The subsections below summarize the WMA strategies, or combinations of collaborative WMA strategies, listed in **Table 4-16**.

4.2.3.1 Santa Margarita River WMA Nutrient Initiative Group

Copermittees will continue to participate in the SMRNIG efforts so long as that group is active. The SMRNIG is further described in **Chapter 2**. SMRNIG efforts include evaluation of implementation scenarios, conducting studies, and providing a forum for development of collaborative watershed strategies with other stakeholders.

4.2.3.2 Permitted Flow Assessment

The Copermittees will also implement additional strategies designed to gather data and improve their understanding of conditions in the watershed. Assessments and evaluations of permitted non-stormwater discharges and a watershed management area analysis are currently planned for implementation and are described below. Permitted flow assessments are anticipated to begin upon acceptance of the WQIP.

To address MS4s with anthropogenic dry-weather flow, the Copermittees will conduct an assessment of flows from MS4 outfalls to determine which flows should be addressed by the Copermittee, and which flows are permitted, or required to be permitted by others, or those flows originating from lands outside the Copermittees' jurisdiction (e.g., Tribal Lands). The assessment will include the following components:

- Work with the Regional Water Board to conduct an inventory of permitted discharge and recycled water conveyances (purple pipes);
- Complete an inventory of natural sources (rising groundwater, springs, etc.); and
- Conduct a flow and load characterization.

As a component of the assessment, a monitoring plan to identify permitted discharges will be developed within the Monitoring and Assessment Program (Permit Provision D). The permitted flow assessment will be initiated during FY 2017/2018, and completed during FY 2020/2021.

4.3 WATERSHED MANAGEMENT AREA ANALYSIS

The Copermittees within the Middle and Lower SMR Subwatersheds have developed a Watershed Management Area Analysis (WMAA), which is an optional task for the purpose of developing watershed-specific requirements for structural BMP implementation. The WMAA is a watershed-scale analysis that identifies important characteristics, such as hydrologic process categories and stream descriptions. The final output of the analysis includes geographic information system (GIS) layers that Copermittees may use to identify candidate projects as offsite alternative compliance options. The WMAA also develops analyses and information to support exemptions from the on-site hydromodification management BMP requirements. Per Permit Provision B.3.b.(4)(a), the WMAA includes the following:

(i) A description of dominant hydrologic processes, such as areas where infiltration or overland flow likely dominates;

(ii) A description of existing streams in the watershed, including bed material and composition, and if they are perennial or ephemeral;

(iii) Current and anticipated future land uses;

(iv) Potential coarse sediment yield areas; and

(v) Locations of existing flood control structures and channel structures, such as stream armoring, constrictions, grade control structures, and hydromodification or flood management basins.

The WMAA also includes a list of candidate projects that could be used as alternative compliance options for Priority Development Projects (PDPs). The WMAA is included as **Appendix 4B** and will be incorporated into the WQIP as part of the adaptive management process.

The Permit allows Copermittees to develop a program as part of their overall JRMP that potentially allows development projects to participate in offsite alternative compliance projects that yield greater overall water quality benefit to the WMA. The Copermittees may use the data generated from the characterization analyses indicated above for two purposes:

(1) To identify candidate projects that could potentially be used as offsite alternative compliance options in lieu of satisfying full onsite retention, biofiltration, and hydromodification management control requirements as is required for PDPs.

(2) To identify and/or prioritize areas where it is appropriate to allow certain exemptions from onsite hydromodification management BMPs.

The updated WMAA builds upon work completed in the 2015 San Diego County Regional Watershed Management Analysis. (http://www.projectcleanwater.org/watershed-management-area-analysis-wmaa) The San Diego analysis developed the tools and mapping for the Lower SMR Subwatershed. This analysis extends into the Middle SMR Subwatershed, and studies hydromodification susceptibility of the SMR to the Pacific Ocean. The WMAA will develop WMA-specific requirements for structural BMPs and identify candidate projects related to hydromodification, stream restoration, or structural BMPs. The elements of the analysis are specific to all Copermittees within the SMR Region, which includes County of Riverside, RCFCWCD, City of Wildomar, City of Murrieta, City of Temecula, and County of San Diego.

5 Monitoring and Assessment Program

Chapter 5 outlines procedures to support assessment of progress toward numeric goals and schedules, progress addressing eutrophication impacts and nutrient loading, and each Copermittee's overall efforts to implement the WQIP. In conducting previous NPDES MS4 Permit required monitoring and by participating in various regional monitoring efforts over the past 20 years, the Copermittees have established water quality monitoring stations throughout the SMR WMA. A select number of existing monitoring stations will continue to be monitored. In addition, new monitoring stations to fulfill requirements not contained in previous versions of the Permit have been identified. The quantity and required characteristics of these new monitoring stations are described under the applicable program component in the sections below. The reporting year for the Monitoring and Assessment Program (MAP) extends from October 1st to September 30th of the following year.

5.1 SMR WMA MAP DESCRIPTION

The SMR WMA MAP includes the Receiving Water Monitoring Program, the MS4 Outfall Discharge Monitoring Program, Special Studies, and Assessment Program. The SMR WMA MAP is designed to determine the following:

- The long-term receiving water trends and whether conditions in receiving waters are improving;
- If urban runoff is contributing to exceedances of WQOs and impacting beneficial uses of receiving waters;
- Pollutant sources and/or stressors;
- The effectiveness of the Copermittees' JRMP toward effectively prohibiting non-storm water discharges into the MS4 and reducing pollutants in stormwater discharges from their MS4s to the MEP; and
- Progress of the water quality improvement strategies implemented as part of this WQIP toward achieving numeric goals and schedules, addressing the HPWQC, and achieving compliance with the discharge prohibitions of the Permit.

5.2 SMR WMA MAP MONITORING QUESTIONS

The SMR WMA MAP is designed to evaluate and address current and/or potential water quality issues in the SMR WMA that may be impacted by discharges of urban runoff from the MS4. The data collected under the MAP will be used to assess the effectiveness of strategies and progress to numeric goals for the WMA. The SMR WMA MAP is designed with the overall goal of answering the following monitoring questions in support of the numeric goals for the WMA presented in **Chapter 4**:

- How much has total nitrogen and total phosphorus loading been reduced in the SMR watershed?
- How much has non-storm water flow been reduced at Copermittee outfalls?

- How much has total nitrogen and total phosphorus loading been reduced at Copermittee outfalls?
- Are there sources of pollutants outside of Copermittee control causing exceedances of targets?

5.3 GENERAL SCOPE OF MONITORING

The monitoring component of the SMR WMA MAP includes the following programs:

1. **Receiving Water Monitoring**
    - Wet Weather Receiving Water Monitoring Program
        - Field Observations and Monitoring, Analytical, and Toxicity
    - Dry Weather Receiving Water Monitoring Program
        - Field Observations and Monitoring, Analytical, Toxicity, Bioassessment, and Hydromodification
    - Regional Monitoring Programs
        - Storm Water Monitoring Coalition (SMC) Regional Monitoring
        - Southern California Bight (Bight) Regional Monitoring
    - Sediment Quality Monitoring Program
    - TMDL Monitoring
2. **MS4 Outfall Monitoring**
    - Wet Weather MS4 Outfall Discharge Monitoring Program
        - Field Observations and Monitoring, Analytical
    - Dry Weather MS4 Outfall Discharge Monitoring Program
        - MS4 Outfall Discharge Field Screening Monitoring
        - Non-Storm Water Persistent Flow MS4 Outfall Discharge Monitoring (including field observations and analytical)
3. **Special Studies**
    - WMA Special Study
    - San Diego Region Special Study

Table 5-1 provides a summary of the major monitoring programs. All monitoring activities are intended to be conducted in general conformance with the recommended protocols provided by the SWAMP. Monitoring program elements are described in the sections to follow, and additional program details for individual monitoring programs are discussed in **Appendix 5A**. The SMR WMA MAP will be reviewed annually, as necessary, and any updates will be submitted to the Regional Water Board as part of the WQIP Annual Report.

Receiving water monitoring will consist of time-weighted or flow-weighted composite samples collected by automated samplers, in addition to grab samples, field measurements, visual

observations, and bioassessment. Wet weather MS4 outfall monitoring will use time-weighted or flow-weighted composite sampling in wet weather, and grab sampling for appropriate analytes. Dry weather MS4 outfall monitoring will generally use a grab sampling approach. When feasible and required, a regional watershed approach is implemented for elements of the monitoring program to enhance consistency of monitoring data within the San Diego Region. Monitoring of wet weather and dry weather flows is included in this SMR WMA MAP. Available USGS gauging station data may be used for continuous flow measurements as applicable. Monitoring events will be coordinated by the Copermittees, and/or with consultants authorized to monitor on behalf of the Copermittees.

Table 5-1. Summary of Monitoring Programs

SMR WMA MAP Component	# Events	Sample Type	Analyses	Permit Provision
Wet Weather Receiving Water Monitoring Program (**Section 5.3.1.1**)	Three per permit term according to sampling schedule[1]	Field Observations	Location, date, duration of storm event, rainfall estimate of storm event, duration between storm event sampled and the end of previous measurable (> 0.1 inch rainfall) storm event. Flow rate and volume. Station condition. Presence and assessment of trash.	D.1.d.(1)
		Field Monitoring	pH, temperature, specific conductivity, dissolved oxygen, and turbidity.	D.1.d.(2)
		Analytical Monitoring	As outlined in **Appendix 5A**.	D.1.d.(3)
		Toxicity	Freshwater testing (salinity < 1 ppt): *Pimephales promelas* (Fathead Minnow), *Ceriodaphnia dubia* (Daphnid), *Selenastrum capricornutum* (Green Algae). Marine and Estuarine testing (salinity ≥ 1 ppt): *Strongylocentrotus purpuratus* (Purple Sea Urchin).	D.1.d.(4)
Dry Weather Receiving Water Monitoring Program (**Sections 5.3.1.1**, **5.3.1.2, and 5.3.1.3**)	Three per permit term according to sampling schedule[2]	Field Observations	Station identification and location, presence of flow, or pooled or ponded water, flow estimation and characteristics, pooled or ponded water characteristics (if applicable), and station description. Presence and assessment of trash.	D.1.c.(1)
		Field Monitoring	pH, temperature, specific conductivity, dissolved oxygen, and turbidity.	D.1.c.(2)
		Analytical Monitoring	As outlined in **Appendix 5A**.	D.1.c.(3)
		Toxicity	Freshwater testing (salinity < 1 ppt): *Pimephales promelas* (Fathead Minnow), *Ceriodaphnia dubia* (Daphnid), and *Selenastrum capricornutum* (Green Algae). Marine and Estuarine testing (salinity ≥ 1 ppt): *Strongylocentrotus purpuratus* (Purple Sea Urchin).	D.1.c.(4)

SMR WMA MAP Component	# Events	Sample Type	Analyses	Permit Provision
	Once per Permit term according to sampling schedule	Bioassessment Monitoring	Macroinvertebrate samples, physical habitat characterization, freshwater algae, and Index of Biological Integrity (IBI) or California Stream Condition Index (CSCI) for benthic macroinvertebrates and algae.	D.1.c.(5)
		Hydromodification Monitoring	Channel conditions, location of discharge points, habitat integrity, photo documentation, channel erosion dimensions, causes of erosion/habitat impact.	D.1.c.(6)
Rainbow Creek Nutrient TMDL Monitoring (**Section 5.3.1.6**)	12 per year (monthly)	Field Observations	Presence of flow and flow rate estimation. Visual observations of odor, color, clarity, floatables, deposits, vegetation and biology.	Attachment E.3.d.(1)
		Field Monitoring	pH, temperature, specific conductivity, dissolved oxygen, and turbidity.	Attachment E.3.d.(1)
		Analytical Monitoring	TDS, dissolved iron, sulfates, ammonia, nitrate, nitrite, organic nitrogen, TKN, total phosphorus, and dissolved ortho-phosphate.	Attachment E.3.d.(1)
Regional Monitoring Programs (**Section 5.3.1.4**)	Annually	SMC Regional Monitoring	Bioassessment monitoring, flow, conventional parameters, nutrients, flow regime, vertebrate occurrence, hydromodification screening and channel engineering checklist (at trend sites).	D.1.e.(1)(a)
Regional Monitoring Programs (**Section 5.3.1.4**)	Every five years	Bight Regional Monitoring	Sediment chemistry, toxicity, and benthic macroinvertebrate community sampling per SQO requirements.	D.1.e.(1)(b)

SMR WMA MAP Component	# Events	Sample Type	Analyses	Permit Provision
Sediment Quality Monitoring Program (**Section 5.3.1.5**)	One event every five years (follow-up sampling as needed)	Sediment Quality Monitoring (may be fulfilled by Bight Monitoring)	Sediment chemistry, toxicity, and benthic macroinvertebrate community sampling per SQO requirements and in accordance with Sediment Monitoring Plan and QAPP (Weston 2014).	D.1.e.(2)
Wet Weather MS4 Outfall Discharge Monitoring Program (**Section 5.3.2.1**)	Once per year at each Copermittee wet weather representative outfall monitoring station	Field Observations	Location, date, duration of storm event, rainfall estimate of storm event, duration between storm event sampled and the end of previous measurable (> 0.1 inch rainfall) storm event. Flow rate and volume.	D.2.c.(3)
		Field Monitoring	pH, temperature, specific conductivity, dissolved oxygen, and turbidity.	D.2.c.(4)
		Analytical Monitoring	As outlined in **Appendix 5A**.	D.2.c.(5)
Dry Weather MS4 Outfall Discharge Monitoring Program (**Sections 5.3.2.2** and **5.3.2.3**)	Two per year at 80% of Copermittee major outfalls	Field Screening Monitoring	Station ID and location, flow (presence, estimation, characteristics, sources) pooled/ponded water (characteristics, sources), station condition, presence and assessment of trash, and evidence of illicit connection or illegal dumping.	D.2.b.(1)
	Two per year at each Copermittee highest priority persistent flow monitoring station	Field Observations	Location, date, duration of storm event, rainfall estimate of storm event, duration between storm event sampled and the end of previous measurable (> 0.1 inch rainfall) storm event. Flow rate and volume.	D.2.b.(2).(c)
		Field Monitoring	pH, temperature, specific conductivity, dissolved oxygen, and turbidity.	D.2.b.(2).(d)
		Analytical Monitoring	As outlined in **Appendix 5A**.	D.2.b.(2).(e)

SMR WMA MAP Component	# Events	Sample Type	Analyses	Permit Provision
Rainbow Creek Progress to Goals Outfall Monitoring (**Section 5.3.2.4**)	At least four times per year	Field Observations	Presence of flow and flow rate estimation. Visual observations of odor, color, clarity, floatables, deposits, vegetation and biology.	Not required
WMA Special Study (**Section 5.3.3**)	On-going	SMRNIG Study	Algal bioassessment, dissolved oxygen, pH, temperature, conductivity, nutrients, water level, velocity, and discharge.	D.3.a.(1)
San Diego Region Special Study (**Section 5.3.3**)	On-going	SMC CLEAN (In-kind) Analytical and Field Monitoring	Nutrients, Indicator bacteria, metals, pH, temperature, specific conductivity, dissolved oxygen, and turbidity.	D.3.a.(2)

1. At least one wet weather monitoring event will be conducted during the first storm of wet season (October 1 – April 30) that meets mobilization criteria, and at least one wet weather monitoring event that occurs after February 1st.
2. At least one monitoring event will be conducted during the dry season (May 1 – September 30) and at least one monitoring event will be conducted during a dry weather period (i.e., antecedent dry period of at least 72 hours following a storm event producing measurable rainfall of greater than 0.1 inch) after the first measurable storm of the wet season (October 1 – April 30).

5.3.1 Receiving Water Monitoring

The Receiving Water Monitoring Program is designed to monitor the condition of the receiving waters in the SMR WMA during dry weather and wet weather conditions. Long-term receiving water monitoring will be conducted to assess the long-term trends and to evaluate attainment of numeric goals established in **Chapter 4**, as applicable and as further described in **Section 5.4.1**. The Permit requires receiving water monitoring at one long-term receiving water monitoring station from among the existing mass loading stations, temporary watershed assessment stations, bioassessment stations, and stream assessment stations previously established by the Copermittees to be representative of the receiving water quality in the SMR WMA; however, three long-term receiving water monitoring stations will be monitored within the WMA to ensure that differences in receiving water quality between the Upper, Middle, and Lower SMR Subwatersheds are adequately characterized. The three long-term receiving water monitoring stations will allow the Copermittees to assess the long-term trends and determine if conditions in receiving waters are improving.

In addition, the long-term receiving water monitoring stations will provide data that is representative of the overall health of the upstream waterbodies. For example, the median total nitrogen and total phosphorus results observed at the long-term receiving water monitoring station at the base of the Middle SMR Subwatershed are 0.70 mg/L and 0.12 mg/L, respectively. These median values fall within the range of the median values observed at the receiving water sites historically monitored within the Middle SMR Subwatershed.[18]

The District conducted reconnaissance to identify a new long-term receiving water monitoring station to be representative of the Upper SMR Subwatershed. The preferred site is located on Wilson Creek a few miles upstream of Vail Lake (**Figure 5-2**). The District will coordinate with the Rancho California Water District, County Transportation, or private property owner to establish long-term access to conduct monitoring at this location. As shown in **Figure 5-1**, Wilson Creek drains a substantial portion of the Upper SMR Subwatershed which includes a variety of land uses. Therefore, the new long-term receiving water station on Wilson Creek should be representative of the receiving water quality in Upper SMR Subwatershed. If long-term access cannot be established at the preferred station, then the new long-term receiving water station will be established at an alternative site on Wilson Creek, or on Temecula Creek as identified in **Figure 5-2**.

Monitoring is required during three wet weather events and three dry weather events per permit term. Both composite and grab sampling regimes will be used for sample collection during dry and wet weather events. Field observations and collection of field monitoring data will be conducted at the stations during all dry and wet weather events.

5.3.1.1 Receiving Water Wet Weather Monitoring and Dry Weather Monitoring

Three receiving water monitoring stations will be monitored. The locations are summarized in **Table 5-2** and mapped in **Figure 5-1** and **Figure 5-2**, respectively. The receiving water

[18] The ranges of median total nitrogen and total phosphorus results for all receiving water sites located within the Middle SMR subwatershed with a minimum sample size of four are 0.60 mg/L to 2.4 mg/L and 0.09 mg/L to 0.78 mg/L, respectively.

monitoring stations were determined by a selection process considering, but not limited to, representativeness, accessibility, safety, and hydrologic considerations.

Table 5-2. Long-Term Receiving Water Monitoring Station Locations

Station Name	Station ID	Latitude[1]	Longitude[1]
Upper Santa Margarita River, d/s confluence[2]	902USM828	33.4740	-117.1423
Wilson Creek[3]	902WLC650	33.4874	-116.9166
Lower Santa Margarita River, u/s Camp Pendleton[4]	SMR-MLS-2	33.3981	-117.2627

1. Latitudinal and longitudinal coordinates are approximate. Actual sampling location(s) may be adjusted accordingly based on monitoring and assessment criteria.
2. Station is representative of the receiving water quality from the Middle SMR.
3. Station is representative of the receiving water quality from the Upper SMR. This location on Wilson Creek has been selected as the new long-term receiving water station. In the event that long-term access cannot be established (e.g., access permissions or safety constraints) an alternative station on Wilson Creek at Sage Road (33°29'10.96"N/116°54'41.75"W), or at Upper Temecula Creek at Highway 79 (33°28'1.01"N/116°55'57.66"W) will be considered for selection as the long-term receiving water monitoring station representative of the Upper SMR Subwatershed.
4. Station is representative of the receiving water quality from the Lower SMR.

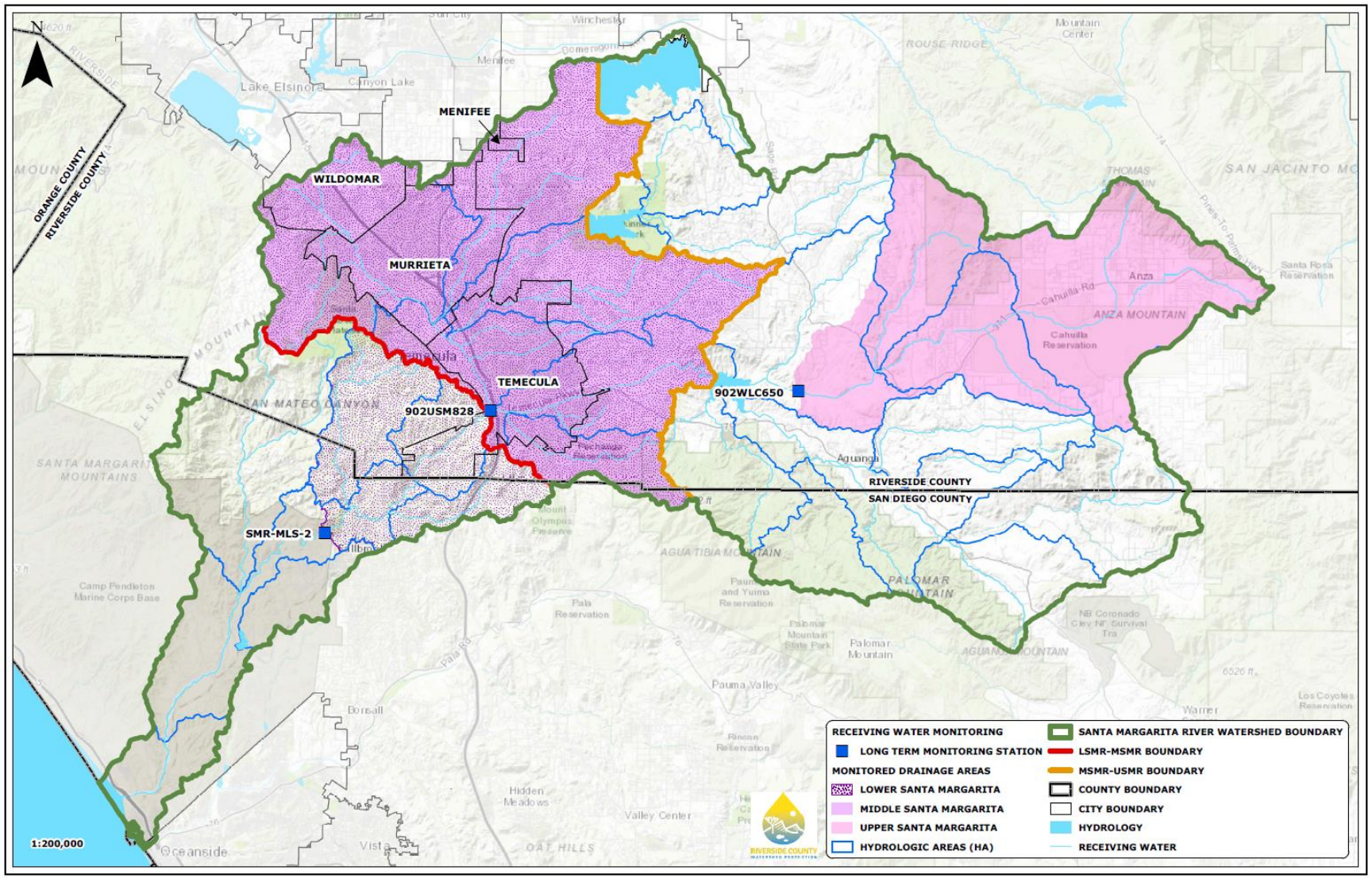

Figure 5-1. Long-Term Receiving Water Monitoring Station Locations for Upper, Middle, and Lower SMR Subwatersheds

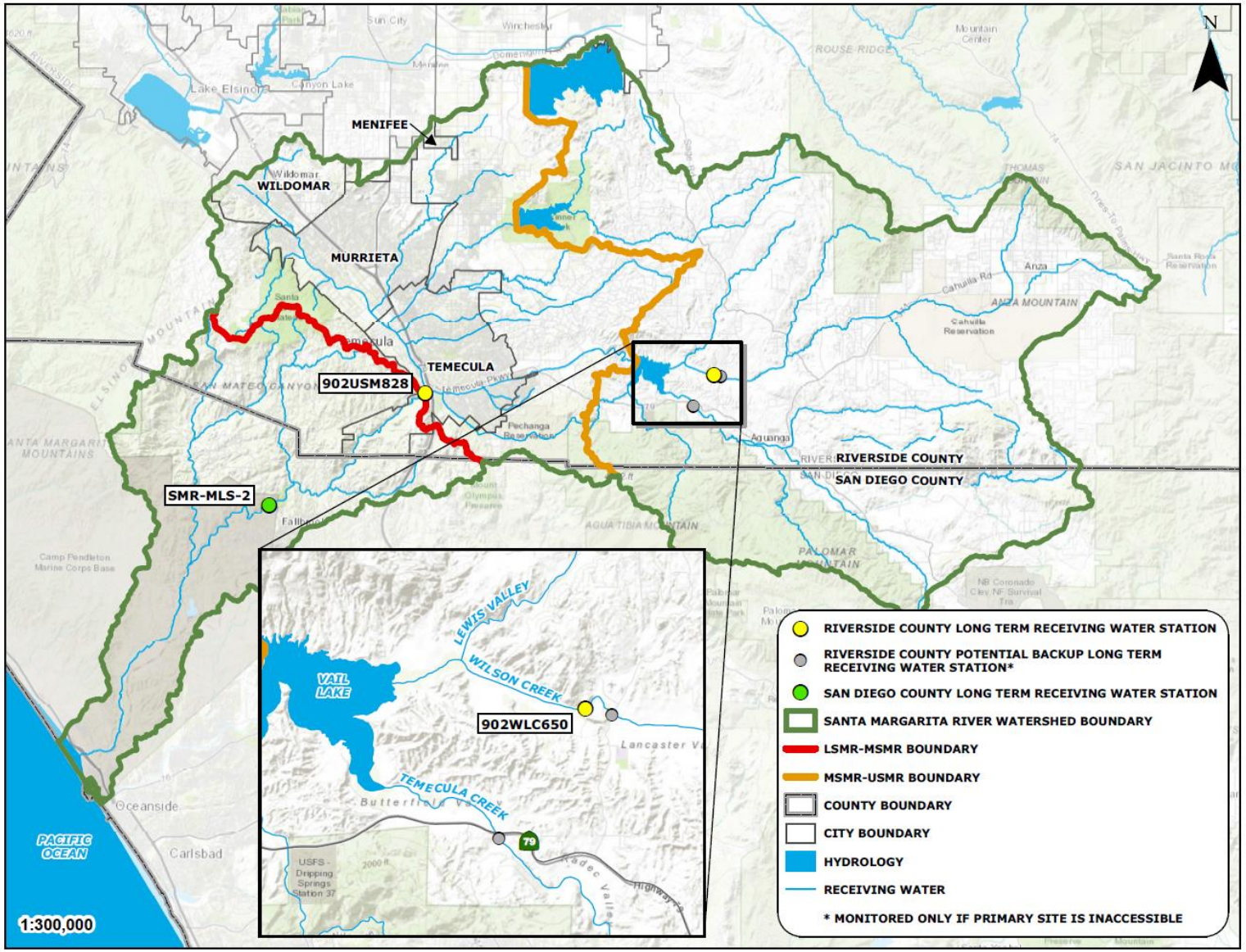

Figure 5-2. New Long-Term Receiving Water Site and Potential Back-up Sites for Upper SMR Subwatershed

Bioassessment monitoring and hydromodification monitoring will be conducted at the receiving water stations during at least one dry weather monitoring event during the permit term. Sediment quality monitoring will also be conducted in the SMR Estuary. Details regarding the analysis for each type of monitoring are provided in **Appendix 5A**. **Table 5-3** outlines a tentative schedule for performing each element of the receiving water monitoring program. Monitoring events are tentatively scheduled to support required assessments per Permit Provision D.4.

Table 5-3. Tentative Receiving Water Monitoring Program Schedule[1]

Receiving Water Monitoring Program Element	Reporting Year (# of Events)[2]				
	18/19	19/20	20/21	21/22	22/23
Wet Weather Monitoring					
Upper SMR Subwatershed		3[3]			
Middle SMR Subwatershed		3[3]			
Lower SMR Subwatershed		3[3]			
Dry Weather Monitoring					
Upper SMR Subwatershed			3[4]		
Middle SMR Subwatershed			3[4]		
Lower SMR Subwatershed		3[4]			
Bioassessment Monitoring					
Upper SMR Subwatershed			1		
Middle SMR Subwatershed			1		
Lower SMR Subwatershed		1			
Hydromodification Monitoring					
Upper Subwatershed			1		
Middle SMR Subwatershed			1		
Lower SMR Subwatershed		1			

1. While the total number of events identified for each receiving water monitoring program element will not change, the reporting years during which monitoring is conducted may change if deemed necessary by the Copermittees.
2. The reporting year for the Monitoring and Assessment Program extends from October 1st to September 30th of the following year.
3. At least one wet weather monitoring event will be conducted during the first storm of the wet season (October 1 – April 30) that meets mobilization criteria, and at least one wet weather monitoring event will be conducted after February 1st. The reporting year during which these events take place will be determined based on rainfall intensity and resource availability.
4. At least one monitoring event will be conducted during the dry season (May 1 – September 30) and at least one monitoring event will be conducted during a dry weather period (i.e., antecedent dry period of at least 72 hours following a storm event producing measurable rainfall of greater than 0.1 inch) after the first measurable storm of the wet season (October 1 – April 30). The reporting year during which these events take place will be determined based on resource availability.

5.3.1.2 Receiving Water Bioassessment Monitoring

The Permit requires bioassessment monitoring for each LTMS for one dry weather event per permit term. Bioassessment monitoring at the receiving water monitoring stations will be conducted simultaneously with a receiving water monitoring station dry weather monitoring event. The bioassessment monitoring will be comprised of collecting macroinvertebrate samples, physical habitat characterization measurements, and freshwater algae samples. Bioassessment monitoring is designed to be SWAMP compatible and samples are used to calculate an Index of biotic integrity (IBI) and/or California Stream Condition Index (CSCI) for macroinvertebrates and algae. Bioassessment monitoring may be conducted in accordance with the "Triad" assessment

approach that includes the collection of water chemistry and toxicity data as well (Stormwater Monitoring Coalition, 2004). Detailed proposed monitoring methods and procedures are presented in **Appendix 5A**.

5.3.1.3 Hydromodification Monitoring

The Permit requires hydromodification monitoring to be conducted as part of the Copermittees' approved Hydromodification Management Plans[19] in **Appendix 5B** (Section III; Appendix K) and **Appendix 5C** (Section 8) as well as hydromodification monitoring at each receiving water monitoring station for one dry weather event per permit term.

Hydromodification monitoring was initiated as specified in the April 2016 revision to Appendix K of the Riverside County SMR Hydromodification Management Plan (HMP Monitoring). HMP Monitoring will be conducted annually at two stations, Warm Springs Creek and Meadowview Stream (**Table 5-4** and **Figure 5-2**) through spring of 2019[20]. Hydromodification monitoring as specified in the 2011 Regional HMP for the County of San Diego did not include any monitoring sites in the SMR WMA.

Dry Weather Receiving Water Hydromodification Monitoring in the Middle SMR Subwatershed will occur in conjunction with receiving water dry weather monitoring, and may be conducted in coordination with special studies and regional monitoring programs, such as the SMC Regional Monitoring Program, when feasible. The monitoring conducted in the Lower SMR subwatershed will coincide with the spring receiving water dry weather monitoring event in May or June and the dry weather receiving water bioassessment monitoring.

Table 5-4. Hydromodification Monitoring Sites (HMP Monitoring)

	Station Name	Station ID	Latitude	Longitude
HMP Monitoring	Warm Springs Creek	901HDM001	33˚32'54.02" N	117˚10'14.24" W
	Meadowview Stream	902HDM002	33˚31'22.66" N	117˚07'51.46" W
Long Term Receiving Water Hydromodification Monitoring	See Table 5-2			

Observations and measurements will be collected in accordance with each County specific HMP. Detailed proposed monitoring methods and procedures are presented in **Appendix 5A Section 2.7**.

[19] Refers to Hydromodification Management Plans as approved under the prior Permit for Riverside County Co-Permittees within the Santa Margarita Watershed (Order No. R9-2010-0016) and under the prior Permit for the County of San Diego within the Santa Margarita Watershed (Order No. R9-2007-0001).

[20] All analytical data and a final report, as described in the April 2016 revision to Appendix K of the Riverside County SMR HMP, will be submitted to the San Diego Water Board by October 31, 2019.

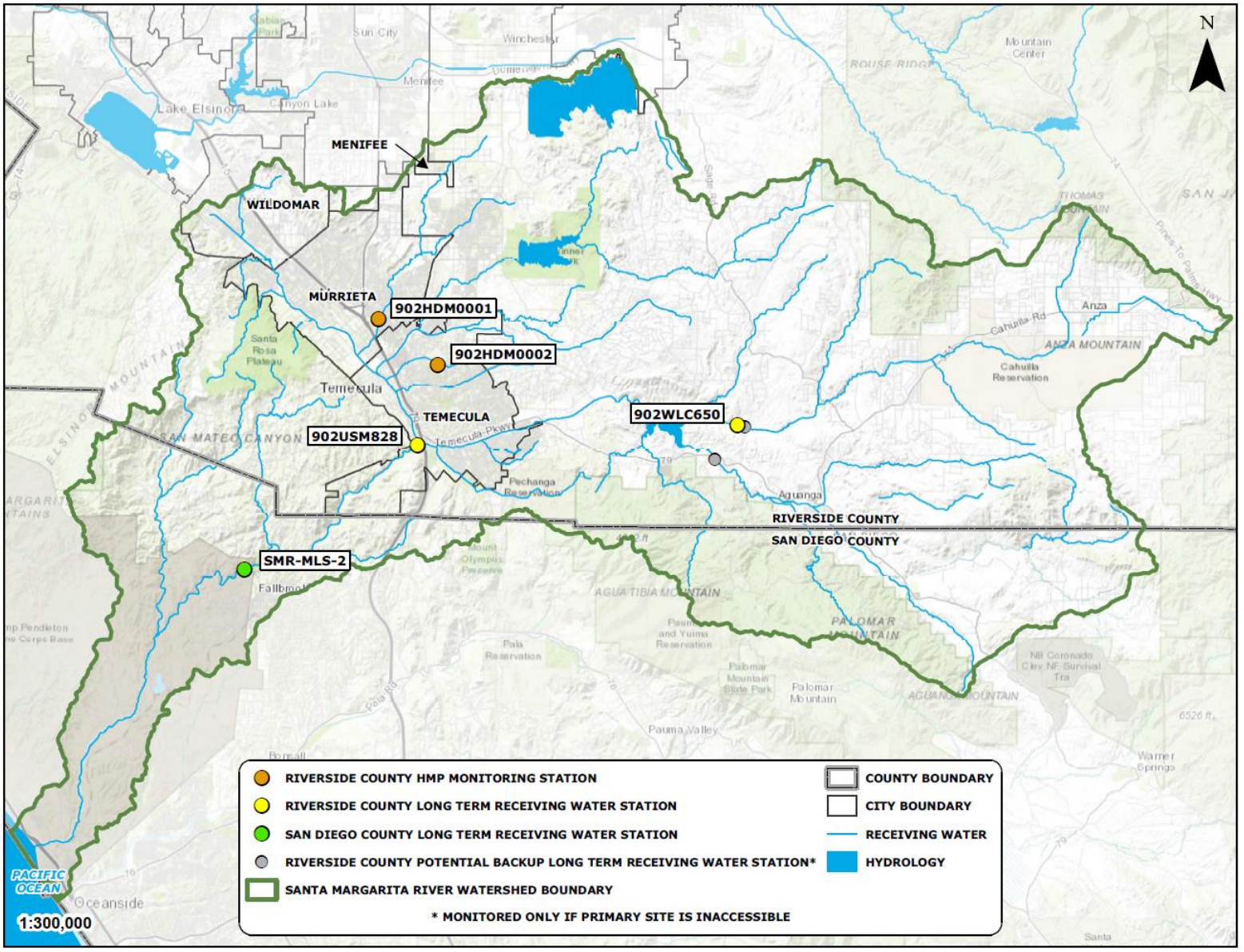

Figure 5-3. Hydromodification Monitoring Station Locations

5.3.1.4 Regional Monitoring Programs

Regional Monitoring Programs have been developed with the purpose of increasing the effectiveness of existing NPDES monitoring programs by integrating the efforts of Copermittees to achieve a large-scale assessment of the watershed condition. Certain monitoring efforts have been incorporated into these regional programs for the purpose of establishing a holistic and coordinated approach, the details of which are available in the applicable regional monitoring plans. Copermittees will participate in these regional programs to meet the requirements of Permit Provision D.1.e (1). These programs are summarized below.

5.3.1.4.1 Southern California Stormwater Monitoring Coalition

Since 2001, the Copermittees have partnered with regulated stormwater municipalities in Southern California, the RWQCBs of Southern California and the Southern California Coastal Water Research Project (SCCWRP) to form the SMC. The Copermittees are continuing to participate in the SMC Regional Freshwater Stream Bioassessment Monitoring Program. In 2015, a new five-year SMC program began that extended the initial survey to answer key management questions about the impacts of stormwater on stream conditions. Several modifications were made to the previous surveys to emphasize detection of trends and to address data gaps. Specifically, monitoring of high-priority stressors (i.e., habitat, nutrients, and ionic composition) was continued, whereas monitoring of low-priority stressors (i.e., water column metals, pyrethroids, and toxicity) was discontinued. Flow regime (hydrologic state checklist derived from Gallart et al. [2010] and water level loggers), vertebrate occurrence, and new stressors of interest (i.e., sediment pyrethroids and toxicity) were added to the list of monitored parameters. Sediment sampling was deferred by the SMC Executive Committee until the 2017 monitoring year.

In addition, the physical habitat assessment has been enhanced with hydromodification screening (modified from Bledsoe et al., 2010) at unarmored or partially armored "condition" sites (i.e., sites selected in a probabilistic way to represent the typical condition of streams in the region) and a channel engineering checklist at all condition sites. The hydromodification screening and channel engineering checklist will be conducted at "trend" sites (i.e., sites that are revisited) at least once during the five-year study. The trend sites were selected from previously sampled sites under earlier probabilistic surveys in order to estimate changes in regional conditions over time, and the condition sites were selected from a new probabilistic sample draw in order to estimate current regional conditions.

5.3.1.4.2 Southern California Bight Regional Monitoring

Provision D.1.e.(1)(b) of the Permit also requires the Copermittees to participate in the Bight Regional Monitoring Program, an integrated assessment of the Southern California Bight, that occurs every five years and consists of a partnership of multiple local, state, and federal agencies overseen by SCCWRP. The Bight Regional Monitoring Program assesses the ecological health of nearshore and offshore marine habitats as well as coastal embayments by measuring indicators of environmental condition (e.g., habitat quality, sediment contamination, toxicity, infaunal communities, and fish communities). Participation in the Bight Regional Monitoring Program may be used to fulfill the sediment quality monitoring requirements of Permit Provision D.1.e.(2).

5.3.1.5 Sediment Quality Monitoring

The Copermittees are required either individually, in association with multiple Copermittees, or through participation in a waterbody monitoring coalition to perform sediment quality monitoring to assess compliance with the sediment quality receiving water limits applicable to MS4 discharges to enclosed bays and estuaries. Provision D.1.e.(2) of the Permit requires the Copermittees to conduct sediment monitoring which satisfies the requirements of the *Water Quality Control Plan for Enclosed Bays and Estuaries of California – Part I Sediment Quality* (Sediment Control Plan) (State Water Board and California Environmental Protection Agency [CA EPA], 2009). Data are assessed using sediment quality objectives (SQOs) which are based on a multiple lines of evidence (MLOE) approach. The lines of evidence (LOE) are sediment toxicity, sediment chemistry, and benthic community condition. The MLOE results are integrated through the evaluation of the severity of biological effects and the potential for chemically-mediated effects to provide a final site level assessment. The integration of all three measurements help to provide a comprehensive assessment of the sediment condition of lagoons in San Diego County using the most up-to-date protocols.

5.3.1.6 TMDL Monitoring

The SMR WMA has one existing TMDL, established in 2006, which is the *Total Maximum Daily Loads for Total Nitrogen and Total Phosphorus in Rainbow Creek Watershed* (Nutrient TMDL). The goal of the Nutrient TMDL is to achieve the pollutant load reductions necessary to restore and protect the designated aquatic life beneficial uses in the Rainbow Creek sub-watershed. The monitoring program provides data on baseline conditions and trends for nutrients in the Rainbow Creek Subwatershed. The resulting data may be used in evaluating BMP effectiveness to reduce nutrient loading to the creek, and tracking changes in water quality and the trajectory to attain the TMDL goals in Rainbow Creek and its tributaries over time. Monitoring in compliance with the Nutrient TMDL addresses the following questions:

- How do the mean concentrations of total nitrogen and total phosphorous vary among the sampling sites in the Rainbow Creek mainstem and tributaries?
- Are there any significant trends in total nitrogen and total phosphorus concentrations in the Rainbow Creek main stem and tributaries over time?

In situ monitoring for field parameters and grab sampling for nutrients, TDS, iron and sulfate are conducted at 14 locations in the Rainbow Creek Subwatershed. Monitoring events are conducted during dry weather (i.e., not within 72 hours of a rain event totaling 0.1 inch or greater) at approximately 30-day intervals from October to September of each monitoring year. The flow rate at each site is estimated using channel cross-section dimensions and either a hand-held flow meter or the floating object technique to measure current velocity.

Monitoring methods are further described in **Appendix 5A**. Compliance with the Nutrient TMDL is evaluated by comparing monitoring results with final receiving water limitations (i.e., 1 mg/L for total nitrogen, 0.1 mg/L for total phosphorus, and 10 mg/L for nitrate as N).

Table 5-5. Rainbow Creek Nutrient TMDL Monitoring Station Locations

Station ID	Site Description	Latitude	Longitude
	Main Stem		
RBC01	Rainbow Creek @ Eastern edge of Hines Nursery	33.42042	-117.13571
RBC02	Rainbow Creek @ Huffstatler Road	33.41544	-117.15199
RBC04	Rainbow Creek @ Old Highway 395	33.41272	-117.15853
RBC06[1]	Rainbow Creek @ 2219 Willow Glen Road	33.40881	-117.20539
RBC10	Rainbow Creek @ MWD Crossing	33.40696	-117.18344
SMG05	Rainbow Creek @ Willow Glen Road	33.40788	-117.20104
SMG06	Rainbow Creek @ Stage Coach Lane	33.41056	-117.21477
	Tributary		
RVT02	Chica Tributary @ 1st Street	33.42126	-117.14983
HST01	Brow Ditch to Rainbow Creek @ Huffstatler Road	33.41526	-117.15204
HST02	Huffstatler Road upstream of HST01	33.41174	-117.15196
MGT01	Margarita Glen Tributary to Rainbow Creek	33.40847	-117.19877
RGT01	Rainbow Glen Tributary to Rainbow Creek	33.41107	-117.18569
WGT01	Willow Glen Tributary @ Willow Glen Road	33.40784	-117.20309
VMT01	Via Milpas Tributary to Rainbow Creek	33.40957	-117.21373

[1] Due to a change in private ownership, as of November 2018, the County of San Diego no longer has access to RBC06 and will no longer monitor this site.

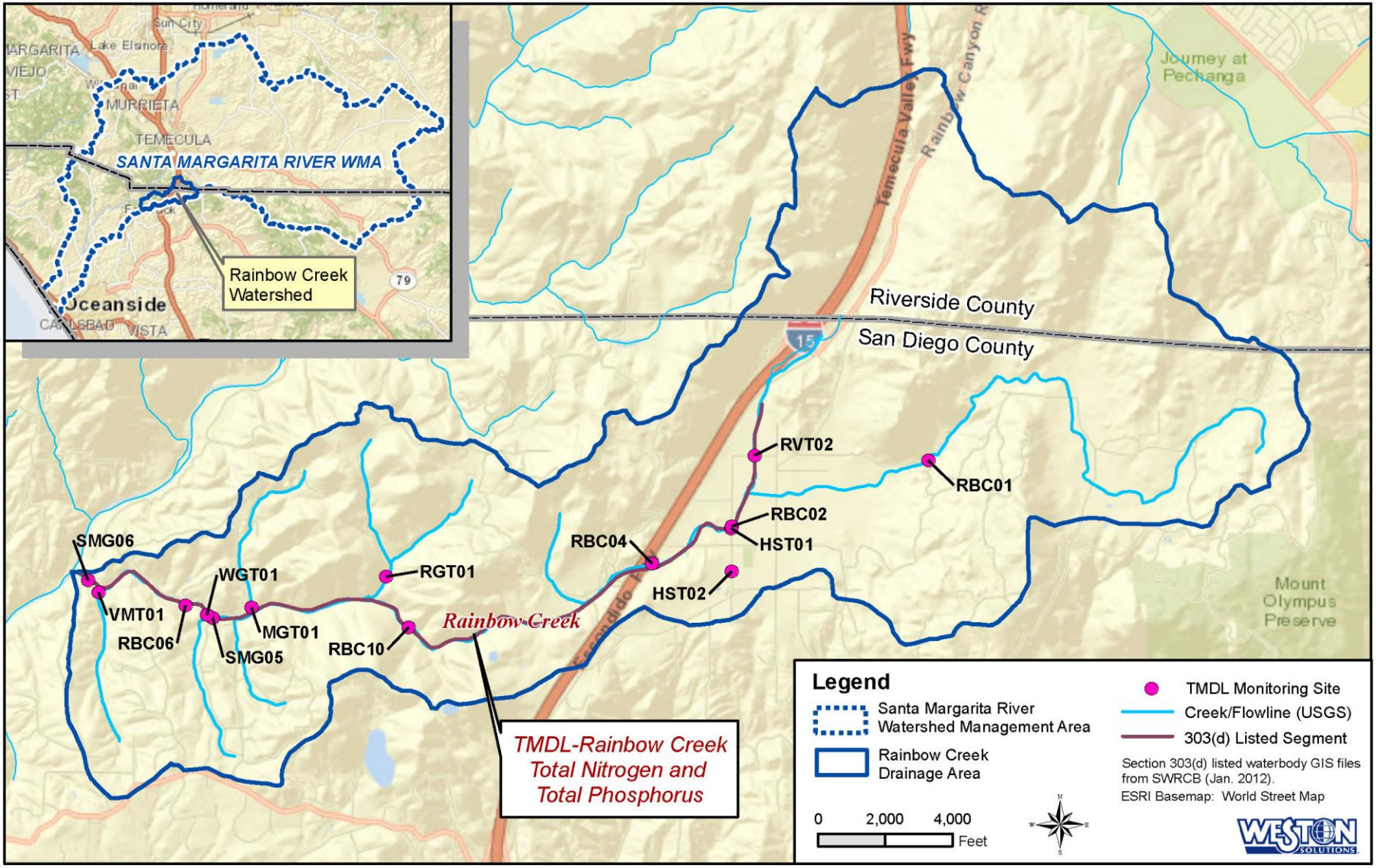

Figure 5-4. Rainbow Creek Nutrient TMDL Monitoring Station Locations

5.3.2 MS4 Outfall Monitoring

The MS4 Outfall Monitoring Program is designed to assess the effectiveness of Copermittees JRMPs and WQIP strategies at prohibiting non-storm water discharges into the MS4 and reducing pollutants in stormwater discharges from their MS4s to the maximum extent practicable (MEP). MS4 outfall monitoring may also be used to evaluate attainment of numeric goals established in **Chapter 4**, as applicable and as further described in **Section 5.4.1**. The MS4 Outfall Program consists of wet weather sampling of discharges from the representative major outfalls, as well as field screening monitoring and non-storm water persistent flow MS4 outfall discharge monitoring during dry weather. In addition, the County of San Diego conducts further MS4 outfall monitoring associated with the HPWQC in the Rainbow Creek Subwatershed in a voluntary monitoring program that provides data to assess progress to goals.

5.3.2.1 MS4 Outfall Wet Weather Monitoring

Each Copermittee with MS4 outfalls within the WMA has identified one major outfall station within their jurisdiction for wet weather MS4 outfall discharge monitoring as shown in **Table 5-6** and **Figure 5-5**. These six representative major outfall stations (or alternative stations identified during adaptive management) will be monitored in the SMR WMA to meet Permit requirements.

Table 5-6. MS4 Outfall Wet Weather Monitoring Station Locations

Station Number	Receiving Water	Permittee[1] Assigned	Site Description	Latitude	Longitude
902MS41 033	Tucalota Creek	RCFCWCD	Outlet to W side of Tucalota Creek south of M.H.S. Rd.	33.5521	-117.1364
902MS42 240	Temecula Creek	County of Riverside	Outlet to Temecula Creek @ South of Breeze Way Pl and Summit View	33.4866	-117.0636
902MS44 034	Warm Springs Creek	Murrieta	RCP Outlet to Warm Springs Creek d/s of M.H.S. Rd.	33.5475	-117.1719
902MS43 015	Murrieta Creek	Temecula	Outlet to Murrieta Creek @ Diaz Rd. behind RCWD pump station	33.5165	-117.1723
902MS45 031	Wildomar Channel	Wildomar	Outlet to NW side of Wildomar Channel @ Gruwell St.	33.6037	-117.2787
HST01	Rainbow Creek	County of San Diego	Brow Ditch to Rainbow Creek @ Huffstatler Street	33.4151	-117.1520

1. The City of Menifee does not have a MS4 outfall.

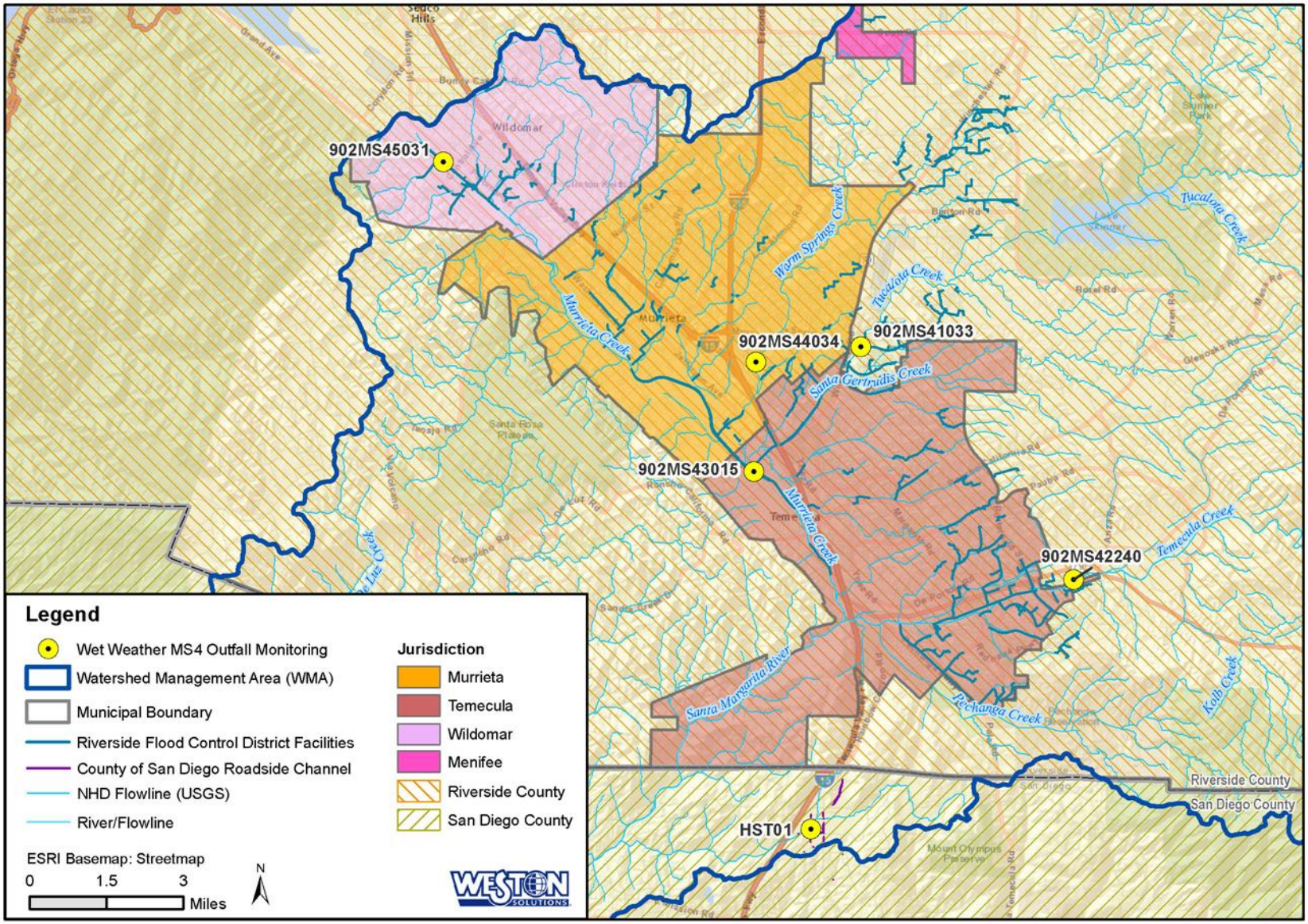

Figure 5-5. MS4 Outfall Wet Weather Monitoring Station Locations

The six representative major outfalls will be monitored once per year during wet weather events. The outfalls will continue to be monitored unless new information becomes available which warrants consideration of new stations. If new information becomes available which warrants consideration of new stations, the Copermittees will re-evaluate the stations and potentially recommend new stations via the adaptive management process. Modifications to monitoring locations will be reported in the WQIP Annual Report. Detailed proposed monitoring methods and procedures are presented in **Appendix 5A**.

5.3.2.2 Dry Weather MS4 Outfall Discharge Field Screening Monitoring

Dry weather MS4 outfall discharge field screening monitoring consists of collecting visual observations at Copermittee major outfalls. The Permit identifies the required frequency for dry weather MS4 outfall discharge field screening monitoring based on the number of major outfalls within a Copermittee's jurisdiction. As shown in **Table 5-7**, each Copermittee has less than 125 major MS4 outfalls within the SMR WMA. The initial requirement for each Copermittee is to visually inspect at least 80 percent of the outfalls twice per year during dry weather conditions. The Permit also allows the Copermittees to adjust the field screening monitoring frequencies and locations for the MS4 outfalls in its inventory, as needed, to identify and eliminate sources of persistent flow non-storm water discharges in accordance with the HPWQC identified in the WQIP, provided the number of visual inspections performed is equivalent to the number of visual inspections initially required. The Copermittees will, at a minimum, conduct the total number of visual inspections identified within **Table 5-7** each year and the frequencies and locations for the MS4 outfalls which are inspected may be adjusted in accordance with the flexibility allowed in the Permit, as needed. Detailed proposed monitoring methods and procedures are presented in **Appendix 5A**.

Table 5-7. Dry Weather MS4 Outfall Discharge Field Screening Monitoring Frequency

Copermittee	Total Number of Major Outfalls in SMR WMA	80% of Major Outfalls	Number of Visual Inspections Required Per Year
RCFCWCD	84	68	136
County of Riverside	7	6	12
Menifee	0	0	0
Murrieta	31	25	50
Temecula	119	96	192
Wildomar	11	9	18
County of San Diego	11	9	18

5.3.2.3 Non-Storm Water Persistent Flow MS4 Outfall Discharge Monitoring

Based upon the dry weather MS4 outfall discharge field screening monitoring records available upon the submittal of the WQIP and other pertinent factors (e.g., safety conditions, site accessibility, flow vs. ponded observations, tributary influences), each Copermittee identified and prioritized the MS4 outfalls observed to have persistent flow. This information was then used by the Copermittees to prioritize the MS4 outfalls based on their potential to contribute to the

HPWQC identified in **Chapter 2**. Target areas within the SMR WMA were identified using several factors (detailed in **Chapter 4**) which are expected to significantly correlate with the nutrient loading being discharged through the MS4. Persistently flowing outfalls are shown in **Figure 5-6**. Copermittees prioritized persistently flowing outfalls; however, where less than five persistently flowing outfalls were identified, the next highest priority transient outfall was selected. **Figure 5-7** illustrates the thirty preliminary highest priority MS4 outfall discharge monitoring stations that will be monitored in the SMR WMA during implementation of the SMR WQIP. Each Copermittee has selected five MS4 outfall discharge monitoring stations within the WMA, except for the City of Menifee, which does not have a MS4 outfall.

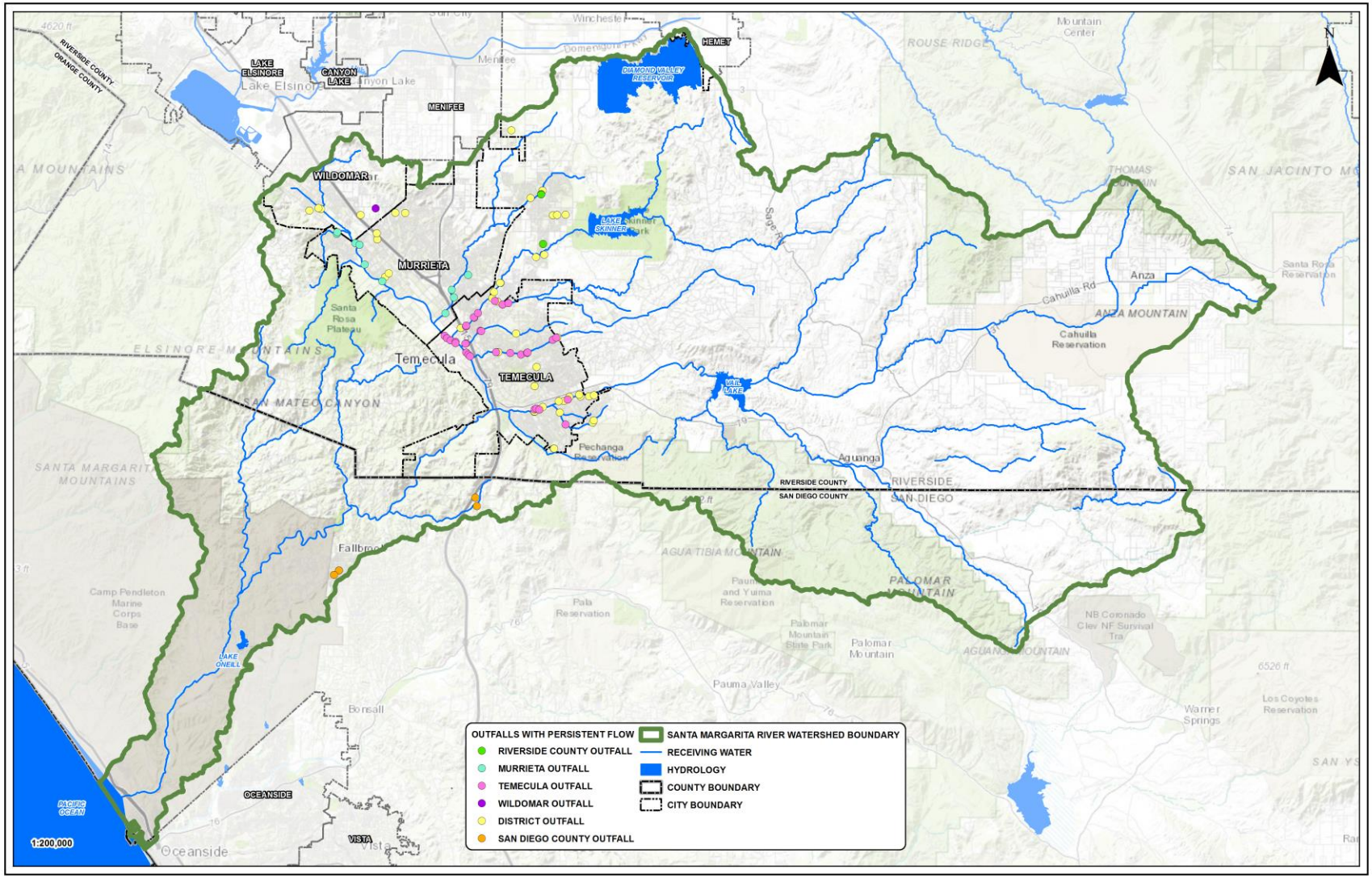

Figure 5-6. Persistently Flowing Outfalls Identified within the SMR WMA

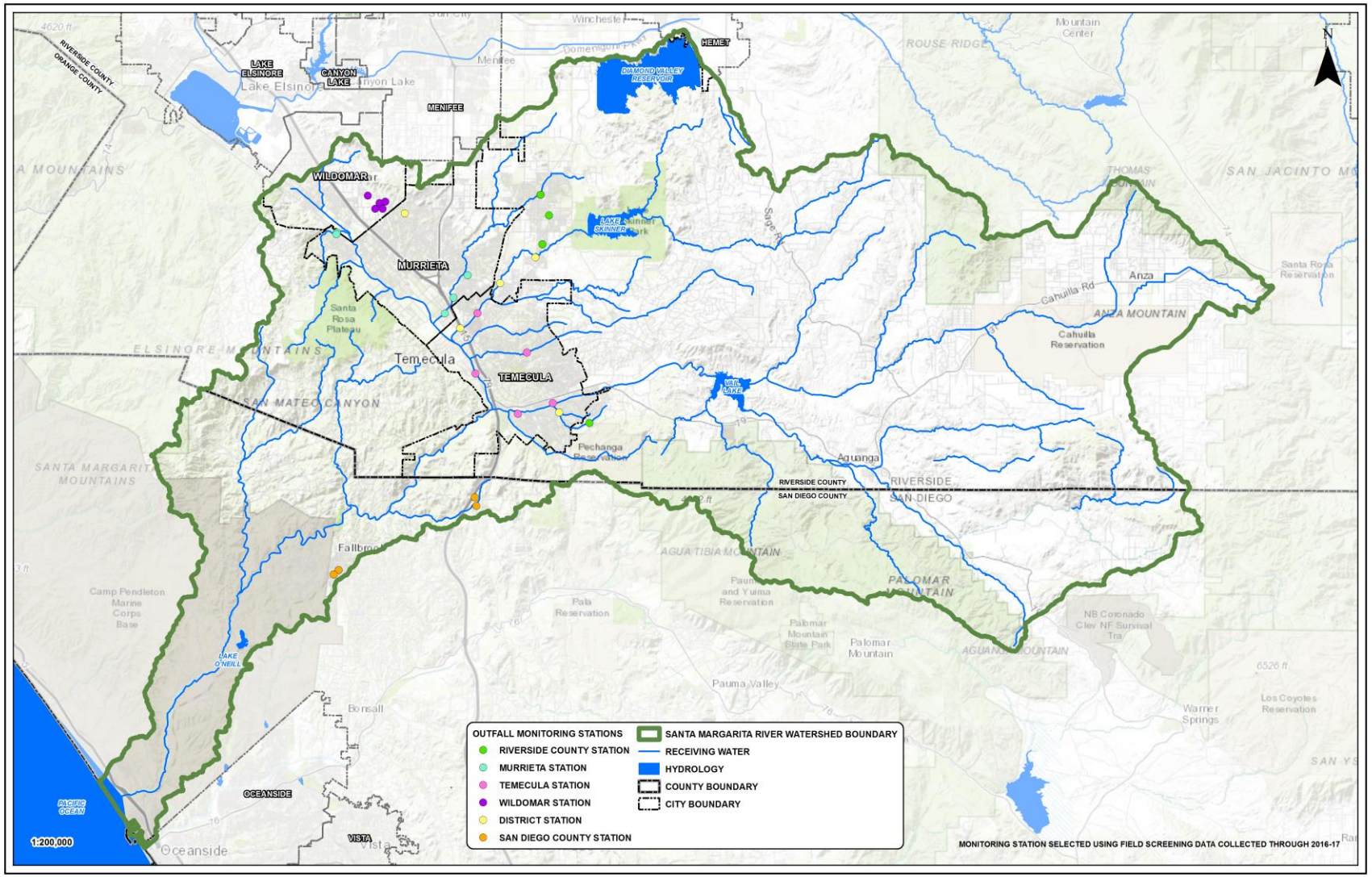

Figure 5-7. Non-Storm Water Persistent Flow MS4 Outfall Discharge Monitoring Station Locations

Table 5-8. Non-Storm Water Persistent Flow MS4 Outfall Discharge Monitoring Station Locations

Station Number	Permittee Assigned	Latitude	Longitude
902MS41010	RCFCWCD	33.4728	-117.0920
902MS41025	RCFCWCD	33.5241	-117.1651
902MS41032	RCFCWCD	33.5521	-117.1361
902MS41037	RCFCWCD	33.5680	-117.1104
902MS41061	RCFCWCD	33.5943	-117.2066
902MS42207	County of Riverside	33.5761	-117.1051
902MS42211	County of Riverside	33.5939	-117.1005
902MS42235	County of Riverside	33.6065	-117.1070
902MS42236	County of Riverside	33.6065	-117.1070
902MS42245	County of Riverside	33.4664	-117.0697
902MS44030	Murrieta	33.5331	-117.1764
902MS44033	Murrieta	33.5428	-117.1702
902MS44039	Murrieta	33.5567	-117.1600
902MS44062	Murrieta	33.5822	-117.2562
902MS44063	Murrieta	33.5812	-117.2566
902MS43038	Temecula	33.5096	-117.1159
902MS43062	Temecula	33.4962	-117.1535
902MS43082	Temecula	33.4718	-117.1221
902MS43099	Temecula	33.4785	-117.0967
902MS43123	Temecula	33.5335	-117.1525
902MS45012	Wildomar	33.5970	-117.2282
902MS45015	Wildomar	33.6006	-117.2251
902MS45019	Wildomar	33.6014	-117.2208
902MS45024	Wildomar	33.6051	-117.2338
902MS45026	Wildomar	33.5971	-117.2228
MS4-SMG-015	County of San Diego	33.3748	-117.2526
MS4-SMG-021	County of San Diego	33.3748	-117.2526
MS4-SMG-057	County of San Diego	33.4203	-117.1532
MS4-SMG-024	County of San Diego	33.3720	-117.2560
HST01	County of San Diego	33.4151	-117.1520

Each of the highest priority non-storm water persistent flow MS4 outfall monitoring stations identified in **Table 5-8** and **Figure 5-7** will be monitored under dry weather conditions at least semi-annually until one of the following criteria occur:

- The non-storm water discharges have been effectively eliminated (i.e. no flowing, pooled, or ponded water) for three consecutive dry weather monitoring events, OR
- The source(s) of the persistent flows has been identified as a category of non-storm water discharges that does not require a NPDES permit and does not have to be addressed as an illicit discharge because it was not identified as a source of pollutants (i.e. constituents in non-storm water discharge do not exceed Non-Storm Water Action Levels [NALs] identified in Permit Provision C.1 [inclusive of any future iterations]), and the persistent flow can be re-prioritized to a lower priority, OR
- The constituents in the persistent flow non-storm water discharge do not exceed NALs, and the persistent flow can be re-prioritized to a lower priority, OR
- The source(s) of the persistent flows has been identified as a non-storm water discharge authorized by a separate NPDES permit.

If one of the criteria for discontinuing monitoring is met, or the threat to water quality has been reduced (per Permit Provision D.2.b.(2)(b)(iii)), a Copermittee can replace the persistent flow MS4 outfall monitoring station with their next highest prioritized outfall within the WMA, unless there are no remaining qualifying major MS4 outfalls within their jurisdiction within the WMA. Copermittees are not required to sample ponded water, as the requirements of Permit Provision D.2.b.(2)(e) specify collection during monitoring events "in which measurable flow is present…". Ponded or pooled water may have conditions not found in flowing water and may not reach receiving waters. Sites visited during semi-annual monitoring events that do not have measurable flow may result in an analytical data gap. Therefore, Copermittees may elect to replace highest priority outfalls that become transient, and a reduced threat to water quality can be demonstrated, with persistently flowing outfalls. **Table 5-8** and **Figure 5-7** will be updated accordingly as stations are rotated and any updates will be presented in the WQIP Annual Report. Detailed proposed monitoring methods and procedures are presented in **Appendix 5A**.

5.3.2.4 Rainbow Creek Progress Towards Goals Outfall Monitoring

The County of San Diego will continue to conduct monitoring in the Rainbow Creek Subwatershed to assess the contribution of urban runoff to Rainbow Creek. This non-storm water monitoring effort currently includes at least quarterly visits to 21 outfalls in this subwatershed during dry weather (i.e., no daily precipitation greater than 0.1 inches within 72 hours prior to the visit). A hand-held flow meter or the floating object technique is used to measure current velocity. **Appendix 5A** provides additional details regarding this monitoring effort including monitoring locations.

5.3.3 Special Studies

Special Studies as required under the Regional Permit are intended to address data gaps and/or to facilitate the development of information necessary to more effectively address the pollutants and/or stressors as relevant to the HPWQC in the WMA, as well as impacts to the receiving waters in the region. A description of these special studies are included in Sections 5.3.3.1 and 5.3.3.2. The Copermittees also participate in additional special studies for the benefit of their local and regional program efforts. A description of other special efforts are included in Section 5.3.3.3. Special Studies have their own separate stand-along workplans. Updates to Special Studies'

Workplans and progress of Special Studies efforts will be included in the Annual Monitoring and Assessment reports.

5.3.3.1.1 WMA Special Study - SMRNIG Study

The SMRNIG, formed in 2011, is a collaboration of stakeholders from within the watershed for the purpose of monitoring and assessing water quality in order to evaluate and address impairments due to biostimulatory substances in the estuary and river. The SMR Stakeholder Group is funded largely through the Integrated Regional Water Management (IRWM) process and is currently receiving a Proposition 84 grant from the State of California with matching funding and in-kind services provided by the County of San Diego, District, Southern California Coastal Water Research Project (SCCWRP), United States Marine Corps (USMC) Base Camp Pendleton, and the Regional Board. A Technical Advisory Committee led by SCCWRP coordinates the technical studies at the bequest of the SMR Stakeholder Group.

Current nitrogen and phosphorus water quality objectives are problematic, in part, because they do not consider site-specific factors. The Nutrient Numeric Endpoint (NNE) framework, an alternative regulatory approach advocated by SWRCB staff and United States Environmental Protection Agency (USEPA) Region 9, is currently in development. As a result, the methods for protecting beneficial uses from biostimulatory substances are aimed at addressing the cause of potential impairments rather than focusing on controlling nutrient concentrations in of themselves. This framework can be used to develop scientifically-sound nutrient water quality goals for the Estuary and river that are protective of their beneficial uses.

In support of the development of the NNE framework the Copermittees targeted sites for in-kind sampling to provide the study with additional nutrient data, selected in coordination with SCCRWP. Samples collected included analysis of ammonium, orthophosphate, TDN, TDP, particulate organic carbon, particulate organic nitrogen, particulate phosphorus, phytoplankton chlorophyll a, algal CN content, and algal phosphorus content. During WQIP implementation Copermittees will continue to support the study effort by including in-kind monitoring of additional NNE relevant parameters at the long-term receiving water station during a dry weather monitoring event. The Copermittees will continue to support future phases of the NNE development efforts.

Currently, the Regional Water Board is preparing a draft resolution and staff report that will support water quality goals for the Estuary that was developed with the consideration of stakeholder input. The resolution is scheduled to be released for public comment in spring 2018 and is based on technical studies supported by the SMR Stakeholder Group (Sutula et al., 2016). The next stage of the project will develop proposed water quality goals for the Santa Margarita River downstream of the confluence with De Luz Creek. By May 2018, the Technical Advisory Committee will develop a preliminary report that evaluated potential goals for this section of the river that is based on scientific studies and model simulations. Additional discussions of the SMR stakeholder Group will ensue that use the results of this preliminary technical report to inform the Stakeholder Group in developing recommended goals for this section of the river for the Regional Water Board's consideration. Final goals developed for the River will be considered as part of the integrated assessment of the WQIP.

5.3.3.1.2 San Diego Region Special Study - SMC CLEAN Project

The SMC California LID Evaluation and Analysis Network (SMC CLEAN) will develop a thorough understanding of the effectiveness of LID BMPs in California: in the short term for use in calibration of performance expectations for watershed programs; and in the long term for modification of LID design, construction, and maintenance. This can only be accomplished with the help of project partners and others performing LID monitoring. The District, on behalf of the Copermittees is a cost-sharing project partner and provides in-kind services for this special study. In-kind monitoring services are accomplished by sharing the data resulting from the District's 15-acre LID Integrated Management Plan Testing and Demonstration Facility. The facility is being used to monitor the performance of LID features in the field, illustrate LID features in training workshops, and assist in the development of technical guidance regarding LID features. Flow data and influent and effluent samples are collected in accordance with the District's LID Monitoring Plan and QAPP (Appendix 5G). The District is collaborating with the SMC CLEAN's overarching LID BMP evaluation project. The results of this monitoring study will be used to establish water quality treatment effectiveness and numeric criteria for crediting flow reductions to developments that implement these BMPs. The SMC CLEAN project will be used to:

- Develop specific LID research questions;
- Research existing LID monitoring data;
- Develop a standard methodology for monitoring LID BMPs including coordination with other SMC projects concerned with monitoring methodology;
- Coordinate ongoing LID monitoring;
- Implement LID monitoring through the standard methodology and monitoring protocol developed;
- Compile and analyze LID monitoring data;
- Develop recommendations; and
- Conduct a review and update of the Southern California LID Manual.[21]

The updated LID Manual will provide enhanced guidance for design, construction, and maintenance of various LID BMPs to improve their performance in removing pollutants and reducing hydrologic changes. This is a regional project with many participating agencies including UCSD, Riverside County Flood Control and Water Conservation District, Orange County Public Works, the Council for Watershed Health, Loyola Marymount University and the US South Coast Research and Extension Center. As the project progresses, improvements in technology and understanding of BMPs effectiveness in treating a variety of stormwater pollutants (including nutrient) will be assessed and implemented. This regional effort will provide information filling the data gap on the effectiveness of LID BMPs and to and provide guidance on the performance expectations for watershed programs. Assessment based on findings of this special study will be dependent on the schedule for the updated LID Manual.

5.3.3.1.3 Additional Special Studies or Related Monitoring Efforts

San Diego Regional Reference Streams Study

[21] https://www.casqa.org/sites/default/files/downloads/socallid-manual-final-040910.pdf

The San Diego Regional Reference Stream Study serves as the regional special study for the Santa Margarita WMA. The study was conceived by the San Diego, Orange County and Riverside Permittees, funded by San Diego and Orange County, and fulfills the regional special study requirement in Permit Provision D.3.(a). The goal of this project was to collect the data necessary to derive reasonable and accurate numeric targets for bacteria, nutrients, and heavy metals by referencing natural, local conditions. The study develops levels that account for natural sources to establish the concentrations or loads from streams in a minimally disturbed or reference condition. The study considers the size, geology and wet or dry conditions of the catchment. This study provides a scientific basis for evaluating compliance levels in TMDLs. The results of this study were used to support the forthcoming reopener of the regionally adopted Bacteria TMDLs and to support numeric targets in future TMDLs for bacteria, nutrients, and metals. For additional details see SCCWRP Technical Report 862: Wet and Dry Weather Natural Background Concentrations of Fecal Indicator Bacteria in San Diego, Orange, and Ventura County, California Streams (Tiefenthaler et al., 2015) (http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/862_StreamFIBs.pdf). The draft report on the measured concentrations of nutrients and metals in streams in minimally disturbed watersheds will be released in the near future for review and comment.

Laboratory Intercalibration

Beginning in 2003, and continuing in 2006 and 2009, the SMC implemented a series of intercalibration studies to promote comparability of water chemistry measurements. The 2003 intercalibration study established common reporting levels and target analytes, and utilized iterative round robin exercises to minimize interlaboratory variation. During this permit term the SMC commissioned an intercalibration study to quantify stormwater-sample testing comparability among laboratories for toxicity methods. This study aimed at assessing variability among laboratories, identifying potential quality improvements, and improving comparability and consistency in toxicity measurements. This regional Intercalibration effort is expected to be useful in addressing data gaps necessary to more effectively address the stressors that are impacting receiving waters on a regional basis in the San Diego, and specifically toxicity is one of the priority water quality conditions of concern in this WMA. The successes and benefits derived from the chemistry laboratory intercalibration, the toxicity testing intercalibration study provides an important first step towards improving toxicity testing data quality and comparability on a regional basis.

A round robin exercise was conducted to characterize and ultimately minimize inter-laboratory variability for testing marine and freshwater species, and developed a manual to provide guidelines for testing precision and sensitivity. The SMC has conducted similar studies with its chemical testing program to address comparability issues. These studies have provided a platform to quantify the range of variability and a vehicle to improve the variability among testing laboratories.

A Laboratory Working Group composed of expert laboratory managers from the participating institutions selected the toxicity methods, species, and endpoints for the round robin exercise. In addition, the group is developing pass/fail comparability evaluation criteria for data generated by participating laboratories. Iterative sample testing with freshwater and marine species was conducted. The species and endpoints selected for testing freshwater samples were the 7-day chronic survival and reproduction test for *Ceriodaphnia* and the 96-hour acute survival test for *Hyalella*. For marine or estuarine receiving environments, the species and endpoints selected are the larval development test with purple sea urchin (72 hours) and larval mussel survival and

development (48 hours). These species were selected by the group because they are the most commonly tested permit organisms; they also are sensitive, easy to conduct the test with, readily available, representative of local species, and have relatively high variability of test method.

This SMC intercalibration study identified poor comparability in *Ceriodaphnia dubia* reproduction results among laboratories, as well as between samples within individual laboratories. This variability raised concerns regarding the ramifications of assessment errors in toxicity test results which can include incorrect status of waterbodies on the Clean Water Act 303(d) listing or the initiation of unnecessary toxicity reduction evaluations. This data was then used to assess real world scenarios of listed waterbodies. Even when assuming the low end of the variability scenarios, more than 50% of the test results could be overturned in either direction. The final recommendations of this study are to either discontinue use of *C. dubia* to be replaced by an alternate species approved by the EPA, or to consider conducting additional interlaboratory intercalibration studies to improve the variability.

As a result of this effort a Guidance Manual was developed based on the lessons learned. The Copermittees will only contract laboratories that have participated in the intercalibration efforts for the purpose of improving and standardizing analytical methods. The Copermittees will continue to participate in future SMC intercalibration studies, as needed, in the next permit term. There is no monitoring plan associated with this activity; however the resulting guidance will be of benefit to future monitoring in the region. The Copermittees will only contract with laboratories that have participated in this effort.

Field Procedure Intercalibration

Prior to the spring bioassessment activities the SMC Regional Bioassessment Subcommittee Technical Subcommittee conducts a follow-up meeting on an annual basis to reflect upon the previous year's field efforts and coordination as well as review the procedures used under the 5-year workplan. This provides an opportunity to share lessons learned and initiate the preparations for the next year's efforts which are kicked-off by a field Intercalibration exercise. The Co-Permittee's contracted bioassessment services consultants participate in this effort. The observations from the past Intercalibration efforts have identified areas of the regional survey that need streamlining for efficient data collection. In general the observations have shown that the participating agencies' field crews are collecting data in a comparable manner and in general conformance with the available SWAMP protocols and program components outlined in the Regional Bioassessment Workplan. The Copermittees' field crews will continue to participate in this activity on an annual basis in the next permit term. Detailed proposed monitoring methods and procedures are presented in **Appendix 5A**.

5.4 PROJECT ORGANIZATION AND RESPONSIBILITIES

The Copermittees are collectively responsible for implementing the SMR WMA MAP. The RCFCWCD, as the Principal watershed Copermittee within the SMR WMA, is the lead agency responsible for overseeing implementation of the Middle SMR Subwatershed Monitoring Program. The County of San Diego is the lead agency responsible for overseeing implementation of the Lower SMR Subwatershed Monitoring Program.

5.4.1 Monitoring to Assess Progress Toward Achieving Goals and Schedules

This section summarizes monitoring to assess progress toward achieving goals related to the HPWQC (the dry weather condition of eutrophication impacts for the SMR Estuary and the year-round conditions of nutrient enrichment for Rainbow Creek). As outlined in **Section 4.2**, strategies to be implemented to demonstrate progress toward meeting goals to address eutrophication impacts in the SMR Estuary support Copermittees' efforts to reduce non-stormwater flows from Copermittees' MS4 outfalls.

5.4.1.1 Monitoring to Assess Progress Toward Achieving Goals and Schedules in the Middle SMR Subwatershed

A multi-tiered approach to setting goals was used for the Middle SMR Subwatershed. The six compliance pathways for Copermittees to meet the WQIP goals are detailed in **Section 4.1.3**. Each Copermittee in the Middle SMR Subwatershed will have the option of demonstrating compliance through one of the six pathways. The date by which the final goal for the Middle SMR Subwatershed must be achieved is preliminarily scheduled for 2038 and will be updated through the adaptive management process when the TMDL Alternative becomes effective. **Table 5-9** presents the compliance pathways for the Middle SMR Subwatershed goals and the monitoring that may be used to track progress toward achieving these goals.

Table 5-9 Monitoring Related to HPWQC – Eutrophication Impacts and Nutrient Loading, Middle Santa Margarita River Subwatershed Copermittees

	Compliance Pathway	Final Numeric Goal[1]	Monitoring Elements
1	Demonstration that the discharger is attaining the load reduction goal of 76% in the Middle SMR Subwatershed in receiving waters.	76% reduction in dry weather loadings in receiving waters	*Dry Weather Receiving Water Monitoring* data for total nitrogen and total phosphorus collected in the Santa Margarita River (receiving water) at the base of the Middle SMR Subwatershed.
	OR		
2	Demonstration that the Santa Margarita River Estuary targets (based on the proposed TMDL Alternative) have been attained.	Numeric goals to be determined based on outcome of TMDL Alternative for the Santa Margarita River Estuary	*TMDL Monitoring* in conjunction with other dischargers based on outcome of TMDL Alternative.
	OR		
3	Demonstration that non-stormwater flows that are within Copermittee control have been reduced to meet load reductions.	100% reduction in non-stormwater flows within Copermittee control (i.e., within their regulatory authority)	*Dry Weather Field Screening Monitoring* for flow at Copermittee major outfalls.
	OR		
4	Demonstration that discharger is meeting required load reductions as described in the TMDL Alternative for the SMR Estuary.	76% reduction in dry weather loadings from MS4 Copermittees	Total nitrogen, total phosphorus, and flow data from *Non-Storm Water Persistent Flow MS4 Outfall Discharge Monitoring*.
	OR		
5	Demonstration that exceedances of targets are due to sources outside of Copermittee control.	Where final goals have not been met, demonstrate that exceedances of targets are due to source of nutrients outside of the control of the Copermittees.	Potential *Special Studies* conducted during future Permit terms.
	OR		
6	Demonstration that management actions to attain load or flow reductions are being implemented through mechanisms defined in the accepted Water Quality Improvement Plan.	The Copermittees assess progress to goals, implement the JRMP, enhanced JRMP strategies, optional jurisdictional strategies, or optional WMA strategies, as triggered through an iterative approach as described in the accepted Water Quality Improvement Plan.	N/A

1. The final goals are preliminary and will be updated through the adaptive management process when the TMDL Alternative becomes effective.

The outfall monitoring data identify if there are direct or indirect discharges from the Copermittees' MS4 outfalls to receiving waters during dry weather. Where discharges are found, analytical data

and flow can be assessed to determine if the concentrations of total nitrogen and total phosphorus exceed the effluent limitations. Combined with the flow data, these concentrations can also be used to calculate loading rates and flux per acre, and further extrapolated to calculate annual loading rates for the Middle SMR Subwatershed.

5.4.1.2 Monitoring to Assess Progress Toward Achieving Goals and Schedules in the Lower SMR Subwatershed

Multiple compliance pathways are set forth for the Rainbow Creek Nutrient TMDL in Attachment E.3 of the Permit. Compliance with the TMDL may be demonstrated via one of the compliance pathways identified in the Permit. The final compliance date for the TMDL is December 31, 2021, which will be during the next permit term. **Table 5-10** presents the compliance options for the Rainbow Creek Nutrient TMDL goals and the monitoring that may be used to track progress toward achieving these goals.

Table 5-10 Monitoring Related to HPWQC – Nutrients in Rainbow Creek, San Diego County[1]

	Compliance Pathway	TMDL Goal	Monitoring Elements
1	No discharge from MS4 outfalls	No direct or indirect discharge from the County of San Diego's MS4 outfalls to the receiving water	At least quarterly visual observation of flow from outfalls to receiving and Dry Weather Field Screening Monitoring.
		OR	
2	Meet final receiving water limitations	No exceedances of the final Receiving Water Limitations	*TMDL Monitoring* data for nitrate, total nitrogen, and total phosphorus collected at Rainbow Creek monitoring locations.
		OR	
3	Meet final effluent limitations	No exceedances of the final effluent limitations at the County of San Diego's MS4 outfalls	Nitrate, total nitrogen, and total phosphorus concentration data collected at outfalls as part of *Outfall Monitoring* and *Non-Storm Water Persistent Flow MS4 Outfall Discharge Monitoring*.
		OR	
4	Reduce annual pollutant loads	The annual pollutant loads from given land uses discharging to and from MS4 outfalls do not exceed the final effluent limitations	The land uses are intermingled and cannot easily be independently monitored. This pathway is not currently addressed.
		OR	
5	Implement Water Quality Improvement Plan	Implement Water Quality Improvement Plan that incorporates the required BMPs supported by a reasonable assurance as accepted by the San Diego Regional Water Board	*See above for paths 1 through 3.* BMP effectiveness monitoring conducted once BMPs are constructed will demonstrate compliance.

1. See Order R9-2013-0001, as amended, Attachment E.3 – Total Maximum Daily Loads for Total Nitrogen and Total Phosphorus in the Rainbow Creek Watershed.

At this time, the County of San Diego plans to leverage current permit-required monitoring programs and augment these programs close to the compliance deadline to demonstrate dry

weather compliance for nutrients for both the SMR Estuary and Rainbow Creek. However, efforts will be accelerated in Rainbow Creek to meet the upcoming compliance deadline of December 31, 2021. Currently, the County inspects all MS4 outfalls in Rainbow Creek at least quarterly and conducts 24 –hour continuous monitoring from May through September at a minimum of one outfall location. These efforts will continue and when staff are available, the outfalls will be monitored monthly to demonstrate progress toward meeting the dry weather goal. Dry weather conditions occur in the watershed about 90 percent of the time during the year. The outfall monitoring data identify if there are direct or indirect discharges from the County of San Diego's MS4 outfalls to Rainbow Creek during dry weather.

For wet weather compliance monitoring in Rainbow Creek, BMP effectiveness monitoring will be used once the BMPs are constructed to demonstrate that the goal is met. This BMP monitoring will include the collection of water quality samples upstream and downstream of the constructed BMPs to measure the change in concentration or loads of nutrients and total suspended solids. In the meantime, for the Rainbow Creek Nutrient TMDL, at least one additional wet weather outfall monitoring event will be added annually as part of the MS4 Outfall Wet Weather Monitoring (**Section 5.3.2.1**) to provide additional characterization data to inform the design of the remedial measures. This additional wet weather outfall monitoring will be selected during the design phase of the structural BMP and tailored to the needs of the engineers for the design of the BMP. The outfall monitoring will be conducted to collect flow-weighted composites, time-weighted composites, or to collect separate aliquots of samples during one part of the storm event, such as during the rising limb of the storm hydrograph. These samples will be analyzed, at a minimum, for nutrients and total suspended solids.

To track progress toward meeting the dry weather goal for the SMR Estuary, the County of San Diego will expand the Dry Weather Field Screening Monitoring (**Section 5.3.2.2**) to major outfalls that discharge to the SMR from semiannually to quarterly to record flow as present, ponded water or no flow. This additional information will further inform the prioritization of outfalls to mitigate potential sources of dry weather flows.

5.5 REPORTING AND ASSESSMENT PROGRAM

The Copermittees will submit a WQIP Annual Report for each reporting period no later than January 31st of the following year. The annual reporting period will consist of two different periods: 1) July 1st to June 30th for JRMP and WQIP implementation, and 2) October 1st to September 30th for the monitoring and assessment programs. The WQIP Annual Reports will be made available to the public via two Regional Clearinghouses (i.e., RCFCWCD and Project Clean Water websites). The following sections detail the information and assessments that will be provided within the WQIP Annual Report or the Report of Waste Discharge (ROWD) that the Copermittees will submit 180 days prior to the end of the permit term.

5.5.1 Water Quality Improvement Plan Annual Reporting Requirements

The Permit sets forth annual reporting requirements for the WQIP Annual Report. Copermittees will provide the following information within the WQIP Annual Report:

- Receiving water and MS4 outfall discharge monitoring data;
- Progress, finding, interpretations, and conclusions of the special studies (or phases of the study), as appropriate;

- Findings, interpretations, and conclusions from the assessments detailed within **Section 5.5.2**;
- Progress of implementing the WQIP, including but not limited to, the following:
    - Progress toward achieving the interim and final numeric goals for the HPWQC for the WMA;
    - Water quality improvement strategies that were implemented and/or no longer implemented by each of the Copermittees during the reporting period and previous reporting periods;
    - The water quality improvement strategies planned for implementation during the next reporting period;
    - Proposed modifications to the water quality improvement strategies, the public comments received, and the supporting rationale for the proposed modifications;
    - Previous modifications or updates incorporated into the WQIP and/or each Copermittee's JRMP document and implemented by the Copermittees in the WMA; and
    - Proposed modifications or updates to the WQIP and/or each Copermittee's JRMP document;
- Completed JRMP Annual Report form for each Copermittee in the WMA;
- Copermittee monitoring data utilized in developing the WQIP Annual Report uploaded to the California Environmental Data Exchange Network (CEDEN). Raw data files will not be included within the WQIP Annual Report.

5.5.2 Assessment Program

The assessment portion of the MAP will evaluate the data collected under the monitoring programs described in **Section 5.2**, as well as the information collected as part of the JRMPs and implementation of WQIP strategies. The data collected from these programs will be used to assess the progress toward achieving the numeric goals and schedules for addressing the HPQWC. **Figure 5-8** depicts how the watershed monitoring activities will support the assessments required by the Permit. Some assessments will be reported annually, as part of the WQIP Annual Report, while others will be included in the ROWD. The SMR WMA MAP will be evaluated and adapted in the context of the WQIP Annual Report and the ROWD. The re-evaluation will consider data gaps and the results of all monitoring program elements. In general, short term evaluations will be included in annual reports, with long term assessments included within the ROWD. The assessment process and feedback loop is described in greater detail in **Chapter 6**, Adaptive Management.

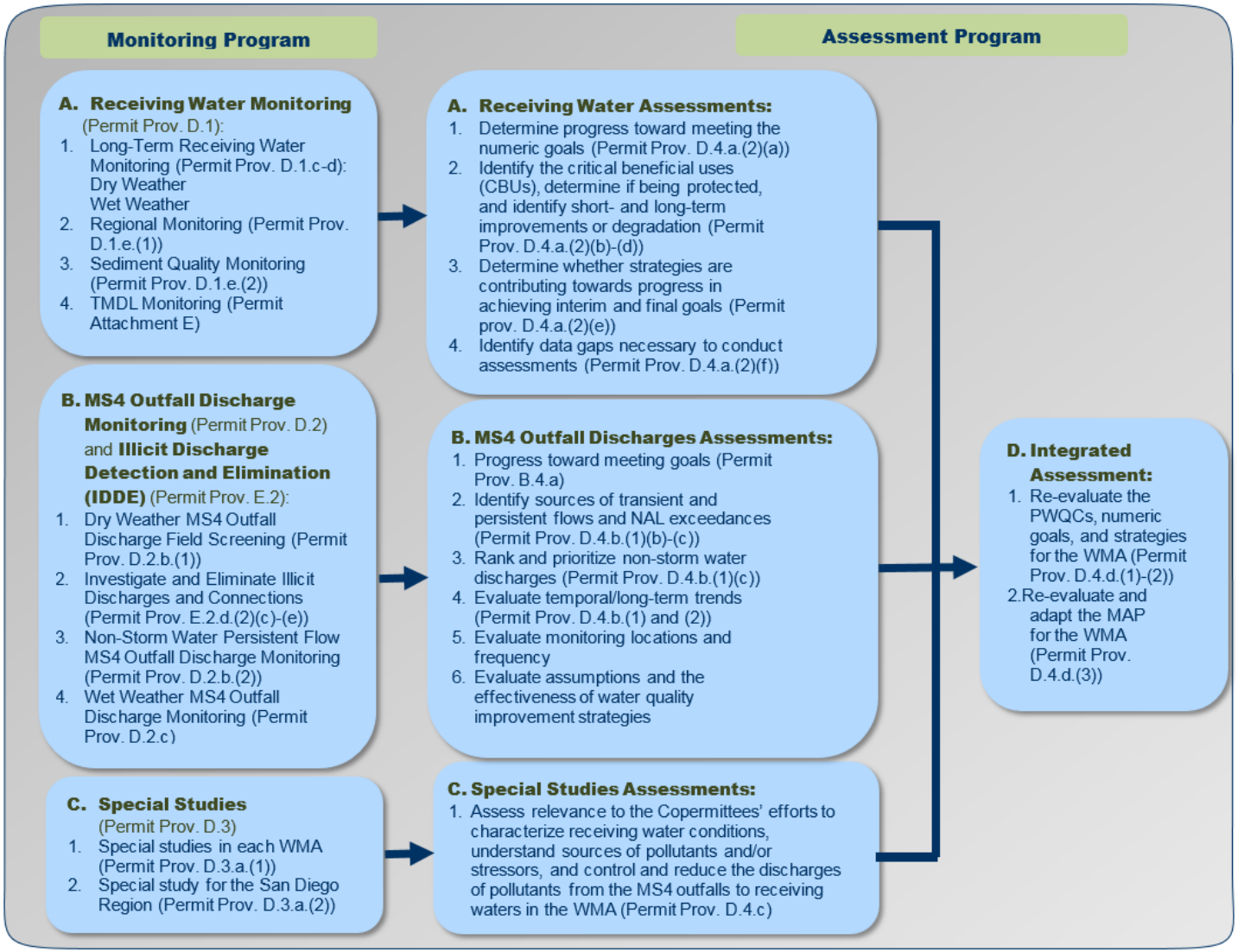

Figure 5-8. MAP Components for the SMR WMA

5.5.2.1 RECEIVING WATER ASSESSMENT

The assessment of receiving waters involves evaluating the physical, chemical, and biological conditions of the receiving waters and sediments. The Copermittees must assess the status and trends of receiving water quality conditions in coastal waters, enclosed bays, estuaries, and streams in the watershed. Receiving water data, regional monitoring programs, sediment quality, and TMDL monitoring programs will be used as applicable. The receiving water assessments to be presented in the WQIP Annual Report or ROWD will:

- Assess whether or not the conditions of the receiving waters are meeting the applicable numeric goals by calculating the percent reduction in dry weather loading in receiving waters;
- Identify the most critical beneficial uses (e.g., HPWQC) that must be protected to ensure the overall health of the receiving water by following procedures consistent with the evaluations outlined in **Chapter 2**;
- Evaluate whether or not those critical beneficial uses are being protected by comparing data to applicable water quality objectives;
- Identify short-term and/or long-term improvements or degradation of those critical beneficial uses by evaluating trends;
- Consider whether or not the WQIP strategies contribute toward progress in achieving the interim and final numeric goals of the WQIP; and
- Identify data gaps in the monitoring data needed to assess the provisions above.

5.5.2.2 MS4 OUTFALL DISCHARGE ASSESSMENTS

The MS4 outfall discharge assessments include evaluating both the dry weather monitoring data associated with the IDDE program collected as part of the JRMP and the wet weather monitoring data collected by the Copermittees. Each Copermittee will assess its dry weather MS4 outfall monitoring programs individually and compile results annually as part of the WQIP Annual Report. Each Copermittee must assess and report the progress of its IDDE program (required pursuant to Permit Provision E.2) toward effectively prohibiting non-storm water and illicit discharges into the MS4s within its jurisdiction. The non-storm water discharge reduction assessments to be presented in the WQIP Annual Report or ROWD will:

- Identify known and suspected controllable sources (e.g. facilities, areas, land uses, pollutant generating activities) of transient and persistent flows within the Copermittee's jurisdiction in the WMA by following procedures consistent with the procedures outlined in **Chapter 3**;
- Identify sources of transient and persistent flows within the Copermittee's jurisdiction in the WMA that have been reduced or eliminated by reviewing information collected as part of the IDDE program and Dry Weather MS4 Outfall Discharge Field Screening Monitoring Program;
- Identify necessary modifications through program assessment to identify and eliminate sources of persistent flow;

- Rank the outfalls according to potential threat to receiving water quality and produce a prioritized outfall list;
- For the highest priority outfalls in exceedance of NALs,
    - Identify known and suspected sources that may cause or contribute to NAL exceedances;
- Using a model or other method, calculate/estimate non-storm water volumes and pollutant loads from all major outfalls with persistent flow to assess progress toward meeting flow reduction and load reduction goals identified in **Section 4.1.3**:
    - With an estimate of the percent contribution from each known source for each MS4 outfall; and
    - Each Copermittee must annually identify and quantify sources of non-storm water not subject to the Copermittee's legal authority that are discharged from the Copermittee's major MS4 outfalls to downstream receiving waters;
- Identify reductions and progress in achieving reductions in non-storm water and illicit discharges to the Copermittee's MS4 in the WMA;
- Assess the effectiveness of water quality improvement strategies (with estimates attributable to the specific strategies if possible) toward addressing MS4 non-storm water discharges by comparing data collected through the Non-Storm Water Persistent Flow MS4 Outfall Discharge Monitoring Program to NALs and assessing additional available information;
- Identify modifications to increase effectiveness of the water quality improvement strategies; and
- Identify data gaps in the monitoring data necessary to assess the provisions above.

The assessments for stormwater pollutant discharge reductions to be presented in the Annual Report will:

- Use a model or other method to calculate/estimate:
    - The average storm water runoff coefficient for each land use within the WMA;
    - The volume of storm water and pollutant loads discharged from monitored outfalls for each storm event with measurable rainfall greater than 0.1 inch;
    - The total flow volume and pollutant loadings discharged from each jurisdiction within the WMA over the course of the wet season (extrapolated from the monitored MS4 outfalls); and
    - The percent contribution of storm water volumes and pollutant loads discharged from each land use type within each hydrologic subarea with a major MS4 outfall to receiving waters or within each major MS4 outfall to receiving waters in the Copermittee's jurisdiction within the WMA for each storm event with measurable rainfall greater than 0.1 inch;
- Evaluate findings against analyses/assumptions from the WQIP to determine whether updates are needed;

- Identify reductions in pollutants concentrations or loads from different land uses and/or drainage areas;
- Assess the effectiveness of water quality improvement strategies (with estimates attributable to the specific strategies if possible) toward reducing pollutants in storm water discharges by comparing data collected through the MS4 Outfall Wet Weather Monitoring Program to storm water action levels (SALs) identified in Permit Provision C.2 [inclusive of any future iterations] and assessing additional available information;
- Identify modifications to increase effectiveness of the water quality improvement strategies;
- Identify data gaps in the monitoring data necessary to assess the provisions above; and
- Evaluate all the wet weather MS4 outfall discharge monitoring data, and incorporate new outfall monitoring data into time series plots for each long-term monitoring constituent for the WMA, and perform statistical trends analysis on the cumulative long-term wet weather MS4 outfall discharge water quality dataset.

5.5.2.3 SPECIAL STUDIES ASSESSMENTS

As part of the WQIP Annual Report, the Copermittees will evaluate the results and findings from the special studies, as available. Depending on the special study, the results may be included in assessments related to receiving waters, MS4 discharges, source identification, or other evaluations, as appropriate. Where applicable, they will use the resulting data to: (1) assess their relevance to the Copermittees' characterization of receiving water conditions, (2) understand sources of pollutants and/or stressors, and (3) control and reduce the discharges of pollutants from the MS4 outfalls to receiving waters. As with the other monitoring programs, the results of the special studies assessment may warrant modifications of or updates to the WQIP.

5.5.2.4 INTEGRATED ASSESSMENT

The Copermittees will integrate the data collected as part of the MAP, along with information collected during the implementation of the JRMP and WQIP strategies. The integrated assessment will evaluate the main components of the WQIP and will follow the assessment process outlined in the Permit. The integrated assessment will include all four WQIP components: (1) Priority Water Quality Conditions, (2) Goals and Schedules, (3) Strategies and Schedules, and (4) MAP. The assessment will be performed during the development of the ROWD and include those assessments specified for "once during the term of the Order". The PWQCs will be reevaluated using the receiving water and MS4 outfall discharge assessments. The goals and schedules in **Chapter 4** will be reviewed based on the results of the receiving water and MS4 outfall discharge assessments, along with data collected as part of the JRMP and WQIP strategies. This evaluation will highlight the progress in achieving the compliance goals. Both water quality monitoring data and maintenance/observational data related to BMP effectiveness will be used to assess the strategies implemented by the Copermittees. Strategies will be evaluated in the WQIP Annual Report based on the data collected as part of the JRMP and WQIP strategies and any new relevant BMP effectiveness data collected by the Copermittees. Finally, the Copermittees must re-evaluate and adapt the MAP for the WMA when new information becomes available to improve the MAP. The re-evaluation of the MAP for the WMA will consider the data gaps identified by the assessments described in **Sections 5.5.2.1** and **5.5.2.2** and results of the special studies.

6 Iterative Approach and Adaptive Management Process

Chapter 6 outlines the iterative approach of the adaptive management process that will be used to evaluate and adapt the WQIP for the SMR WMA. The adaptive management process is the framework to evaluate progress and make adjustments in implementation approaches and timing to attain goals. It will be used, in conjunction with data collected, as part of the Monitoring and Assessment Program (MAP), to evaluate whether modifications to goals, schedules, and/or strategies are necessary to meet the interim and final goals for eutrophication impacts and nutrient loading in the SMR WMA. Through the implementation of strategies and an iterative, adaptive management approach, it is anticipated that the numeric goals will be achieved and the water quality will be improved. **Figure 6-1** summarizes the framework of the adaptive management process.

The WQIP will be adapted in response to triggers identified in Permit Provisions B.5.a-c. Triggers that may warrant program adaptation include exceedances of water quality standards in receiving waters, new information, Regional Water Board recommendations, and input received during the public participation process. The Regional Water Board may require updates to the WQIP based on information they receive from outside parties. Additional Permit requirements for adaptive management are summarized in **Table 6-1**. Effectiveness assessments of JRMP or LIP programs and strategies may also trigger adaptations to the WQIP. The diagram below outlines the process for the development and implementation of the WQIP and includes the iterative approach and adaptive management process steps.

Each trigger calls for specific responses within timeframes specified in the Permit. While the adaptive management process would typically be implemented annually or at the end of the permit term, other adaptations could occur on a different schedule.

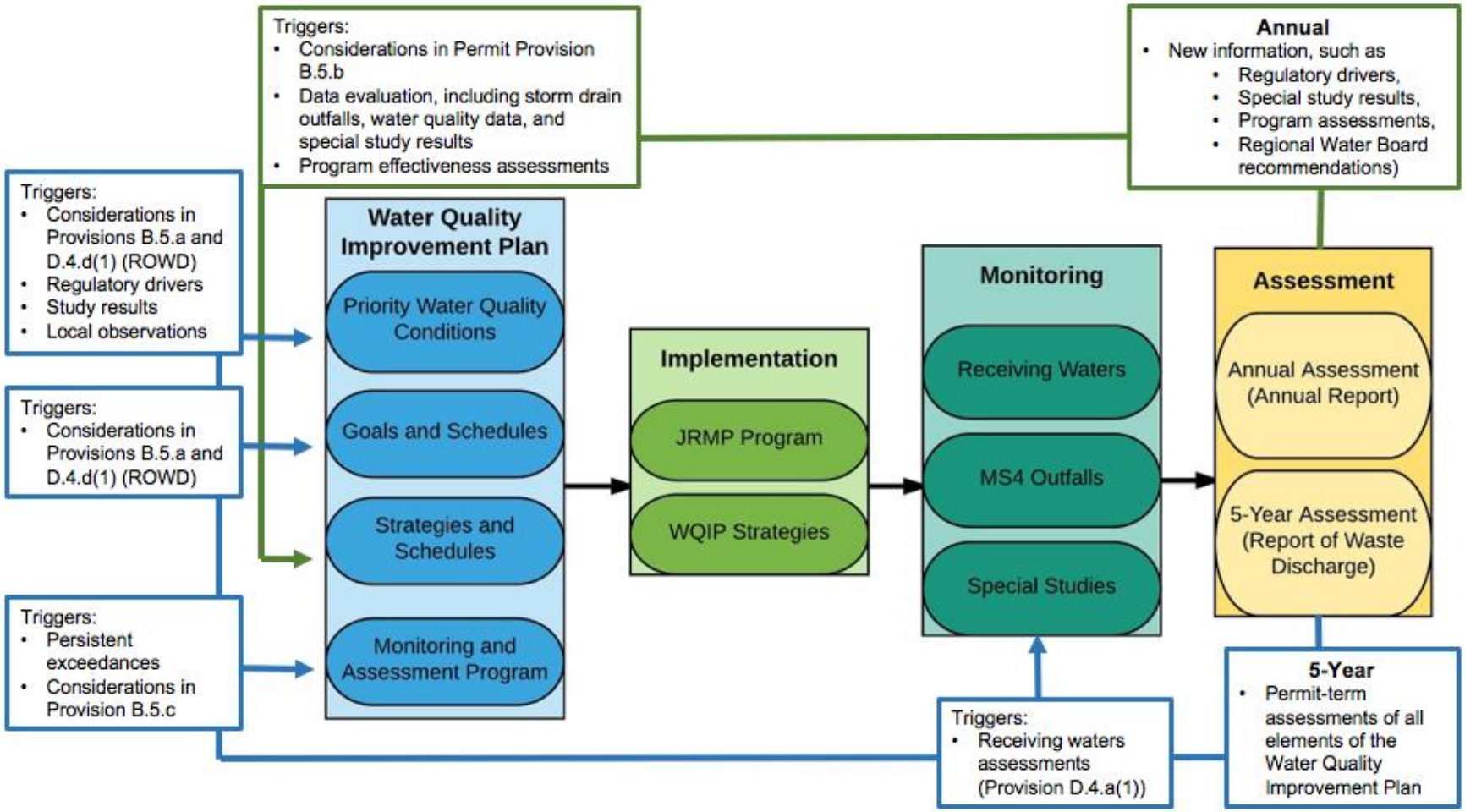

Figure 6-1. Adaptive Management Process Framework

Table 6-1. Permit Requirements for the Adaptive Management Process

Permit Provision	Requirements	Frequency
Provision A.4	The Water Quality Improvement Plan must be designed and adapted to ultimately achieve compliance with the discharge prohibitions (Provisions A.1.a and A.1.c) and receiving water limitations (Provision A.2.a) specified in the Permit.	Report of Waste Discharge
Provision B.5	Specific considerations must be included in the adaptive management process. This includes the re-evaluation of PWQCs; adaptation of goals, strategies, and schedules; and adaptation of the Monitoring and Assessment Program.	Re-evaluation of Water Quality Conditions, Goals/Schedules, and the Monitoring and Assessment Program to be provided in Report of Waste Discharge; Strategies and Schedules to be considered annually.
Provision D.4.d	Contains the processes for the assessments and adaptive management that must occur once during the Permit term.	Report of Waste Discharge
Provision F.2.c	Describes the requirements for updates to the Water Quality Improvement Plan that could result from implementation of the adaptive management requirements.	Copermittees must submit updates to the Water Quality Improvement Plan either in the Annual Report or in the Report of Waste Discharge

6.1 RE-EVALUATION OF PRIORITY WATER QUALITY CONDITIONS

Permit Provision B.5.a describes the process for re-evaluation of the PWQCs. PWQCs may be re-evaluated as needed by the Copermittees during the permit term, and must be re-evaluated in the Report of Waste Discharge. The HPWQC and PWQCs selected during the development of the WQIP are intended to remain for the duration of the permit term, but may be adjusted if new, pertinent information becomes available that would directly influence priorities. Provisions B.5.a and D.4.d(1) describe the considerations that would trigger an assessment of the PWQCs and HPWQC. The following additional considerations may trigger an assessment of the PWQCs and HPWQC, including, but not limited to:

- Regulatory drivers, such as revised WQOs issued by the State Water Board, approval of a TMDL Basin Plan Amendment, modifications to the TMDL Alternative, and/or adoption of the TMDL Alternative Resolution;
- Results of special studies conducted within the watershed, and relevant results from outside the watershed related to the PWQCs and HPWQC;
- Additional relevant and appropriately collected data and information related to the Upper SMR Subwatershed, including data to be collected at the new monitoring station described in Section 5.3.1;

- New data and recommendations developed from the Rainbow Creek Nutrient TMDL Monitoring and assessment of progress toward achieving goals and schedules in the Lower SMR Subwatershed; and
- Local observations, such as the number of homeless encampments in creek systems, or local evidence of eutrophication.

Data collected during the permit term will be used to update the analysis of the PWQCs as part of the Report of Waste Discharge**. Table 6-2** lists the considerations that must be included when Copermittees re-evaluate the PWQCs for the watershed.

Table 6-2. Re-evaluation of Priority Water Quality Conditions

Frequency	Trigger[1]	Considerations
5-Years	Report of Waste Discharge (B.5.a, D.4.d(1))	***Provision B.5.a Iterative Approach and Adaptive Management Considerations*** • Achievement of the outcome of improved water quality through the implementation of strategies identified in the Water Quality Improvement Plan. • New information developed in the re-assessment of receiving water conditions, impacts from MS4 discharges, and subsequent re-evaluation of priorities. • Spatial and temporal accuracy of monitoring data. • Availability of new information and data from sources outside the JRMP programs that inform the effectiveness of strategies and actions. • Recommendations from the Regional Water Board. • Recommendations received through a public participation process.
		Provision D.4.d(1) Integrated Assessment Considerations • Re-evaluation of the receiving water conditions and the impacts of MS4 discharges on receiving waters per the process developed in **Chapter 2**. This includes the identification of beneficial uses in receiving waters that are protected per the Monitoring and Assessment Program. • Re-evaluation of the identification of stormwater conveyance sources and/or stressors if corresponding to elevation of a new highest priority condition.

1. Following approval of a TMDL with wasteload allocations by the Office of Administrative Law (OAL) and the USEPA, the Copermittees must initiate an update of the WQIP within six months – this may impact the PWQCs and HPWQC for the SMR WMA.

6.2 ADAPTATION OF GOALS, STRATEGIES, AND SCHEDULES

The adaptation of goals, strategies, and schedules must occur as part of the Report of Waste Discharge, and may occur on an annual basis under certain conditions. The two conditions that warrant annual adaptation of goals and schedules are: (1) where a new TMDL is approved by the State of California Office of Administrative Law (OAL) and the USEPA or (2) where annual evaluations of receiving water and MS4 outfall monitoring data provide new information impacting the goals. The three conditions that warrant annual adaptation of strategies and

schedules are: (1) where a new TMDL is approved by OAL and USEPA, (2) where annual evaluations of receiving water and MS4 outfall monitoring data provide new information impacting implementation schedules, or (3) where program effectiveness assessments provide information adequate to justify modification.

6.2.1 Adaptation of Goals and Schedules

As part of the preparation of the Report of Waste Discharge, the Copermittees will evaluate the progress toward achieving the watershed goals established in **Chapter 4**. The watershed goals and schedules that will be assessed as part of the Report of Waste Discharge are provided in **Table 4-2** in **Section 4.1**.

Assessment of the watershed goals and compliance pathways will be performed using data collected per the Monitoring and Assessment Program (MAP) and JRMP/LIPs, along with the schedules developed in conjunction with each goal. Depending on the results of the assessment, it may be appropriate to adjust either the numeric goals and/or the schedules associated with each goal. The ability to modify goals and schedules based on the TMDL Alternative for the SMR Estuary will be dependent on the flexibility afforded by the Resolution for the TMDL Alternative, which has yet to be adopted by the Regional Water Board. **Table** 6-3 lists the considerations that will be included in the process of evaluating progress towards defined goals and schedules.

Table 6-3. Adaptation of Goals and Schedules for the HPWQC

Frequency	Trigger [a]	Considerations
5-Years	Report of Waste Discharge (B.5.b, D.4.d.(1))	***Provision B.5.b Iterative Approach and Adaptive Management Considerations*** • Modifications to the PWQCs based on Provision B.5.a. • Progress toward achieving numeric goals for the highest priority water quality conditions. • Progress in meeting established schedules. • New policies or regulations that may affect goals. • Reductions of non-storm water discharges. • Reductions of pollutants in storm water discharges from the stormwater conveyance to the MEP. • New information resulting from the re-evaluation of impacts from MS4 discharges and/or pollutants and stressors. • Efficiency in implementing the Water Quality Improvement Plan. • Recommendations from the Regional Water Board. • Recommendations received through a public participation process. ***Provision D.4.d(1) Integrated Assessment Considerations*** • Evaluation of the progress toward achieving interim and final numeric goals for protecting impacted beneficial uses in receiving waters.

1. Following approval of a TMDL with wasteload allocations by OAL and the USEPA, the Co-Permittees must initiate an update of the WQIP within six months.

6.2.2 Adaptation of Strategies and Schedules

The strategies and implementation schedules developed to address the HPWQC in the watershed will be re-evaluated as part of the Annual Reporting process and the preparation of the Report of Waste Discharge. These re-evaluations may result in modifications to or elimination of strategies as well as the development of new strategies. Ultimately, the effectiveness of the strategies will be based on the progress toward achieving the interim and final numeric goals. However, an evaluation of strategies based on the achievement of the interim and final numeric goals may take many years of implementation and monitoring to assess. To supplement the "goal-based" assessments, programmatic data collected over the permit term may be incorporated into the assessment and adaptive process to modify strategies and implementation schedules as appropriate.

6.2.2.1 Water Quality Data Evaluation and Linkage to Strategies

Receiving water data will be assessed as described in **Section 5.5**. The assessment will indicate progress toward longer term goals and protection of beneficial uses. These data may be used to evaluate the collective effectiveness of the strategies. This information will provide a "big picture" assessment of the success of the strategies over the long term. The data evaluation also has the potential to trigger mandatory updates to the WQIP per Permit Provision A.4 where exceedances of water quality standards persist in receiving waters. This part of the adaptive management process is described further in **Section 6.5** and detailed in **Figure 6-1.**

MS4 outfall visual observations, water quality data, and special study results may provide information that is more directly linked to the implementation of individual strategies. Where possible, this information will be used to modify, eliminate, and/or develop new strategies to address the HPWQC in the watershed. Where appropriate, these assessments will include a comparison of the data with the NALs and SALs as required per Provision C of the Permit. These data will provide the foundation for the MS4 outfall discharge assessments described in **Chapter 5**, which will examine the results of Illicit Discharge Detection and Elimination Programs and MS4 Outfall Discharge Monitoring Programs. Where strategies can be linked to measurable or demonstrable reductions of non-storm water discharges or to reductions of pollutants in storm water, appropriate modifications will be made.

6.2.2.2 Program Assessments

Where available, the results of program effectiveness assessments performed at the jurisdictional or watershed scale may also factor into the adaptation of specific strategies. The level of information will vary by jurisdiction and by program, as these types of assessments are not explicitly required by the Permit. However, in many cases, the jurisdictions are performing programmatic assessments to ensure the most effective use of available resources. These assessments have the potential to provide information to determine the effectiveness of specific strategies that is more relevant than water quality data collected at MS4 outfalls or in receiving waters and may be a key driver in adapting strategies. In some cases, modifications to strategies may also be the result of internal jurisdictional opportunities or constraints such as increases or decreases in available funding or staffing. Modifications to strategies based on program effectiveness assessment may occur annually or on a permit term.

Table 6-4 lists the considerations that will be evaluated when adapting strategies and schedules, whether on an annual timeframe within the Annual Report or on a 5-year permit term timeframe (i.e., Report of Waste Discharge).

Table 6-4. Adaptation of Water Quality Strategies and Schedules

Frequency	Trigger[1]	Considerations
Annual	New Information (B.5.b)	***Permit Provision B.5.b Iterative Approach and Adaptive Management Considerations*** • Modifications to the priority water quality conditions. • Progress toward achieving numeric goals for the highest priority water quality conditions. • Progress in meeting established schedules. • New policies or regulations that may affect goals. • Reductions of non-storm water discharges. • Reductions of pollutants in storm water discharges from the stormwater conveyance to the maximum extent practicable (MEP). • New information resulting from the re-evaluation of impacts from MS4 discharges and/or pollutants and stressors. • Efficiency in implementing the Water Quality Improvement Plan. • Recommendations from the Regional Water Board. • Recommendations received through a public participation process.
5-Years	Report of Waste Discharge (D.4.d.(2))	***Permit Provision D.4.d(2) Integrated Assessment Considerations*** • Identification of the non-storm water and storm water pollutant loads from the MS4 outfalls per Provision D.4.b. • Identification of the non-storm water and storm water pollutant load reductions, or other improvements that are necessary to attain the interim and final numeric goals. • Identification of the non-storm water and storm water pollutant load reductions, or other improvements, that are necessary to demonstrate that non-storm water and storm water discharges are not causing or contributing to exceedances of receiving water limitations. • Evaluation of the progress of the strategies toward achieving interim and final numeric goals for protecting beneficial uses in receiving waters.
5-Years	Persistent Exceedances Not Addressed (A.4.a.(2))	***Permit Provision A.4.a(2) Integrated Assessment Considerations*** [2] • Water quality standard exceedances for pollutants that are addressed by the Water Quality Improvement Plan; implementation of the accepted plan continues and is updated as necessary. • If MS4 discharges are causing or contributing to a new exceedance of an applicable water quality standard for pollutants that are not addressed by the Water Quality Improvement Plan, the Water Quality Improvement Plan will be updated as part of the Annual Report (unless directed to update it earlier by the Regional Water Board). Following Regional Water Board approval of modifications to the Water Quality Improvement Plan, the Copermittees must update their JRMP accordingly.

1. Following approval of a TMDL with wasteload allocations by the OAL and the USEPA, the Copermittees must initiate an update of the WQIP within six months.
2. The procedure need not be repeated for continuing or recurring exceedances of the same water quality standard(s) once scheduled strategies are implemented unless directed to do so by the Regional Water Board.

6.3 ADAPTATION OF MONITORING AND ASSESSMENT PROGRAM

As part of the Report of Waste Discharge, the Copermittees will consider modifications to the Monitoring and Assessment Program (MAP), consistent with the requirements in Permit Provision D.4.d.(3). During the permit term, modifications must be consistent with the requirements of Permit Provisions D.1, D.2, and D.3 (receiving water, MS4 outfall, and special study monitoring requirements, respectively), which limit the amount of adaptation that is possible. However, recommendations within the Report of Waste Discharge provide an opportunity to make more meaningful modifications to the Monitoring and Assessment Program. Examples of modifications to the Monitoring and Assessment Program include the following adjustments:

- Determine whether discharges from the MS4 outfalls are linked to exceedances in the receiving water;
- Address data gaps via re-assessment of monitoring locations and frequencies; and/or
- Address results of special studies.

Table 6-5 lists considerations that will be evaluated when adapting the Monitoring and Assessment Program.

Table 6-5. Adaptation of Monitoring and Assessment Program

Frequency	Trigger [1]	Considerations
Annual	New Information (B.5.c)	***Permit Provision B.5.c Iterative Approach and Adaptive Management Considerations*** • Re-evaluation based on new information such as modified priority water quality conditions, goals, strategies, or schedules. • New information, including new regulations. • Must include information gained from Permit required monitoring.
5-Years	Persistent Exceedances Not Addressed (A.4.a.(2))	***Permit Provision A.4.a(2) Integrated Assessment Considerations*** [2] May include modifying the monitoring program to fill data gaps. Modifications could include moving monitoring locations, adding additional sample collection, or changing type of sample collected.
5-Years	Report of Waste Discharge (B.5.c)	***Permit Provision B.5.c Iterative Approach and Adaptive Management Considerations*** • Review of Program based on the requirements in Provision D. • Adjustment of the monitoring program to determine whether discharges from the stormwater conveyance are causing/contributing to exceedances in the receiving water when new exceedances persist; identification and addressing of data gaps via re-assessment of monitoring locations and frequencies; adjustment of monitoring program to address results of special studies.

1. Following approval of a TMDL with wasteload allocations by the OAL and the USEPA, the Copermittees must initiate an update of the WQIP within six months.
2. The procedure need not be repeated for continuing or recurring exceedances of the same water quality standard(s) once scheduled strategies are implemented unless directed to do so by the Regional Water Board.

6.4 TIMING OF ADAPTIVE MANAGEMENT REQUIREMENTS

Adaptive management via the iterative process, based on the Permit-required evaluations described previously, will be integral to the success of the WQIP. However, the Copermittees will adapt different components of the WQIP at different rates, depending on a variety of factors. In most cases, annual modifications will consist of updates to strategies or timelines, reflective of information gained through implementation. Significant updates to the WQIP may be required as part of the Report of Waste Discharge, performed once per permit term. For parts of the WQIP (e.g., PWQCs, goals) a longer timeline is appropriate for evaluation, as accurate and more robust information is necessary to change the course of the WQIP. The following sections provide more insight and details related to the timing of the adaptive management process and the impacts on revisions to the WQIP.

6.4.1 Annual Assessments and Adaptive Management

The Permit indicates that new information should be considered on an annual basis for adaptations to the WQIP. Modifications may be appropriate for the water quality goals, strategies, schedules, and/or Monitoring and Assessment Program. The PWQCs and Monitoring and Assessment Program may be modified as needed during the permit term, but would likely be modified only as a result of assessments conducted for the Report of Waste Discharge.

6.4.1.1 Annual Evaluation of New Information

The adaptive management process may be triggered as new information becomes available as discussed in the following subsections. Where appropriate, modifications may be made to goals, strategies, schedules, and/or the Monitoring and Assessment Program and reported in the Annual Report.

6.4.1.1.1 Regulatory Drivers

Where new regulations or policies are adopted that impact watershed planning and implementation processes in the near term, modifications to the goals, strategies, schedules, and/or Monitoring and Assessment Program may be warranted, and, in some cases, required. For example, an update will be initiated no later than six months following approval of a TMDL Basin Plan Amendment by the OAL and the USEPA, or adoption of the TMDL Alternative Resolution. The trigger applies to TMDLs containing wasteload allocations assigned to Copermittees within the watershed during the term of the Order (Provision F.2.c.(2)). Similarly, modifications to the TMDL Alternative, in development during preparation of the WQIP, may also necessitate adaptations. The WQIP is based on the best available information related to the TMDL Alternative at the time of development, but modifications to the TMDL Alternative during the adoption process may necessitate modifications to the WQIP.

Other examples of regulatory drivers that may trigger modifications include new state policies or plans (e.g., biostimulatory substances amendments, biological objectives) and changes resulting from modifications to existing Permit requirements (e.g., as a result of revising a TMDL).

6.4.1.1.2 Special Study Results

As part of the Monitoring and Assessment Program, Copermittees have performed special studies related to the HPWQC for the watershed. As further described in **Chapter 5** of this WQIP, the Copermittees supported a WMA special study which consisted of providing in-kind monitoring

support for Phase II of the SMRNIG Characterization Studies. In addition, the Copermittees participated in the San Diego Regional Stream Reference Study, which included the collection and reporting of nutrient data. Future special studies will be designed to provide information related to sources of the HPWQC within the watershed, will be implemented during the permit term, and are typically performed over multiple years. As relevant data, conclusions, and lessons learned become available from these studies, the WQIP may be modified. The study results may impact the goals, strategies, schedules, and the Monitoring and Assessment Program. Additionally, lessons learned and study results from outside the watershed, especially those related to the HPWQC, may also be incorporated into the WQIP.

6.4.1.1.3 Program Assessments

WQIP strategies will be incorporated into individual Copermittees' JRMPs. The Copermittees will implement program refinements to increase focus on the particular water quality issues identified in the WQIP, and utilize various assessment methods to determine which program refinements are effective and which are not. The program effectiveness assessment results would provide useful information that may lead to adaptation of goals, strategies, schedules, and the Monitoring and Assessment Program. For example, as various water conservations strategies are implemented in coordination with water districts in target areas, the water conservation strategies that are found to be effective at reducing flow may be expanded, while those that are ineffective may be modified, reduced, or eliminated.

6.4.1.1.4 Regional Water Board Recommendations

Adaptation of the WQIP may also be required based on recommendations from the Regional Water Board. The Regional Water Board may require updates to the WQIP based on information they receive from outside parties. The Regional Water Board's recommendations could be a result of the public participation process, Consultation Committee input, review of submitted reports, or other Regional Water Board interests.

6.4.2 Permit Term Assessments and Adaptive Management

The Permit also contains specific assessments to be performed during preparation of the Report of Waste Discharge. These assessments are longer term in nature, occurring only once during the permit cycle. During Report of Waste Discharge preparation, all elements of the WQIP are eligible for modifications through the required adaptive management processes. Elements that could be evaluated include the water quality conditions (i.e., priorities), goals and accompanying schedules, strategies and accompanying schedules, and the Monitoring and Assessment Program.

6.4.2.1 Receiving Waters Assessments

Evaluation of receiving water and MS4 outfall discharge data will be performed annually as part of the Annual Report and is described in **Chapter 5**. More comprehensive evaluations of receiving water data will be performed for the Report of Waste Discharge (Permit Provision D.4.a.(1)). These evaluations will summarize receiving water data collected within the watershed and provide information with the potential to trigger the adaptive management process to achieve compliance with Permit discharge prohibitions and receiving water limitations as required in Provision A.

Provision A.4 describes adaptive management procedures that the Copermittees must implement "if exceedance(s) of water quality standards persist in receiving waters." If the adaptive

management process is triggered under this provision, the process will include the following assessments:

- Whether the MS4 outfall is a source of pollutants causing the exceedances to persist in the receiving waters, and
- Whether or not the exceedances are addressed by the WQIP.

If the receiving water exceedances are addressed under the WQIP, the Copermittees will continue implementation. If the receiving water exceedances are not addressed, the Copermittees will update the WQIP to address the exceedances as described in Provision A.4.a.(2) and submit the updates with the Report of Waste Discharge. The updates will include, as applicable:

- A description of strategies that are currently being implemented, are effective, and will continue,
- A description of strategies that will be implemented to reduce or eliminate pollutants or conditions that are a source of the receiving water exceedances,
- Updates to the implementation schedules for existing, revised, or additional strategies, and
- Updates to the Monitoring and Assessment Program to track progress toward achieving compliance with Provisions A.1.a, A.1.c, and A.2.a.

The adaptive management process as required under Provision A.4 is illustrated in **Figure 6-2**.

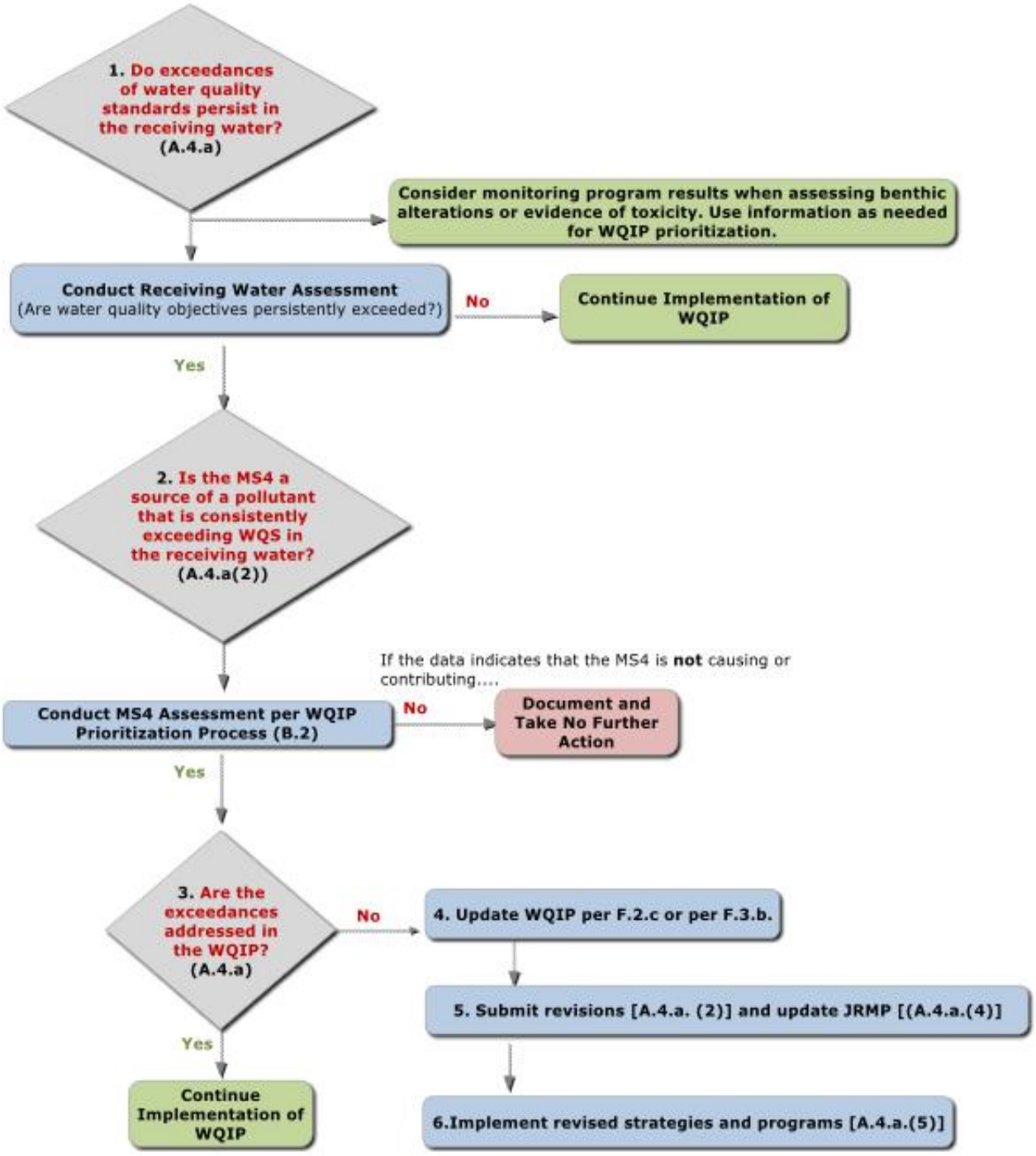

Figure 6-2. Receiving Waters Water Quality Standards Exceedance Process

6.5 WATER QUALITY IMPROVEMENT PLAN UPDATES AND REPORTING

Updates to the WQIP will include a public participation process as required by Provision F of the Permit. Annual updates will likely include a more abbreviated public process unless substantial modifications are identified. A full public process will be implemented as part of updates associated with the Report of Waste Discharge. Updates will include a process to obtain data from the public, participation by the Consultation Committee, and submittal for approval. As applicable, updates to the WQIP will be initiated within six months following OAL and USEPA approval of any TMDLs with Waste Load Allocations (WLAs) assigned to the Copermittees. Updates will be deemed appropriate for inclusion in the WQIP 90 days following submission to the Regional Water Board unless otherwise directed by the Regional Water Board Executive Officer. Updates to the WQIP will also be made available to the public via two Regional Clearinghouses (i.e., RCFCWCD and Project Clean Water websites) following acceptance by the Regional Water Board. **Table 6-6** provides a tentative timeline for WQIP implementation and the adaptive management process.

Table 6-6. Water Quality Improvement Plan Implementation and Adaptive Management Process, as required by Order No. R9-2013-0001, as amended by Order Nos. R9-2015-0001 and R9-2015-0100

Milestone	Target Date	Adaptive Management Triggered
Report of Waste Discharge	December 2017	
WQIP Submittal	January 2018	
Anticipated WQIP Acceptance	Spring 2018	
WQIP Implementation	90 Days following Acceptance by Regional Water Board	
Annual Reporting	January (2019)	Strategies and schedules
Anticipated Permit Adoption	February 2019	
Effective date for Permit	50 days after Adoption	
Annual Reporting	January of each year (2020, 2021, 2022, 2023)	Strategies and schedules
Report of Waste Discharge	180 days prior to Permit Expiration	• Priority water quality conditions • Goals and schedules • Monitoring and assessment program

7 Glossary of Terms

Agencies – Copermittees and the City of Menifee

Controllable – (or "within agency control") consistent with the scope of the Permit, conditions that are within the regulatory authority of the agency and can feasibly be addressed or treated at the point of entry, within, or at the MS4 outlets are controllable. This requires the availability of feasible options for treating the condition. (See accepted San Luis Rey WMA WQIP, Section 2.3.1)

Co-Permittee – A permittee to a NPDES permit that is only responsible for permit conditions related to the discharge for which it is operator [40 CFR 122.26(b)(1)]. For the purposes of the MS4 Permit, a Copermittee is one of the individual permittees identified in Tables 1a – 1c of the Permit. (See Permit Attachment C)

Dry Season – May 1 to September 30. (See Permit Attachment C)

Dry Weather – Weather is considered dry if the preceding 72 hours has been without measurable precipitation (>0.1 inch). (See Permit Attachment C)

Existing Development – Any area that has been developed and exists for municipal, commercial, industrial, or residential purposes, uses, or activities. May include areas that are not actively used for its originally developed purpose, but may be re-purposed or redeveloped for another use or activity. (See Permit Attachment C)

Municipal Separate Storm Sewer System (MS4) – A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains): (i) Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or designated and approved management agency under section 208 of the CWA that discharges to waters of the United States; (ii) Designated or used for collecting or conveying storm water; (iii) Which is not a combined sewer; (iv) Which is not part of the Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.26. (See Permit Attachment C)

Open Space – Undeveloped areas of the watershed that are do not contain areas of existing development (e.g., commercial, residential, industrial, municipal facilities) and are not under construction. (See Permit Fact Sheet, Provision E.5)

Storm Drain – [need new definition]

Wet Season (aka Rainy or Storm Season) – October 1 to April 30. (See Permit Attachment C)

Wet Weather – Weather is considered wet up to 72 hours after a storm event of 0.1 inches and greater, unless otherwise defined by another regulatory mechanism (e.g., a TMDL). (See Permit Attachment C)

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Appendix 1 – Comments and Responses

COMPLIANCE CHECKLIST COMMENTS FROM THE WQIP JANUARY 4, 2018 SUBMITTAL AND COPERMITTEE RESPONSES 10-9-18

PROVISION B.2: PRIORITY WATER QUALITY CONDITIONS

PROVISION B.2.A: ASSESSMENT OF RECEIVING WATER CONDITIONS

PROVISION B.2: PRIORITY WATER QUALITY CONDITIONS
PROVISION B.2.a: ASSESSMENT OF RECEIVING WATER CONDITIONS

Provision	Requirement	Y/N	Location in Plan	Comments	Co-Permittee Response
B.2.a.(3)	Sensitive or highly valued receiving waters (e.g. CWA 320 estuaries, MPAs, wetlands, BIOL BU RWs, ASBS)?	N	Chapter 3	Diamond Lake, Vail Lake, and Skinner Lake are not clearly identified as drinking water reservoirs that depend on the runoff from the watershed. Both the MWD and water agencies identify urban runoff as an ongoing issue for nutrients and the ability to treat water to meet drinking water standards. This information must be included in the WQIP and strategies must be identified that address water agency concerns.	New Section 1.4 was added with additional description of the lakes. The section includes description of the operation of the lakes as drinking water supplies and identifies all their beneficial uses. The lakes have no 303(d) listings. The strategies identified in Section 4 will be implemented in the Upper SMR Subwatershed as applicable per the JRMPs for the Counties of Riverside and San Diego to addres any pollutants from developed areas.
B.2	The Copermittees must identify the water quality priorities within each Watershed Management Area that will be addressed by the Water Quality Improvement Plan. Where appropriate, Watershed Management Areas may be separated into subwatersheds to focus water quality prioritization and jurisdictional runoff management program implementation efforts by receiving water.	Y	Chapter 3	Copermittees assigned a single HPWQC to the entire WMA and developed strategies, schedules and numeric goals for the Upper and Lower Santa Margarita River subwatersheds. However, the “upper watershed” does not extend to the entire watershed and excludes areas east of the three drinking water reservoirs. These drinking water reservoirs are included as part of the Basin Plan and are considered waters of the United States. It is inappropriate to exclude this portion of the watershed based on the rationale that these reservoirs “act as a sump.” Discharges occur from these facilities to the lower portion of the WMA. The WQIP must be revised to graphically show that this area is part of the HPWQC. In addition, there are no MS4 facilities located in this part of the WMA. The WQIP must use the CWA definition of MS4 in attachment C. As currently written throughout the WQIP, the term “storm drain” is intended in many locations to refer to the narrow definition of this term and not the regulatory definition set forth in the Regional MS4 Permit, Attachment C The Copermittees must clearly identify the extent of the MS4 conveyance system as defined in Attachment C, inclusive of creek systems used to convey urban runoff flow. It is unclear if the land use tables exclude in section 3 exclude the east WMA area or not (ie Table 3-1).	Note that two HPWQCs were assigned: eutrophication impacts (dry weather); and nutrient loading to waterbodies (dry and wet weather). The WQIP has been revised to divide the SMR WMA into three subwatersheds, the Upper, Middle, and Lower. Two new maps were added to help describe the Upper SMR Subwatershed which show existing drainage and transportation infrastructure. All of the WQIP maps, tables, and text were revised for consistency. New Section 1.4 includes description of the operation of the lakes as drinking water supplies and identifies all their beneficial uses. The Upper SMR Subwatershed was evaluated with the same methodology as the Middle and Lower Subwatersheds. However, their were insufficient recent data on receiving water conditions and virtually no data regarding MS4 discharges in the Upper SMR Subwatershed. Therefore, HPWQCs were not assigned to the subwatershed. The Upper SMR Subwatershed will be further evaluated as new data become available. A new monitoring site will be established on one of the main tributaries to Vail Lake to provide such data. The Upper SMR Subwatershed includes the three subject lakes. Discharges from the lakes to the Middle SMR Subwatershed only occur in very rare circumstances. Additional research was conducted to verify how the lakes are operated with regard to filling of the lakes and releases from the lakes to downstream areas. Diamond Valley Lake is filled predominantly by imported water via aqueducts, and would release from the dam to downstream waters only in emergencies. Skinner is also filled predominantly from imported flows but does receive significant inflows from the contributing watershed area in wet years. It releases flows to downstream drainages onky in emergencies. Vail Lake receives most inflows from the large upstream drainage area during storms, but rarely releases flows over the spillway. Stored water from the lake is routed to a system of downstream spreading basins and does not feed downstream channels. Instead, the Rancho California Water District releases imported water directly into Murrieta Creek near the SMR gorge to fulfil downstream flow requirements. The term “storm drain” is now used in the text only where appropriate. The terms “MS4,” “storm drain,” and “storm drain system” are not synonomous and the text has been revised accordingly throughout

PROVISION B.2: PRIORITY WATER QUALITY CONDITIONS

PROVISION B.2.a: ASSESSMENT OF RECEIVING WATER CONDITIONS

Provision	Requirement	Y/N	Location in Plan	Comments	Co-Permittee Response
					the WQIP. Every effort was made to ensure that the WQIP is consistent with the definitions in the Regional MS4 Permit. Table 3-1 has been verified so that it is correct for the entire WMA.
B.2.a.(1)	Receiving waters on 303(d) List?	Y	Chapter 3	The Plan is inconsistent and has conflicting statements as to which 303(d) list is used for the development of the Plan. Both the EPA 2010 approved list and the 2016 San Diego Water Board list are referenced as the basis for Plan development (ie Plan text and Appendices). Data has been submitted in support of the 2016 303(d) listings and is required to be considered in the Plan development.	See 2.3.1.1: the Step 1B assessment includes a review of the data used for the 2010 list, and the data used for the development of the 2014/2016 list to identify additional constituents that may be contributing to impairments based on data collected since the 2010 303(d) list. Every effort was made to ensure the related text is consistent.
B.2.a.(2)	TMDLs adopted and in development?	Y	Chapter 3	The Plan includes and considers the Rainbow Creek TMDL. And the Santa Margarita River Estuary initiative.	N/A
B.2.a.(5)	Known historical vs. current physical, chemical, and biological water quality conditions?	Y	Chapter 3	• Include the results of the PPPC Study in the Data set assessment • Include recent results of the bacteria Cost Benefit Analysis /HF 183 Study • Include Locations of steelhead trout preserve studies in the WMA. Identify strategies that affect this protected population.	These studies were evaluated as part of the data review. The Steelhead Trout rehabilitation efforts are occurring within the Santa Margarita Ecologiocal Reserve. This area is identified on the Critical Coarse Sediment Yield Map (WMAA: Attachment G). Development projects that propose to discharge to the Reserve area are required to conduct an analysis and mitigate any potential impacts to coarse sediment supply.
B.2.a.(7)	Available evidence of erosional (i.e. hydromodification) impacts?	Y	Table 2-12	Copermittees included areas of concern by Consultation Panel members and known areas of hydromodification in the WMA.	N/A
B.2.a	Did the Copermittees consider the following to identify priorities? The Copermittees must consider the following, at a minimum, to identify water quality priorities based on impacts of MS4 discharges on receiving water beneficial uses:	Y	Chapter 3		
B.2.a.(4)	Receiving water limitations of Provision A.2?	Y	Chapter 3		
B.2.a.(6)	Available, relevant, and appropriately collected and analyzed RW monitoring data?	Y	Section 2.2		
B.2.a.(8)	Available evidence of adverse chemical, physical, and biological integrity impacts?	Y	Section 2.2		
B.2.a.(9)	Potential improvements to overall condition of WMA that can be achieved?	Y	Section 2.6		

PROVISION B.2.B: ASSESSMENT OF IMPACTS FROM MS4 DISCHARGES

PROVISION B.2: PRIORITY WATER QUALITY CONDITIONS **PROVISION B.2.b: ASSESSMENT OF IMPACTS FROM MS4 DISCHARGES**					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Comments**	**Co-Permittee Response**
B.2.b	Did the Copermittees consider the following to identify potential impacts to RWs from MS4 discharges:	Y	General Comment	RCFCWD activities are still not included in applicable assessment categories for some of the provisions despite several discussions with RCFCWD that potential pollutant generating activities and areas conducted by RCFCWD were not exempt from the assessment. There is no discussion of activities or areas that RCFWCD has authority or control over under some of the assessment categories (i.e. Municipal.	Regarding the HPWQC, nitrogen and phosphorus loads for the RCFCWCD were not calculated or included in the SMRNIG model. However, RCFCWCD facilities were considered in the assessment (e.g., Table 3-3 and Figure 3-3). The RCFCWCD understands that the strategies identified in Table 4-11 are designed to address impacts from its facilities and activities.
B.2.b.(2)	Available, relevant, and appropriately collected and analyzed MS4 outfall storm water and non-storm water monitoring data?	Y	Section 2.7	It is not clear how the "*...connectivity from the outfalls to the receiving waters*…" in dry weather conditions limits the geographic extent of the HPWQC based on algal biomass. It is unclear what is meant by "dry weather." This seems contradictory to the results of the estuary modeling and other discussions in the Plan. The geographic extent described for the HPWQC for the Upper Santa Margarita is inconsistent throughout the Plan text, tables, and appendices. The Plan appendices have a longer list of the geographic extent for the HPWQC which are more in accordance with the Basin Plan intent (i.e. beneficial uses and supporting WQOs are year-round). The WQIP must include the area east of the reservoirs as part of the geographic extent given these part of the WMA is urbanized and conveys pollutants directly to the reservoirs via creek systems which are considered part of the MS4 system.	Note that we do not find the referenced text regarding "connectivity" in the submitted WQIP; and the WQIP does not include a Section 2.7. The hydrologic connectivity between the Upper and Middle SMR Subwatersheds is described in new Section 1.4 (as in responses above). Dry weather is defined in the WQIP in several places (Section 4.1.1; Table 5-1) as "where there is less than 0.1 inch of rainfall within the previous 72 hours" consistent with the Regional MS4 Permit. The Upper SMR Subwatershed was evaluated with the same methodology as the Middle and Lower Subwatersheds. However, their were insufficient recent data on receiving water conditions and virtually no data regarding MS4 discharges in the Upper SMR Subwtareshed. Therefore, HPWQCs were not assigned to the subwatershed. The Upper SMR Subwatershed will be further evaluated as new data become available. Every effort was made to ensure the WQIP (text, tables, figures) is internally consistent and consistent with the Regional MS4 Permit. The strategies identified in Section 4 will be implemented in the Upper SMR Subwatershed as applicable per the JRMPs for the Counties of Riverside and San Diego to address any pollutants from the developed areas.

PROVISION B.2: PRIORITY WATER QUALITY CONDITIONS **PROVISION B.2.b: ASSESSMENT OF IMPACTS FROM MS4 DISCHARGES**					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Comments**	**Co-Permittee Response**
B.2.b.(3)	Locations of each Copermittee's MS4 outfalls?	Y	Section 2.6	See comment to B.2.b (2)	See response to Comment to B.2.b(2), above.
B.2.b.(4)	Locations of MS4 outfalls with persistent non-storm water discharges that cause and contribute?	Y	Section 2.6	See comment to B.2.b (2)	See response to Comment to B.2.b(2), above.
B.2.b.(5)	Locations of MS4 outfalls known to discharge pollutants in storm water that cause and contribute?	Y	Section 2.9	See comment to B.2.b (2)	See response to Comment to B.2.b(2), above.
B.2.b.(1)	Prohibitions of Provision A.1 and Effluent Limitations of Provision A.3?	Y	Section 2.6, 2.7		
B.2.b.(6)	Potential improvements to quality of MS4 discharges that can be achieved?	Y	Section 2.10		

PROVISION B.2.C: IDENTIFICATION OF PRIORITY WATER QUALITY CONDITIONS

PROVISION B.2: PRIORITY WATER QUALITY CONDITIONS **PROVISION B.2.C: IDENTIFICATION OF PRIORITY WATER QUALITY CONDITIONS**					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Comments**	**Co-Permittee Response**
B.2.c.(1)(b)	Geographic extent of condition in WMA, or indicate not known?	Y	Sections 2.6, 2.7, 2.8	It is still unclear how the Copermittees determined the geographic extent of the conditions in the WMA. It appears that the WMA is still excluded non-perenniel stream systems in the development of the geographical extent for the HPWQC in the WMA on the basis that MS4 outfalls discharging to dry receiving waters would not result in impacts. This is inconsistent with the San Diego Water Board Basin Plan which designates beneficial uses in receiving waters year round. The geographic extent described is also inconsistent with the Santa Margarita Estuary technical reports and identified nutrient load sources. It is also inconsistent with footnotes and the geographical extent described in the plan text, tables, and technical appendices. In addition, it appears that the Copermittees are excluding receiving waters in developed areas from the MS4 system.	Non-perennial stream systems are included in the analysis as noted in Section 1.5.2.5.1: "Perennial/non-perennial criteria were removed from the revised prioritization process and the assessments no longer exclude areas based on flow." The WQIP has been revised to divide the SMR WMA into three subwatersheds, the Upper, Middle, and Lower. Two new maps were added to help describe the Upper SMR Subwatershed which show existing drainage and transportation infrastructure. All of the WQIP maps were revised for consistency. Text and tables have been revised accordingly Every effort was made to ensure that the WQIP (text, table, figures) is consistent with the definitions in the Regional MS4 Permit.
B.2.c.(2)	Did the Copermittees identify the highest priority water quality conditions to be addressed?	Y	Sections 2.8,2.9	The Copermittees selected a HPWQC for Upper and Lower Santa Margarita River. The "upper" WMA does not include any part of the WMA above the reservoirs (Diamond, Vail, Skinner). It is unclear how the HPWQCs are addressed in this area or how the Tables are consistent throughout the WQIP.	The WQIP has been revised to divide the SMR WMA into three subwatersheds, the Upper, Middle, and Lower. All of the WQIP maps, text, and tables were revised for consistency. The Upper SMR Subwatershed was evaluated with the same methodology as the Middle and Lower Subwatersheds. However, their were insufficient recent data on receiving water conditions and virtually no data regarding MS4 discharges in the Upper SMR Subwtareshed. Therefore, HPWQCs were not assigned to the subwatershed. The Upper SMR Subwatershed will be further evaluated as new data become available. The strategies identified in Section 4 will be implemented in the Upper SMR Subwatershed as applicable per the JRMPs for the Counties of Riverside and San Diego to minimize any adverse impacts pollutants from developed areas

B.2.c.(1)(c)	Temporal extent of condition (e.g. dry and/or wet weather)?	Y	Sections 2.7, 2.8	Copermittees selected both wet and dry PWQCs and HPWQCs for the WMA (Eutrophication for WMA (Dry) and Rainbow Creek TN and TP TMDL (Wet and Dry))	N/A
B.2.c.(2)	Did the Copermittees provide a rationale for selecting a subset of the conditions identified in B.2.c.(1)?	Y	Sections 2.8, 2.9	Copermittees selected a HPWQC for Upper and Lower Santa Margarita River. See previous comment.	N/A
B.2.c.(1)(d)	The Copermittees with MS4 discharges that may cause or contribute to condition?	Y	Section 2.9		
B.2.c.(1)(e)	An assessment of the adequacy of and data gaps in monitoring data?	Y	Section 2.9		
B.2.c.(1)	Did the Copermittees use information from Provisions B.2.a and B.2.b to develop a list of priority water quality conditions?	Y	Sections 2.5, 2.6		
B.2.c.(1)	Did the Copermittees' priority water quality condition in the list include:		N/A		
B.2.c.(1)(a)	Beneficial use associated with condition?	Y	Section 2.5		

PROVISION B.2.D: IDENTIFICATION OF MS4 POLLUTANT SOURCES AND/OR STRESSORS

PROVISION B.2: PRIORITY WATER QUALITY CONDITIONS **PROVISION B.2.d: IDENTIFICATION OF MS4 POLLUTANT SOURCES AND/OR STRESSORS**					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Comments**	**Co-Permittee Response**
B.2.d.(3)(a)	Other MS4 outfalls (e.g. Phase II and Caltrans)?	Y	Section 2.6	It is still unclear in the Plan how other MS4 outfalls (ie Caltrans, Phase II facilities) are addressed, identified, or considered to adequately meet this provision. This still appears to be missing from the assessment. Clarify where this is included in the Plan.	These discharges and related regulations are described in Section 3.4.1. Note that Caltrans and Camp Pendleton are stakeholders in the SMRNIG.
B.2.d.(3)(b)	Other NPDES permitted discharges?	Y	Sections 2.6, 2.9	Agricultural lands within Copermittee's land use authority are under their control. Statements are still inconsistent in the WQIP. It is unclear what land uses in the WQIP and how these are defined as not under the Copermittee's authority. Identify in the Plan what land use authority the Copermittees do have over agricultural land uses or operations. Provide a clearer discussion of what types of agricultural land uses in the WMA fall under the San Diego Water Board Agricultural Orders and which do not.	We do not find any inconsistencies regarding Copermittee land use authority in Section 2.6. Section 3.2.4.2 defines commercial agriculture operations and describes the agriculture regulatory approach, which includes enrollment in the Regional Water Board's Ag WDRs, and actions by Copermitees—including authority under their ordinances.
B.2.d.(1)(e)	Areas not within the Copermittees' jurisdiction (Phase II, tribal, state, federal)?	Y	Sections 2.8, 2.9	The Plan is still vague and unclear in describing these areas. Clearly identify and define areas not in Copermittee jurisdiction. Ie undeveloped lands are not clearly described. The Plan still does not clearly define terms used through out the text, tables, and appendices (ie non- MS4, controllable, uncontrollable, storm drain). The Plan must be clear what is meant by these terms and provide a clear discussion how these terms link or relate to the Rainbow Creek TMDL and the terms being used for the development of the Santa Margarita River Estuary.	New Section 1.4 describes areas outside Copermittee jurisdiction in the Upper SMR Subwatershed and includes a map. The term "storm drain" is now used in the text only where appropriate. The terms "MS4," "storm drain," and "storm drain system" are not synonomous and the text has been revised accordingly throughout the WQIP. Every effort was made to ensure that the WQIP is consistent with the definitions in the Regional MS4 Permit.
B.2.d.(3)(d)	Other non-point sources (e.g. ag, wildlife/natural)?	Y	Sections 2.6, 2.7,2.8,2.9 and 2.10	Copermittees provided summary of studies for natural background sources in WMA.	
B.2.d.(4)(a)	Findings from Copermittees' ICID programs?	Y	Sections 2.6, 2.7,2.8,2.9 and 2.10	Copermittees expanded discussion of ICID program	
B.2.d.(4)(b)	Findings from Copermittees' Outfall monitoring?	Y	Sections 2.6, 2.7,2.8,2.9 and 2.10	See prior comments on basis for geographic extent	
B.2.d.(4)(c)	Findings from Copermittees' RW monitoring?	Y	Sections 2.6, 2.7,2.8,2.9 and 2.10	See prior comments on basis for geographic extent	
B.2.d.(4)(d)	Findings from MS4 outfall and RW assessments?	Y	Sections 2.6, 2.7,2.8,2.9 and 2.10	See prior comments on basis for geographic extent	
B.2.d.(4)(e)	Other available, relevant, and appropriately collected data, information, or studies?	Y	Sections 2.6, 2.7,2.8,2.9 and 2.10	Include studies identified in prior comments	

PROVISION B.2: PRIORITY WATER QUALITY CONDITIONS PROVISION B.2.d: IDENTIFICATION OF MS4 POLLUTANT SOURCES AND/OR STRESSORS					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Comments**	**Co-Permittee Response**
B.2.d.(5)	Adequacy of available data to identify and prioritize sources and/or stressors?	Y	Sections 2.6, 2.7,2.8,2.9 and 2.10	Include studies identified in prior comments. Plan stressors excludes sources to the MS4 identified in SMR Estuary technical reports (agriculture) which are the majority of the load. Statements are still inconsistent with these findings throughout the WQIP.	The referenced studies have been included. Agricultural sources have been considered as described in 3.3.3.1 (Special study); 3.3.3.3 (Stuart Mesa Ag fields); 3.3.4 (SMRNIG Model findings show Ag as the largest source of N and P loads); and Table 4.1.2 shows percentage of N and P loads for San Diego County.
B.2.d	Did the Copermittees identify and prioritize known and suspected sources of storm water and non-storm water pollutants and/or other stressors that cause or contribute to the high priority conditions?	Y	Sections 2.8, 2.9		
B.2.d	Did the Copermittees consider:	Y	Sections 2.8, 2.9		
B.2.d.(1)(a) The	Each Copermittee's inventory or construction sites, industrial facilities, and areas of existing development?	Y	Sections 2.8, 2.9		
B.2.d.(1)(b)	Publicly owned parks and/or recreational areas?	Y	Sections 2.8, 2.9		
B.2.d.(1)(c)	Open space areas?	Y	Sections 2.8, 2.9		
B.2.d.(1)(d)	All currently operating or closed municipal landfills or other facilities for municipal waste?	Y	Sections 2.8, 2.9		
B.2.d.(2)(a)	Locations of Copermittees' MS4 outfall that discharge to receiving waters?	Y	Section 2.6		
B.2.d.(2)(b)	Locations of major structural controls (e.g. retention basins, detention basins, infiltration devices, etc.)?	Y	Section 2.9		
B.2.d.(3)(c)	Other point sources (e.g. private outfalls)?	Y	Sections 2.6, 2.7,2.8,2.9 and 2.10		

Provision B.2.E: Identification of Potential Water Quality Improvement Strategies

PROVISION B.2: PRIORITY WATER QUALITY CONDITIONS PROVISION B.2.e: IDENTIFICATION OF POTENTIAL WATER QUALITY IMPROVEMENT STRATEGIES					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Comments**	**Co-Permittee Response**
B.2.e	Did the Copermittees identify potential strategies based on findings from Provisions B.2.a-d to address highest priority conditions from Provision B.2.c, or MS4 pollutant sources or stressors from Provision B.2.d?	Y	Section 3.0 General Comment	Provision E.5 is not adequately addressed in the strategies. The WQIP should identify strategies to address protected Steelhead populations and drinking reservoirs.	Steelhead rehabilitation area in the SMR Ecological Reserve-the main stressor, sediment supply, is addressed by WQMP requirements for Critical Coarse Sediment Yield. MUN beneficial uses in the lakes in the Upper SMR Subwatershed are not impaired as described in new Section 1.4, and WQIP Strategy implementation as applicable through the JRMPs will address pollutants from developed areas.
B.2.e.(3)	Stream, channel, and/or habitat rehabilitation projects?	Y	Section 3	Copermittees identified a net pollution load reduction would be achieved	N/A
B.2.e	Do potential strategies to address highest priority conditions from Provision B.2.c, or MS4 pollutant sources or stressors from Provision B.2.d include:	Y	Section 3.0		
B.2.e.(1)	Structural BMPs, non-structural BMPs, incentives, or programs that can potentially be implemented?	Y	Section 3.0		
B.2.e.(2)	Retrofitting projects in areas of existing development?	Y	Section 3.0		

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

Provision B.3.A: Water Quality Improvement Goals and Schedules

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES PROVISION B.3.a: WATER QUALITY IMPROVEMENT GOALS AND SCHEDULES					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**	**Co-Permittee Response**
Numeric Goals					
B.3.a.(1)(a)	**Final numeric goals** capable of demonstrating: (i) MS4 discharges will not cause or contribute to exceedances in RWs; AND/OR (ii) Conditions in RWs and associated habitat are protected from MS4 discharges; AND/OR (iii) Beneficial uses of RWs are protected from MS4 discharges and will be supported.	Y	Section 3.1,3.2	Final Numeric Goals are identified for Rainbow Creek TMDL and HPWQC for Upper and Lower Santa Margarita River. Pathway descriptions are unclear what non-stormwater flows are under Copermittee control. NSWDs to the MS4 are prohibited. It is unclear what the basis for the metric for assessment of flow or what the metric is. The WQIP compliance pathway for the Rainbow Creek TMDL includes a compliance analysis in Appendix 3B. The San Diego Water Board is not in agreement with the tiered compliance approach in the analysis. Tier 1 excludes agricultural operations in the analysis in Appendix 3B. This is inconsistent with Attachment E of the Regional MS4 Permit,	Section 4.2.2.1 has been revised, which outlines structural BMP strategies for the Rainbow Creek TMDL area, and additional clarification has been provided at 4.2.2.2.4.3; the **Rainbow Creek Nutrient Reduction and Management Plan**—as discussed between Regional Board and staff from the County of San Diego in September and October 2018.
B.3.a.(1)(b)(i)	One or more interim numeric goals to demonstrate progress toward achieving each final numeric goal	Y	Section 3.1,3.2	See prior comment. It is unclear if the final numeric goal is the interim numeric goal for the Rainbow Creek TMDL. The HPWQC has interim numeric goals.	See Rainbow Creek TMDL response above.
B.3.a.(1)(b)(ii)	At least one interim numeric goal expressed as a reasonable increment of final numeric goal	Y	Section 3.1,3.2	See prior comments.	See above response.
B.3.a.(1)(b)(iii)	At least one interim numeric goal for each 5 year period between acceptance of Plan and achievement of each final numeric goal	Y	Section 3.1	See prior comments. It is unclear for the Rainbow Creek TMDL if the final numeric goal is the interim numeric goal for the 5 year period.	See above response.
Schedules for Final and Interim Numeric Goals					
B.3.a.(2)(a)	**Dates for achieving all final numeric goals** based on:		N/A	Provide the City of Menifee interim and final numeric goals. The City has "TBD" in the Plan.	Goals and schedules applicable to the Ciy of Menifee are included in Table 4-2.
B.3.a.(2)(a)(i)	Final compliance dates of applicable TMDLs	Y	Section 3.1,3.2	Based on draft schedule proposed for SMR Estuary and Rainbow Creek Adopted TMDL in Att. E.	N/A
B.3.a.(2)(a)(iii)	Achievement of final numeric goals must be as soon as possible	Y	Section 3.1,3.2	Based on draft schedule proposed for SMR Estuary and Rainbow Creek Adopted TMDL in Att. E.	N/A

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.a: WATER QUALITY IMPROVEMENT GOALS AND SCHEDULES

Provision	Requirement	Y/N	Location in Plan	Notes	Co-Permittee Response
B.3.a.(2)(a)(iv)	Achievement of final numeric goals must reflect a realistic assessment of shortest practicable time based on temporal and spatial extent and time reasonably required to implement strategies	Y	Section 3.1,3.2	Based on draft schedule proposed for SMR Estuary and Rainbow Creek Adopted TMDL in Att. E.	See Rainbow Creek TMDL response above.
B.3.a.(2)(b)(i)	Interim compliance dates of applicable TMDLs	Y	Section 3.1,3.2	Based on draft schedule proposed for SMR Estuary and Rainbow Creek Adopted TMDL in Att. E. Clarify what date is interim compliance date for Rainbow Creek TMDL.	See Rainbow Creek TMDL response above.
B.3.a.(2)(b)(iii)	Achievement of interim numeric goals must reflect a realistic assessment of shortest practicable time based on time reasonably required to implement new programs and secure funding	Y	Section 3.1,3.2	Based on draft schedule proposed for SMR Estuary and Rainbow Creek Adopted TMDL in Att. E. Clarify what date is interim compliance date for Rainbow Creek TMDL.	See Rainbow Creek TMDL response above.
B.3.a.(2)(b)(iv)	For each final numeric goal, at least one interim numeric goal within term of Order	Y		Based on draft schedule proposed for SMR Estuary Alternative TMDL and Rainbow Creek Adopted TMDL in Att. E. Clarify what date is interim compliance date for Rainbow Creek TMDL for the Order term.	See Rainbow Creek TMDL response above.
B.3.a.(1)	Did the Copermittees establish numeric goals that meet the following:		N/A	N/A	
B.3.a.(1)(b)	Interim numeric goals capable of demonstrating incremental progress that meet the following:		N/A	N/A	
B.3.a.(2)	Did the Copermittees incorporate schedules for achieving numeric goals that meet the following:		N/A	N/A	
B.3.a.(2)(a)(ii)	ASBS compliance schedules		N/A	N/A	
B.3.a.(2)(b)	Dates for achieving all interim numeric goals based on:		N/A	N/A	

Provision B.3.B: Water Quality Improvement Strategies and Schedules

CITY OF MENIFEE

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**	
CITY OF MENIFEE					
Jurisdictional Strategies					
B.3.b.(1)(a)	Did **each** Copermittee identify **Jurisdictional Strategies** to be implemented under Provisions E.2 through E.7, including descriptions of the following:	Y	Section 3.2, Appendix 3A	Table 4-5: Footnote 2. Based on land area and potential sources of nutrients, for the purposes of the Water Quality Improvement Plan development, Menifee is considered to be a less than significant contributor to nitrogen and phosphorus loading. If determined necessary by the SMRNIG, loading estimates may be developed in the future, at which time, they will be included within the Water Quality Improvement Plan through the adaptive management process. This footnote must be revised – Menifee is required to participate in the TMDL. This is only if Menifee fully implements the strategies and this is what is considered as in lieu load reduction.	Menifee footnote revised per discussion with Regional Board staff.
B.3.b.(1)(a)(i)	For inventories required to be developed for the jurisdiction, identify known or suspected areas or sources causing or contributing to highest priority	Y	Sections 2.8, 2.9		
B.3.b.(1)(a)(ii)	BMPs Copermittee will implement, or require to be implemented, as applicable, for those areas or sources	Y	Section 3.2, Appendix 3A	The use of LIP strategies are acceptable due to single water board agreement.	
B.3.b.(1)(a)(iii)	Education programs that will be implemented, as applicable for those areas or sources	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(a)(iv)	Frequencies inspections will be conducted on those areas or sources	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(a)(v)	Incentive and enforcement programs that will be implemented, as applicable, for those areas and sources	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(a)(vi)	Any other BMPs, incentives, or programs that will be implemented for those areas or sources	Y	Section 3.2, Appendix 3A	Annual residential inspections	
Optional Jurisdictional Strategies					

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES					
PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**	
CITY OF MENIFEE					
B.3.b.(1)(b)	Did **each** Copermittee identify **Optional Jurisdictional Strategies** to be implemented as necessary when Jurisdictional Strategies not making adequate progress, with descriptions that include the following:		NA	NA	
B.3.b.(1)(b)(i)	BMPs, incentives, or programs the Copermittee may implement in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A	Four Optional Strategies including Annual residential inspections, outreach, HPWQC businesses, mitigation project support	
B.3.b.(1)(b)(ii)	Incentives or programs the Copermittee may implement to encourage or implement projects to retrofit areas of existing development	Y	Section 3.2, Appendix 3A	Industrial/Commercial	
B.3.b.(1)(b)(iii)	Incentives or programs the Copermittee may implement to encourage or implement projects to rehabilitate channels or habitats	Y	Section 3.2, Appendix 3A	Mitigation project support	
B.3.b.(1)(b)(iv)	The funds and/or resources that must be secured to implement optional strategies from (i)-(iii)	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(b)(v)	Circumstances necessary to trigger implementation of optional strategies in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A		
Jurisdictional Cooperation/Coordination Strategies					
B.3.b.(1)(c)	Did **each** Copermittee identify strategies that will be implemented in coordination with or with the cooperation of other agencies and/or entities?	Y	Section 3.2, Appendix 3A		
Schedules for Jurisdictional Strategies					
B.3.b.(3)(a)	Did **each** Copermittee incorporate schedules that specify the following:		NA	NA	
B.3.b.(3)(a)(i)	If each **Jurisdictional Strategy** will or will not be initiated upon acceptance of Plan	Y	Section 3.2, Appendix 3A		
B.3.b.(3)(a)(ii)	If not initiated upon acceptance, shortest practicable time **Jurisdictional Strategy** will be initiated	Y	Section 3.2, Appendix 3A		
B.3.b.(3)(a)(iii)	For each **Optional Jurisdictional Strategy**, a realistic assessment of shortest practicable time to: [a] Secure resources to fund strategy [b] Procure resources, materials, labor, permits necessary to initiate strategy	Y	Section 3.2, Appendix 3A		
B.3.b.(3)(a)(iv)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be continuously implemented, or completed within a schedule	Y	Section 3.2, Appendix 3A		

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES					
PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**	
CITY OF MENIFEE					
B.3.b.(3)(a)(v)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be completed within a schedule, the anticipated time to complete based on realistic assessment	Y	Section 3.2, Appendix 3A		

CITY OF MURRIETTA

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES

Provision	Requirement	Y/N	Location in Plan	Notes
CITY OF MURRIETTA				
Jurisdictional Strategies				
B.3.b.(1)(a)	Did **each** Copermittee identify **Jurisdictional Strategies** to be implemented under Provisions E.2 through E.7, including descriptions of the following:	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(i)	For inventories required to be developed for the jurisdiction, identify known or suspected areas or sources causing or contributing to highest priority	Y	Sections 2.8, 2.9	
B.3.b.(1)(a)(ii)	BMPs Copermittee will implement, or require to be implemented, as applicable, for those areas or sources	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(iii)	Education programs that will be implemented, as applicable for those areas or sources	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(iv)	Frequencies inspections will be conducted on those areas or sources	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(v)	Incentive and enforcement programs that will be implemented, as applicable, for those areas and sources	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(vi)	Any other BMPs, incentives, or programs that will be implemented for those areas or sources	Y	Section 3.2, Appendix 3A	
Optional Jurisdictional Strategies				
B.3.b.(1)(b)	Did **each** Copermittee identify **Optional Jurisdictional Strategies** to be implemented as necessary when Jurisdictional Strategies not making adequate progress, with descriptions that include the following:		NA	NA
B.3.b.(1)(b)(i)	BMPs, incentives, or programs the Copermittee may implement in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A	Optional Strategies focus on water district incentive programs
B.3.b.(1)(b)(ii)	Incentives or programs the Copermittee may implement to encourage or implement projects to retrofit areas of existing development	Y	Section 3.2, Appendix 3A	Municipal properties
B.3.b.(1)(b)(iii)	Incentives or programs the Copermittee may implement to encourage or implement projects to rehabilitate channels or habitats	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(b)(iv)	The funds and/or resources that must be secured to implement optional strategies from (i)-(iii)	Y	Section 3.2, Appendix 3A	

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES

Provision	Requirement	Y/N	Location in Plan	Notes
CITY OF MURRIETTA				
B.3.b.(1)(b)(v)	Circumstances necessary to trigger implementation of optional strategies in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A	
Jurisdictional Cooperation/Coordination Strategies				
B.3.b.(1)(c)	Did **each** Copermittee identify strategies that will be implemented in coordination with or with the cooperation of other agencies and/or entities?	Y	Section 3.2, Appendix 3A	
Schedules for Jurisdictional Strategies				
B.3.b.(3)(a)	Did **each** Copermittee incorporate schedules that specify the following:		NA	NA
B.3.b.(3)(a)(i)	If each **Jurisdictional Strategy** will or will not be initiated upon acceptance of Plan	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(ii)	If not initiated upon acceptance, shortest practicable time **Jurisdictional Strategy** will be initiated	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(iii)	For each **Optional Jurisdictional Strategy**, a realistic assessment of shortest practicable time to: [a] Secure resources to fund strategy [b] Procure resources, materials, labor, permits necessary to initiate strategy	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(iv)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be continuously implemented, or completed within a schedule	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(v)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be completed within a schedule, the anticipated time to complete based on realistic assessment	Y	Section 3.2, Appendix 3A	

CITY OF TEMECULA

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES

Provision	Requirement	Y/N	Location in Plan	Notes
CITY OF TEMECULA				
Jurisdictional Strategies				
B.3.b.(1)(a)	Did **each** Copermittee identify **Jurisdictional Strategies** to be implemented under Provisions E.2 through E.7, including descriptions of the following:	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(i)	For inventories required to be developed for the jurisdiction, identify known or suspected areas or sources causing or contributing to highest priority	Y	Sections 2.8, 2.9	
B.3.b.(1)(a)(ii)	BMPs Copermittee will implement, or require to be implemented, as applicable, for those areas or sources	Y	Section 3.2, Appendix 3A	The focus of the strategies is “urban runoff”, however, it is unclear if this is the primary source of the HPWQC in the City. It is not clear what enhanced strategies the City use to address the HPWQC (dry) for nutrients and the source of the nutrients in the strategy. No construction JRMP program baseline or enhanced strategies are identified. Provide.
B.3.b.(1)(a)(iii)	Education programs that will be implemented, as applicable for those areas or sources	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(iv)	Frequencies inspections will be conducted on those areas or sources	Y	Section 3.2, Appendix 3A	Provide for enhanced and Baseline JRMP strategies. “As Needed” does not address this requirement,
B.3.b.(1)(a)(v)	Incentive and enforcement programs that will be implemented, as applicable, for those areas and sources	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(vi)	Any other BMPs, incentives, or programs that will be implemented for those areas or sources	Y	Section 3.2, Appendix 3A	
Optional Jurisdictional Strategies				
B.3.b.(1)(b)	Did **each** Copermittee identify **Optional Jurisdictional Strategies** to be implemented as necessary when Jurisdictional Strategies not making adequate progress, with descriptions that include the following:		NA	NA
B.3.b.(1)(b)(i)	BMPs, incentives, or programs the Copermittee may implement in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A	Optional Strategies focus on Park retrofits, sanitary diversions of dry weather flow.
B.3.b.(1)(b)(ii)	Incentives or programs the Copermittee may implement to encourage or implement projects to retrofit areas of existing development	Y	Section 3.2, Appendix 3A	Irrigation Controllers
B.3.b.(1)(b)(iii)	Incentives or programs the Copermittee may implement to encourage or implement projects to rehabilitate channels or habitats	Y	Section 3.2, Appendix 3A	

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES

Provision	Requirement	Y/N	Location in Plan	Notes
CITY OF TEMECULA				
B.3.b.(1)(b)(iv)	The funds and/or resources that must be secured to implement optional strategies from (i)-(iii)	Y	Section 3.2, Appendix 3A	Provide funding sources
B.3.b.(1)(b)(v)	Circumstances necessary to trigger implementation of optional strategies in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A	
Jurisdictional Cooperation/Coordination Strategies				
B.3.b.(1)(c)	Did **each** Copermittee identify strategies that will be implemented in coordination with or with the cooperation of other agencies and/or entities?	Y	Section 3.2, Appendix 3A	Water District
Schedules for Jurisdictional Strategies				
B.3.b.(3)(a)	Did **each** Copermittee incorporate schedules that specify the following:		NA	NA
B.3.b.(3)(a)(i)	If each **Jurisdictional Strategy** will or will not be initiated upon acceptance of Plan	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(ii)	If not initiated upon acceptance, shortest practicable time **Jurisdictional Strategy** will be initiated	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(iii)	For each **Optional Jurisdictional Strategy**, a realistic assessment of shortest practicable time to: [a] Secure resources to fund strategy [b] Procure resources, materials, labor, permits necessary to initiate strategy	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(iv)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be continuously implemented, or completed within a schedule	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(v)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be completed within a schedule, the anticipated time to complete based on realistic assessment	Y	Section 3.2, Appendix 3A	

CITY OF WILDOMAR

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**	
CITY OF WILDOMAR					
Jurisdictional Strategies					
B.3.b.(1)(a)	Did **each** Copermittee identify **Jurisdictional Strategies** to be implemented under Provisions E.2 through E.7, including descriptions of the following:	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(a)(i)	For inventories required to be developed for the jurisdiction, identify known or suspected areas or sources causing or contributing to highest priority	N	Sections 2.8, 2.9		Response was provided with the January 4, 2018 WQIP submittal and response to comments. Wildomar strategies were revised per these notes: - The targeted weather conditions (wet, dry, or both) have now been identified for each strategy. - Agricultural sources have been added (see Strategies CON-1, ED-4, and PubEd-2).
B.3.b.(1)(a)(ii)	BMPs Copermittee will implement, or require to be implemented, as applicable, for those areas or sources	Y	Section 3.2, Appendix 3A	The focus of the strategies is “urban runoff”, however, it is unclear if this is the primary source of the HPWQC in the City. It is not clear what enhanced strategies the City use to address the HPWQC (dry) for nutrients and the source of the nutrients in the strategy. No construction JRMP program baseline or enhanced strategies are identified. Provide.	
B.3.b.(1)(a)(iii)	Education programs that will be implemented, as applicable for those areas or sources	Y	Section 3.2, Appendix 3A	Outreach to nurseries	
B.3.b.(1)(a)(iv)	Frequencies inspections will be conducted on those areas or sources	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(a)(v)	Incentive and enforcement programs that will be implemented, as applicable, for those areas and sources	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(a)(vi)	Any other BMPs, incentives, or programs that will be implemented for those areas or sources	Y	Section 3.2, Appendix 3A		
Optional Jurisdictional Strategies					
B.3.b.(1)(b)	Did **each** Copermittee identify **Optional Jurisdictional Strategies** to be implemented as necessary when Jurisdictional Strategies not making adequate progress, with descriptions that include the following:		NA	NA	
B.3.b.(1)(b)(i)	BMPs, incentives, or programs the Copermittee may implement in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A	Optional Strategies focus on water district coordination and IDDE	

B.3.b.(1)(b)(ii)	Incentives or programs the Copermittee may implement to encourage or implement projects to retrofit areas of existing development	Y	Section 3.2, Appendix 3A	Street sweeping, irrigation controllers	
B.3.b.(1)(b)(iii)	Incentives or programs the Copermittee may implement to encourage or implement projects to rehabilitate channels or habitats	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(b)(iv)	The funds and/or resources that must be secured to implement optional strategies from (i)-(iii)	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(b)(v)	Circumstances necessary to trigger implementation of optional strategies in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A		
Jurisdictional Cooperation/Coordination Strategies					
B.3.b.(1)(c)	Did **each** Copermittee identify strategies that will be implemented in coordination with or with the cooperation of other agencies and/or entities?	Y	Section 3.2, Appendix 3A	Water District	
Schedules for Jurisdictional Strategies					
B.3.b.(3)(a)	Did **each** Copermittee incorporate schedules that specify the following:		NA	NA	
B.3.b.(3)(a)(i)	If each **Jurisdictional Strategy** will or will not be initiated upon acceptance of Plan	Y	Section 3.2, Appendix 3A		
B.3.b.(3)(a)(ii)	If not initiated upon acceptance, shortest practicable time **Jurisdictional Strategy** will be initiated	Y	Section 3.2, Appendix 3A		
B.3.b.(3)(a)(iii)	For each **Optional Jurisdictional Strategy**, a realistic assessment of shortest practicable time to: [a] Secure resources to fund strategy [b] Procure resources, materials, labor, permits necessary to initiate strategy	Y	Section 3.2, Appendix 3A		
B.3.b.(3)(a)(iv)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be continuously implemented, or completed within a schedule	Y	Section 3.2, Appendix 3A		
B.3.b.(3)(a)(v)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be completed within a schedule, the anticipated time to complete based on realistic assessment	Y	Section 3.2, Appendix 3A		

COUNTY OF RIVERSIDE

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES

Provision	Requirement	Y/N	Location in Plan	Notes
COUNTY OF RIVERSIDE				
Jurisdictional Strategies				
B.3.b.(1)(a)	Did **each** Copermittee identify **Jurisdictional Strategies** to be implemented under Provisions E.2 through E.7, including descriptions of the following:	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(i)	For inventories required to be developed for the jurisdiction, identify known or suspected areas or sources causing or contributing to highest priority	Y	Sections 2.8, 2.9	
B.3.b.(1)(a)(ii)	BMPs Copermittee will implement, or require to be implemented, as applicable, for those areas or sources	Y	Section 3.2, Appendix 3A	The focus of the strategies is “urban runoff”, however, the County has multiple strategies that address HPWQCs for designated land uses and sources.
B.3.b.(1)(a)(iii)	Education programs that will be implemented, as applicable for those areas or sources	Y	Section 3.2, Appendix 3A	Outreach to OWTS for all land uses, minimum BMPs required to address HPWQCs.
B.3.b.(1)(a)(iv)	Frequencies inspections will be conducted on those areas or sources	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(v)	Incentive and enforcement programs that will be implemented, as applicable, for those areas and sources	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(vi)	Any other BMPs, incentives, or programs that will be implemented for those areas or sources	Y	Section 3.2, Appendix 3A	
Optional Jurisdictional Strategies				
B.3.b.(1)(b)	Did **each** Copermittee identify **Optional Jurisdictional Strategies** to be implemented as necessary when Jurisdictional Strategies not making adequate progress, with descriptions that include the following:		NA	NA
B.3.b.(1)(b)(i)	BMPs, incentives, or programs the Copermittee may implement in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A	Optional Strategies focus on water district coordination and IDDE
B.3.b.(1)(b)(ii)	Incentives or programs the Copermittee may implement to encourage or implement projects to retrofit areas of existing development	Y	Section 3.2, Appendix 3A	Stream restoration, turf replacement, OWTS, live stock operations/equestrian
B.3.b.(1)(b)(iii)	Incentives or programs the Copermittee may implement to encourage or implement projects to rehabilitate channels or habitats	Y	Section 3.2, Appendix 3A	Warm Springs
B.3.b.(1)(b)(iv)	The funds and/or resources that must be secured to implement optional strategies from (i)-(iii)	Y	Section 3.2, Appendix 3A	

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES

Provision	Requirement	Y/N	Location in Plan	Notes
COUNTY OF RIVERSIDE				
B.3.b.(1)(b)(v)	Circumstances necessary to trigger implementation of optional strategies in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A	
Jurisdictional Cooperation/Coordination Strategies				
B.3.b.(1)(c)	Did **each** Copermittee identify strategies that will be implemented in coordination with or with the cooperation of other agencies and/or entities?	Y	Section 3.2, Appendix 3A	Turf replacement
Schedules for Jurisdictional Strategies				
B.3.b.(3)(a)	Did **each** Copermittee incorporate schedules that specify the following:		NA	NA
B.3.b.(3)(a)(i)	If each **Jurisdictional Strategy** will or will not be initiated upon acceptance of Plan	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(ii)	If not initiated upon acceptance, shortest practicable time **Jurisdictional Strategy** will be initiated	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(iii)	For each **Optional Jurisdictional Strategy**, a realistic assessment of shortest practicable time to: [a] Secure resources to fund strategy [b] Procure resources, materials, labor, permits necessary to initiate strategy	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(iv)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be continuously implemented, or completed within a schedule	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(v)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be completed within a schedule, the anticipated time to complete based on realistic assessment	Y	Section 3.2, Appendix 3A	

COUNTY OF SAN DIEGO

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES

Provision	Requirement	Y/N	Location in Plan	Notes
COUNTY OF SAN DIEGO				
Jurisdictional Strategies				
B.3.b.(1)(a)	Did **each** Copermittee identify **Jurisdictional Strategies** to be implemented under Provisions E.2 through E.7, including descriptions of the following:	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(i)	For inventories required to be developed for the jurisdiction, identify known or suspected areas or sources causing or contributing to highest priority	Y	Sections 2.8, 2.9	
B.3.b.(1)(a)(ii)	BMPs Copermittee will implement, or require to be implemented, as applicable, for those areas or sources	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(iii)	Education programs that will be implemented, as applicable for those areas or sources	Y	Section 3.2, Appendix 3A	Outreach to OWTS for all land uses, minimum BMPs required to address HPWQCs.
B.3.b.(1)(a)(iv)	Frequencies inspections will be conducted on those areas or sources	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(v)	Incentive and enforcement programs that will be implemented, as applicable, for those areas and sources	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(a)(vi)	Any other BMPs, incentives, or programs that will be implemented for those areas or sources	Y	Section 3.2, Appendix 3A	Equestrian BMPs
Optional Jurisdictional Strategies				
B.3.b.(1)(b)	Did **each** Copermittee identify **Optional Jurisdictional Strategies** to be implemented as necessary when Jurisdictional Strategies not making adequate progress, with descriptions that include the following:		NA	NA
B.3.b.(1)(b)(i)	BMPs, incentives, or programs the Copermittee may implement in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A	Turf replacement, sewer diversion, OWTS, green street retrofit, channel rehab.
B.3.b.(1)(b)(ii)	Incentives or programs the Copermittee may implement to encourage or implement projects to retrofit areas of existing development	Y	Section 3.2, Appendix 3A	Stream restoration, turf replacement, OWTS, live stock operations/equestrian
B.3.b.(1)(b)(iii)	Incentives or programs the Copermittee may implement to encourage or implement projects to rehabilitate channels or habitats	Y	Section 3.2, Appendix 3A	
B.3.b.(1)(b)(iv)	The funds and/or resources that must be secured to implement optional strategies from (i)-(iii)	Y	Section 3.2, Appendix 3A	

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES

Provision	Requirement	Y/N	Location in Plan	Notes
COUNTY OF SAN DIEGO				
B.3.b.(1)(b)(v)	Circumstances necessary to trigger implementation of optional strategies in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A	
Jurisdictional Cooperation/Coordination Strategies				
B.3.b.(1)(c)	Did **each** Copermittee identify strategies that will be implemented in coordination with or with the cooperation of other agencies and/or entities?	Y	Section 3.2, Appendix 3A	
Schedules for Jurisdictional Strategies				
B.3.b.(3)(a)	Did **each** Copermittee incorporate schedules that specify the following:		NA	NA
B.3.b.(3)(a)(i)	If each **Jurisdictional Strategy** will or will not be initiated upon acceptance of Plan	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(ii)	If not initiated upon acceptance, shortest practicable time **Jurisdictional Strategy** will be initiated	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(iii)	For each **Optional Jurisdictional Strategy**, a realistic assessment of shortest practicable time to: [a] Secure resources to fund strategy [b] Procure resources, materials, labor, permits necessary to initiate strategy	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(iv)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be continuously implemented, or completed within a schedule	Y	Section 3.2, Appendix 3A	
B.3.b.(3)(a)(v)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be completed within a schedule, the anticipated time to complete based on realistic assessment	Y	Section 3.2, Appendix 3A	

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSEVATION DISTRICT

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES

Provision	Requirement	Y/N	Location in Plan	Notes	Co-Permittee Response
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT					
Jurisdictional Strategies					
B.3.b.(1)(a)	Did **each** Copermittee identify **Jurisdictional Strategies** to be implemented under Provisions E.2 through E.7, including descriptions of the following:	N	Section 3.2, Appendix 3A	Table 4-5 Footnote 3. Based on land area and potential sources of nutrients, for the purposes of the Water Quality Improvement Plan development, RCFCWCD is considered to be a less than significant contributor to nitrogen and phosphorus loading. If determined necessary by the SMRNIG, loading estimates may be developed in the future, at which time, they will be included within the Water Quality Improvement Plan through the adaptive management process. This footnote must be revised or confirmed with the Stakeholder Group – RFCFCD is required to participate in the TMDL. RFCFD must fully implement the strategies. The WQIP does not provide adequate explanation of activities and land uses that may contribute to dry weather loading of nutrients for this footnote to be in the WQIP.	Footnote revised. The RCFCWCD facilities were evaluated, but the District was not assigned loads in the SMRNIG Model. The District will implement the strategies to address the PWQCs and HPWQCs.
B.3.b.(1)(a)(iii)	Education programs that will be implemented, as applicable for those areas or sources	Y	Section 3.2, Appendix 3A	Outreach to HOAs, yard waste reduction, river clean up.	
B.3.b.(1)(a)(vi)	Any other BMPs, incentives, or programs that will be implemented for those areas or sources	Y	Section 3.2, Appendix 3A	Outreach Strategies	
B.3.b.(1)(a)(i)	For inventories required to be developed for the jurisdiction, identify known or suspected areas or sources causing or contributing to highest priority	Y	Sections 2.8, 2.9		
B.3.b.(1)(a)(ii)	BMPs Copermittee will implement, or require to be implemented, as applicable, for those areas or sources	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(a)(iv)	Frequencies inspections will be conducted on those areas or sources	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(a)(v)	Incentive and enforcement programs that will be implemented, as applicable, for those areas and sources	Y	Section 3.2, Appendix 3A		
Optional Jurisdictional Strategies					
B.3.b.(1)(b)(i)	BMPs, incentives, or programs the Copermittee may implement in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A	Streambed protection, HOAs, outreach, clean up	

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES

Provision	Requirement	Y/N	Location in Plan	Notes	Co-Permittee Response
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT					
B.3.b.(1)(b)(ii)	Incentives or programs the Copermittee may implement to encourage or implement projects to retrofit areas of existing development		Section 3.2, Appendix 3A	Stream restoration, turf replacement, OWTS, live stock operations/equestrian	
B.3.b.(1)(b)	Did **each** Copermittee identify **Optional Jurisdictional Strategies** to be implemented as necessary when Jurisdictional Strategies not making adequate progress, with descriptions that include the following:		NA	NA	
B.3.b.(1)(b)(iii)	Incentives or programs the Copermittee may implement to encourage or implement projects to rehabilitate channels or habitats	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(b)(iv)	The funds and/or resources that must be secured to implement optional strategies from (i)-(iii)	Y	Section 3.2, Appendix 3A		
B.3.b.(1)(b)(v)	Circumstances necessary to trigger implementation of optional strategies in addition to Provision B.3.b.(1)(a) strategies	Y	Section 3.2, Appendix 3A		
Jurisdictional Cooperation/Coordination Strategies					
B.3.b.(1)(c)	Did **each** Copermittee identify strategies that will be implemented in coordination with or with the cooperation of other agencies and/or entities?	Y	Section 3.2, Appendix 3A		
Schedules for Jurisdictional Strategies					
B.3.b.(3)(a)	Did **each** Copermittee incorporate schedules that specify the following:		NA	NA	
B.3.b.(3)(a)(i)	If each **Jurisdictional Strategy** will or will not be initiated upon acceptance of Plan	Y	Section 3.2, Appendix 3A		
B.3.b.(3)(a)(ii)	If not initiated upon acceptance, shortest practicable time **Jurisdictional Strategy** will be initiated	Y	Section 3.2, Appendix 3A		
B.3.b.(3)(a)(iii)	For each **Optional Jurisdictional Strategy**, a realistic assessment of shortest practicable time to: [a] Secure resources to fund strategy [b] Procure resources, materials, labor, permits necessary to initiate strategy	Y	Section 3.2, Appendix 3A		
B.3.b.(3)(a)(iv)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be continuously implemented, or completed within a schedule	Y	Section 3.2, Appendix 3A		

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES					
PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**	**Co-Permittee Response**
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT					
B.3.b.(3)(a)(v)	If **Jurisdictional Strategy** or **Optional Jurisdictional Strategy** is expected to be completed within a schedule, the anticipated time to complete based on realistic assessment	Y	Section 3.2, Appendix 3A		

WATERSHED MANAGEMENT AREA

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES					
PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**	**Co-Permittee Response**
Watershed Management Area Strategies					
B.3.b.(2)(d)	Funds and/or resources that must be secured to implement optional strategies from (a)-(c)	N	Section 3.2, Appendix 3A, Table 3-17		
B.3.b.(2)(e)	Circumstances necessary to trigger implementation of optional regional or multi-jurisdictional strategies to achieve numeric goals within schedules	N	Section 3.2, Appendix 3A, Table 3-17		
B.3.b.(2)	Did the Copermittees identify **Optional Regional or Multi-Jurisdictional Strategies** to be implemented, as necessary?	Y	Section 3.2, Appendix 3A, Table 3-17		
B.3.b.(2)	Do descriptions of **Optional Regional or Multi-Jurisdictional Strategies** include the following:		NA	NA	
B.3.b.(2)(a)	BMPs, incentives, or programs that may be implemented by Copermittees in the WMA	Y	Section 3.2, Appendix 3A, Table 3-17		
B.3.b.(2)(b)	Incentives or programs that may be implemented by Copermittees in the WMA to encourage or implement regional or multi-jurisdictional projects to retrofit areas of existing development	Y	Section 3.2, Appendix 3A, Table 3-17		
B.3.b.(2)(c)	Incentives or programs that may be implemented by Copermittees in the WMA to encourage or implement regional or multi-jurisdictional projects to rehabilitate channels, streams or habitats in WMA	Y	Section 3.2, Appendix 3A, Table 3-17		
Schedules for Watershed Management Area Strategies					
B.3.b.(3)(b)	Did the Copermittees incorporate schedules that specify the following:		NA	NA	
B.3.b.(3)(b)(i)	For each **Optional Regional or Multi-Jurisdictional Strategy**, a realistic assessment of shortest practicable time to: [a] Secure resources to fund strategy [b] Procure resources, materials, labor, permits necessary to initiate strategy	Y	Section 3.2, Appendix 3A, Table 3-17		
B.3.b.(3)(a)(ii)	If **Optional Regional or Multi-Jurisdictional Strategy** is expected to be continuously implemented, or completed within a schedule	Y	Section 3.2, Appendix 3A, Table 3-17		
B.3.b.(3)(a)(v)	If **Optional Regional or Multi-Jurisdictional Strategy** is expected to be completed within a schedule, the anticipated time to complete based on realistic assessment	Y	Section 3.2, Appendix 3A, Table 3-17		

. OPTIONAL WMAA

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**	**Co-Permittee Response**
Optional Watershed Management Area Analysis					
B.3.b.(4)(a)(i)	A description of dominant hydrological processes	N	Section 4.3, Appendix 4B	Does not assess impacts to the Santa Margarita River Estuary from proposed exemption and any impacts to the success of achieving the water quality objectives in the estuary.	New evaluation and rationale were provided in the WMAA, Section 4.3.3. The proposed hydromodification exemption for the SM River is not expected to adversely impact the Estuary.
B.3.b.(4)(c)	If the Copermittees performed a WMAA, did the Copermittees identify areas within the WMA where it is appropriate to allow PDPs to be exempt from hydromodification BMP requirements with supporting rationale?	N	Section 3.3, Appendix 4B	Copermittees received comments from San Diego Water Board during the WQMP review on the WMAA. WMAA was not revised when submitted as part of the complete WQIP. Copermittees have actively worked to address the WMAA comments with the San Diego Water Baord since the time of the January 2018 WQIP submittal. Comments submitted to the CoPs on the WMAA previously remain unaddressed. See attached WQMP commetns dated March 16, 2018 and 5/8/18.	All WMAA comments have been addressed as outlined below.
B.3.b.(4)(a)	Did the Copermittees perform a Watershed Management Area (WMAA) analysis?	Y	Section 4.3, Appendix 4B	WMAA is not completed for a single watershed. Must be unified for SMR watershed. Currently separated into upper and lower SMR analyses separately performed by San Diego County and Riverside County Copermittees. A unifed study is required in order to be compliant with provision B.3.b.(4)(a).	The data source tables for San Diego and Riverside Counties were combined and a more comprehensive analysis was conducted for the entire WMA.
B.3.b.(4)(a)(ii)	A description of existing streams in the watershed, including bed material and composition, and if perennial or ephemeral	Y	Section 4.3, Appendix 4B	WMAA is not completed for a single watershed. Must be unified for SMR watershed. Currently separated into upper and lower SMR analyses separately performed by San Diego County and Riverside County Copermittees. A unifed study is required in order to be compliant with provision B.3.b.(4)(a).	The data source tables for San Diego and Riverside Counties were combined and a more comprehensive analysis was conducted for the entire WMA.
B.3.b.(4)(a)(iii)	Current and anticipated land uses	Y	Section 4.3, Appendix 4B	See previous comment. Not a unified analysis.	
B.3.b.(4)(a)(iv)	Potential coarse sediment yield areas	Y	Section 4.3, Appendix 4B	See previous comment. Not a unified analysis.	
B.3.b.(4)(a)(v)	Locations of existing flood control and channel structures	Y	Section 4.3, Appendix 4B	See previous comment. Not a unified analysis.	

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES					
PROVISION B.3.b: WATER QUALITY IMPROVEMENT STRATEGIES AND SCHEDULES					
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**	**Co-Permittee Response**
B.3.b.(4)(b)	If the Copermittees performed a WMAA, did the Copermittees identify and compile a list of candidate projects?	N	Section 4.3, Appendix 4B	List of candidate projects do not meet the requirements for alternative compliance projects under provision E.3 and consist of water agency projects that do not support water supply. No projects were listed for the upper Santa Margarita River by Riverside Copermittees.	Several Candidate Projects have been included for Riverside County areas.
B.3.b.(4)(a)	Does the WMAA include the following:		N/A	N/A	

Provision B.3.c: Prohibitions and Limitations Compliance Option

CITY OF MENIFEE

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION				
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**
CITY OF MENIFEE				
B.3.c.(1)(a)	Did **each Copermittee** identify numeric goals, water quality improvement strategies, and schedules developed pursuant to Provisions B.3.a and B.3.b that includes the following:		This option has not yet been exercised by the City of Menifee	NA
B.3.c.(1)(a)(i)	Interim and final WQBELs established by the TMDLs in Attachment E applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(ii)	Interim and final goals for any ASBS subject to the provisions of Attachment B to applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(iii) B.3.c.(1)(a)(iv)	Interim and final numeric goals applicable to the Copermittee's MS4 discharges expressed as numeric concentration-based or load-based goals for all pollutants and conditions listed on the CWA Section 303(d) List for all receiving waters in the WMA that do not have a TMDL AND/OR Interim and final numeric goals for [ALL] pollutants and conditions identified as receiving water priorities in the Water Quality Improvement Plan that will result in chemical, physical, and biological conditions protective of beneficial uses of receiving water impacted by MS4 discharges			
B.3.c.(1)(a)(v)	OPTIONAL: Interim and final numeric goals applicable to the Copermittee's MS4 discharges and/or receiving waters within the WMA for any pollutants or conditions in addition to those described in for B.3.c.(1)(a)(iii) AND/OR (iv)			
B.3.c.(1)(a)(vi)	Schedules for achieving each final numeric goal that reflect a realistic assessment of the shortest practicable time need for achievement			

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES				
PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION				
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**
CITY OF MENIFEE				
B.3.c.(1)(a)(vii)	For each final numeric goal developed pursuant to Provisions B.3.a and B.3.c.(1)(a)(i)-(v), annual milestones* and the dates for their achievement must be included within each of the next five (5) Water Quality Improvement Plan Annual Report reporting periods, or until the final numeric goal is achieved. * Annual milestones must be clearly and directly linked to, or demonstrate progress is being made toward the achievement of the final numeric goal. Annual milestones may consist of strategy implementation phases, interim numeric goals, and other acceptable metrics. Annual milestones may address multiple numeric goals and/or multiple water bodies, as applicable and appropriate.			
B.3.c.(1)(b)	Is there an analysis that meets all the following conditions:			
B.3.c.(1)(b)(i)	The analysis, with clearly stated assumptions included in the analysis, must quantitatively demonstrate that the implementation of the water quality improvement strategies required under B.3.b will achieve the final numeric goals within the schedules developed pursuant to B.3.a and B.3.c.(1)(a)			
B.3.c.(1)(b)(ii)	The development of the analysis must include a public participation process that allowed the public to review and provide comments on the analysis methodology utilized and the assumptions included in the analysis.			
	Public comments and responses must be included as part of the analysis documentation			
B.3.c.(1)(b)(iii)	The analysis may be performed by an individual Copermittee or jointly by two or more Copermittees			
B.3.c.(1)(b)(iv)	The analysis must be updated as part of the iterative approach and adaptive management process required under B.5.a-b			

CITY OF MURRIETA

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES **PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION**				
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**
CITY OF MURRIETA				
B.3.c.(1)(a)	Did **each Copermittee** identify numeric goals, water quality improvement strategies, and schedules developed pursuant to Provisions B.3.a and B.3.b that includes the following:		This option has not yet been exercised by the City of Murrieta	NA
B.3.c.(1)(a)(i)	Interim and final WQBELs established by the TMDLs in Attachment E applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(ii)	Interim and final goals for any ASBS subject to the provisions of Attachment B to applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(iii) B.3.c.(1)(a)(iv)	Interim and final numeric goals applicable to the Copermittee's MS4 discharges expressed as numeric concentration-based or load-based goals for all pollutants and conditions listed on the CWA Section 303(d) List for all receiving waters in the WMA that do not have a TMDL AND/OR Interim and final numeric goals for [ALL] pollutants and conditions identified as receiving water priorities in the Water Quality Improvement Plan that will result in chemical, physical, and biological conditions protective of beneficial uses of receiving water impacted by MS4 discharges			
B.3.c.(1)(a)(v)	OPTIONAL: Interim and final numeric goals applicable to the Copermittee's MS4 discharges and/or receiving waters within the WMA for any pollutants or conditions in addition to those described in for B.3.c.(1)(a)(iii) AND/OR (iv)			
B.3.c.(1)(a)(vi)	Schedules for achieving each final numeric goal that reflect a realistic assessment of the shortest practicable time need for achievement			

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES				
PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION				
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**
CITY OF MURRIETA				
B.3.c.(1)(a)(vii)	For each final numeric goal developed pursuant to Provisions B.3.a and B.3.c.(1)(a)(i)-(v), annual milestones* and the dates for their achievement must be included within each of the next five (5) Water Quality Improvement Plan Annual Report reporting periods, or until the final numeric goal is achieved. * Annual milestones must be clearly and directly linked to, or demonstrate progress is being made toward the achievement of the final numeric goal. Annual milestones may consist of strategy implementation phases, interim numeric goals, and other acceptable metrics. Annual milestones may address multiple numeric goals and/or multiple water bodies, as applicable and appropriate.			
B.3.c.(1)(b)	Is there an analysis that meets all the following conditions:			
B.3.c.(1)(b)(i)	The analysis, with clearly stated assumptions included in the analysis, must quantitatively demonstrate that the implementation of the water quality improvement strategies required under B.3.b will achieve the final numeric goals within the schedules developed pursuant to B.3.a and B.3.c.(1)(a)			
B.3.c.(1)(b)(ii)	The development of the analysis must include a public participation process that allowed the public to review and provide comments on the analysis methodology utilized and the assumptions included in the analysis.			
	Public comments and responses must be included as part of the analysis documentation			
B.3.c.(1)(b)(iii)	The analysis may be performed by an individual Copermittee or jointly by two or more Copermittees			
B.3.c.(1)(b)(iv)	The analysis must be updated as part of the iterative approach and adaptive management process required under B.5.a-b			

les CITY OF TEMECULA

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES **PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION**				
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**
CITY OF TEMECULA				
B.3.c.(1)(a)	Did **each Copermittee** identify numeric goals, water quality improvement strategies, and schedules developed pursuant to Provisions B.3.a and B.3.b that includes the following:		This option has not yet been exercised by the City of Temecula	NA
B.3.c.(1)(a)(i)	Interim and final WQBELs established by the TMDLs in Attachment E applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(ii)	Interim and final goals for any ASBS subject to the provisions of Attachment B to applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(iii) B.3.c.(1)(a)(iv)	Interim and final numeric goals applicable to the Copermittee's MS4 discharges expressed as numeric concentration-based or load-based goals for all pollutants and conditions listed on the CWA Section 303(d) List for all receiving waters in the WMA that do not have a TMDL AND/OR Interim and final numeric goals for [ALL] pollutants and conditions identified as receiving water priorities in the Water Quality Improvement Plan that will result in chemical, physical, and biological conditions protective of beneficial uses of receiving water impacted by MS4 discharges			
B.3.c.(1)(a)(v)	OPTIONAL: Interim and final numeric goals applicable to the Copermittee's MS4 discharges and/or receiving waters within the WMA for any pollutants or conditions in addition to those described in for B.3.c.(1)(a)(iii) AND/OR (iv)			
B.3.c.(1)(a)(vi)	Schedules for achieving each final numeric goal that reflect a realistic assessment of the shortest practicable time need for achievement			

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION

Provision	Requirement	Y/N	Location in Plan	Notes
CITY OF TEMECULA				
B.3.c.(1)(a)(vii)	For each final numeric goal developed pursuant to Provisions B.3.a and B.3.c.(1)(a)(i)-(v), annual milestones* and the dates for their achievement must be included within each of the next five (5) Water Quality Improvement Plan Annual Report reporting periods, or until the final numeric goal is achieved. * Annual milestones must be clearly and directly linked to, or demonstrate progress is being made toward the achievement of the final numeric goal. Annual milestones may consist of strategy implementation phases, interim numeric goals, and other acceptable metrics. Annual milestones may address multiple numeric goals and/or multiple water bodies, as applicable and appropriate.			
B.3.c.(1)(b)	Is there an analysis that meets all the following conditions:			
B.3.c.(1)(b)(i)	The analysis, with clearly stated assumptions included in the analysis, must quantitatively demonstrate that the implementation of the water quality improvement strategies required under B.3.b will achieve the final numeric goals within the schedules developed pursuant to B.3.a and B.3.c.(1)(a)			
B.3.c.(1)(b)(ii)	The development of the analysis must include a public participation process that allowed the public to review and provide comments on the analysis methodology utilized and the assumptions included in the analysis.			
	Public comments and responses must be included as part of the analysis documentation			
B.3.c.(1)(b)(iii)	The analysis may be performed by an individual Copermittee or jointly by two or more Copermittees			
B.3.c.(1)(b)(iv)	The analysis must be updated as part of the iterative approach and adaptive management process required under B.5.a-b			

CITY OF WILDOMAR

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES **PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION**				
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**
CITY OF WILDOMAR				
B.3.c.(1)(a)	Did **each Copermittee** identify numeric goals, water quality improvement strategies, and schedules developed pursuant to Provisions B.3.a and B.3.b that includes the following:		This option has not yet been exercised by the City of Wildomar	NA
B.3.c.(1)(a)(i)	Interim and final WQBELs established by the TMDLs in Attachment E applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(ii)	Interim and final goals for any ASBS subject to the provisions of Attachment B to applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(iii) B.3.c.(1)(a)(iv)	Interim and final numeric goals applicable to the Copermittee's MS4 discharges expressed as numeric concentration-based or load-based goals for all pollutants and conditions listed on the CWA Section 303(d) List for all receiving waters in the WMA that do not have a TMDL AND/OR Interim and final numeric goals for [ALL] pollutants and conditions identified as receiving water priorities in the Water Quality Improvement Plan that will result in chemical, physical, and biological conditions protective of beneficial uses of receiving water impacted by MS4 discharges			
B.3.c.(1)(a)(v)	OPTIONAL: Interim and final numeric goals applicable to the Copermittee's MS4 discharges and/or receiving waters within the WMA for any pollutants or conditions in addition to those described in for B.3.c.(1)(a)(iii) AND/OR (iv)			
B.3.c.(1)(a)(vi)	Schedules for achieving each final numeric goal that reflect a realistic assessment of the shortest practicable time need for achievement			

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES				
PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION				
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**
CITY OF WILDOMAR				
B.3.c.(1)(a)(vii)	For each final numeric goal developed pursuant to Provisions B.3.a and B.3.c.(1)(a)(i)-(v), annual milestones* and the dates for their achievement must be included within each of the next five (5) Water Quality Improvement Plan Annual Report reporting periods, or until the final numeric goal is achieved. * Annual milestones must be clearly and directly linked to, or demonstrate progress is being made toward the achievement of the final numeric goal. Annual milestones may consist of strategy implementation phases, interim numeric goals, and other acceptable metrics. Annual milestones may address multiple numeric goals and/or multiple water bodies, as applicable and appropriate.			
B.3.c.(1)(b)	Is there an analysis that meets all the following conditions:			
B.3.c.(1)(b)(i)	The analysis, with clearly stated assumptions included in the analysis, must quantitatively demonstrate that the implementation of the water quality improvement strategies required under B.3.b will achieve the final numeric goals within the schedules developed pursuant to B.3.a and B.3.c.(1)(a)			
B.3.c.(1)(b)(ii)	The development of the analysis must include a public participation process that allowed the public to review and provide comments on the analysis methodology utilized and the assumptions included in the analysis.			
	Public comments and responses must be included as part of the analysis documentation			
B.3.c.(1)(b)(iii)	The analysis may be performed by an individual Copermittee or jointly by two or more Copermittees			
B.3.c.(1)(b)(iv)	The analysis must be updated as part of the iterative approach and adaptive management process required under B.5.a-b			

COUNTY OF RIVERSIDE

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES **PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION**				
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**
COUNTY OF RIVERSIDE				
B.3.c.(1)(a)	Did **each Copermittee** identify numeric goals, water quality improvement strategies, and schedules developed pursuant to Provisions B.3.a and B.3.b that includes the following:		This option has not yet been exercised by the County of Riverside	NA
B.3.c.(1)(a)(i)	Interim and final WQBELs established by the TMDLs in Attachment E applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(ii)	Interim and final goals for any ASBS subject to the provisions of Attachment B to applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(iii) B.3.c.(1)(a)(iv)	Interim and final numeric goals applicable to the Copermittee's MS4 discharges expressed as numeric concentration-based or load-based goals for all pollutants and conditions listed on the CWA Section 303(d) List for all receiving waters in the WMA that do not have a TMDL AND/OR Interim and final numeric goals for [ALL] pollutants and conditions identified as receiving water priorities in the Water Quality Improvement Plan that will result in chemical, physical, and biological conditions protective of beneficial uses of receiving water impacted by MS4 discharges			
B.3.c.(1)(a)(v)	OPTIONAL: Interim and final numeric goals applicable to the Copermittee's MS4 discharges and/or receiving waters within the WMA for any pollutants or conditions in addition to those described in for B.3.c.(1)(a)(iii) AND/OR (iv)			
B.3.c.(1)(a)(vi)	Schedules for achieving each final numeric goal that reflect a realistic assessment of the shortest practicable time need for achievement			

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION

Provision	Requirement	Y/N	Location in Plan	Notes
COUNTY OF RIVERSIDE				
B.3.c.(1)(a)(vii)	For each final numeric goal developed pursuant to Provisions B.3.a and B.3.c.(1)(a)(i)-(v), annual milestones* and the dates for their achievement must be included within each of the next five (5) Water Quality Improvement Plan Annual Report reporting periods, or until the final numeric goal is achieved. * Annual milestones must be clearly and directly linked to, or demonstrate progress is being made toward the achievement of the final numeric goal. Annual milestones may consist of strategy implementation phases, interim numeric goals, and other acceptable metrics. Annual milestones may address multiple numeric goals and/or multiple water bodies, as applicable and appropriate.			
B.3.c.(1)(b)	Is there an analysis that meets all the following conditions:			
B.3.c.(1)(b)(i)	The analysis, with clearly stated assumptions included in the analysis, must quantitatively demonstrate that the implementation of the water quality improvement strategies required under B.3.b will achieve the final numeric goals within the schedules developed pursuant to B.3.a and B.3.c.(1)(a)			
B.3.c.(1)(b)(ii)	The development of the analysis must include a public participation process that allowed the public to review and provide comments on the analysis methodology utilized and the assumptions included in the analysis.			
	Public comments and responses must be included as part of the analysis documentation			
B.3.c.(1)(b)(iii)	The analysis may be performed by an individual Copermittee or jointly by two or more Copermittees			
B.3.c.(1)(b)(iv)	The analysis must be updated as part of the iterative approach and adaptive management process required under B.5.a-b			

-3 COUNTY OF SAN DIEGO

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES				
PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION				
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**
COUNTY OF SAN DIEGO				
B.3.c.(1)(a)	Did **each Copermittee** identify numeric goals, water quality improvement strategies, and schedules developed pursuant to Provisions B.3.a and B.3.b that includes the following:		This option has not yet been exercised by the County of San Diego	NA
B.3.c.(1)(a)(i)	Interim and final WQBELs established by the TMDLs in Attachment E applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(ii)	Interim and final goals for any ASBS subject to the provisions of Attachment B to applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(iii) B.3.c.(1)(a)(iv)	Interim and final numeric goals applicable to the Copermittee's MS4 discharges expressed as numeric concentration-based or load-based goals for all pollutants and conditions listed on the CWA Section 303(d) List for all receiving waters in the WMA that do not have a TMDL AND/OR Interim and final numeric goals for [ALL] pollutants and conditions identified as receiving water priorities in the Water Quality Improvement Plan that will result in chemical, physical, and biological conditions protective of beneficial uses of receiving water impacted by MS4 discharges			
B.3.c.(1)(a)(v)	OPTIONAL: Interim and final numeric goals applicable to the Copermittee's MS4 discharges and/or receiving waters within the WMA for any pollutants or conditions in addition to those described in for B.3.c.(1)(a)(iii) AND/OR (iv)			
B.3.c.(1)(a)(vi)	Schedules for achieving each final numeric goal that reflect a realistic assessment of the shortest practicable time need for achievement			

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION

Provision	Requirement	Y/N	Location in Plan	Notes
COUNTY OF SAN DIEGO				
B.3.c.(1)(a)(vii)	For each final numeric goal developed pursuant to Provisions B.3.a and B.3.c.(1)(a)(i)-(v), annual milestones* and the dates for their achievement must be included within each of the next five (5) Water Quality Improvement Plan Annual Report reporting periods, or until the final numeric goal is achieved. * Annual milestones must be clearly and directly linked to, or demonstrate progress is being made toward the achievement of the final numeric goal. Annual milestones may consist of strategy implementation phases, interim numeric goals, and other acceptable metrics. Annual milestones may address multiple numeric goals and/or multiple water bodies, as applicable and appropriate.			
B.3.c.(1)(b)	Is there an analysis that meets all the following conditions:			
B.3.c.(1)(b)(i)	The analysis, with clearly stated assumptions included in the analysis, must quantitatively demonstrate that the implementation of the water quality improvement strategies required under B.3.b will achieve the final numeric goals within the schedules developed pursuant to B.3.a and B.3.c.(1)(a)			
B.3.c.(1)(b)(ii)	The development of the analysis must include a public participation process that allowed the public to review and provide comments on the analysis methodology utilized and the assumptions included in the analysis.			
	Public comments and responses must be included as part of the analysis documentation			
B.3.c.(1)(b)(iii)	The analysis may be performed by an individual Copermittee or jointly by two or more Copermittees			
B.3.c.(1)(b)(iv)	The analysis must be updated as part of the iterative approach and adaptive management process required under B.5.a-b			

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES				
PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION				
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT				
B.3.c.(1)(a)	Did **each Copermittee** identify numeric goals, water quality improvement strategies, and schedules developed pursuant to Provisions B.3.a and B.3.b that includes the following:		This option has not yet been exercised by the RCFCWCD	NA
B.3.c.(1)(a)(i)	Interim and final WQBELs established by the TMDLs in Attachment E applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(ii)	Interim and final goals for any ASBS subject to the provisions of Attachment B to applicable to the Copermittee's jurisdiction			
B.3.c.(1)(a)(iii) B.3.c.(1)(a)(iv)	Interim and final numeric goals applicable to the Copermittee's MS4 discharges expressed as numeric concentration-based or load-based goals for all pollutants and conditions listed on the CWA Section 303(d) List for all receiving waters in the WMA that do not have a TMDL AND/OR Interim and final numeric goals for [ALL] pollutants and conditions identified as receiving water priorities in the Water Quality Improvement Plan that will result in chemical, physical, and biological conditions protective of beneficial uses of receiving water impacted by MS4 discharges			
B.3.c.(1)(a)(v)	OPTIONAL: Interim and final numeric goals applicable to the Copermittee's MS4 discharges and/or receiving waters within the WMA for any pollutants or conditions in addition to those described in for B.3.c.(1)(a)(iii) AND/OR (iv)			
B.3.c.(1)(a)(vi)	Schedules for achieving each final numeric goal that reflect a realistic assessment of the shortest practicable time need for achievement			

PROVISION B.3: WATER QUALITY IMPROVEMENT GOALS, STRATEGIES AND SCHEDULES

PROVISION B.3.c: PROHIBITIONS AND LIMITATIONS COMPLIANCE OPTION

Provision	Requirement	Y/N	Location in Plan	Notes
RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT				
B.3.c.(1)(a)(vii)	For each final numeric goal developed pursuant to Provisions B.3.a and B.3.c.(1)(a)(i)-(v), annual milestones* and the dates for their achievement must be included within each of the next five (5) Water Quality Improvement Plan Annual Report reporting periods, or until the final numeric goal is achieved. * Annual milestones must be clearly and directly linked to, or demonstrate progress is being made toward the achievement of the final numeric goal. Annual milestones may consist of strategy implementation phases, interim numeric goals, and other acceptable metrics. Annual milestones may address multiple numeric goals and/or multiple water bodies, as applicable and appropriate.			
B.3.c.(1)(b)	Is there an analysis that meets all the following conditions:			
B.3.c.(1)(b)(i)	The analysis, with clearly stated assumptions included in the analysis, must quantitatively demonstrate that the implementation of the water quality improvement strategies required under B.3.b will achieve the final numeric goals within the schedules developed pursuant to B.3.a and B.3.c.(1)(a)			
B.3.c.(1)(b)(ii)	The development of the analysis must include a public participation process that allowed the public to review and provide comments on the analysis methodology utilized and the assumptions included in the analysis.			
	Public comments and responses must be included as part of the analysis documentation			
B.3.c.(1)(b)(iii)	The analysis may be performed by an individual Copermittee or jointly by two or more Copermittees			
B.3.c.(1)(b)(iv)	The analysis must be updated as part of the iterative approach and adaptive management process required under B.5.a-b			

Santa Margarita River HU Watershed Management Area

LEASESPROVISION B.4: WATER QUALITY IMPROVEMENT MONITORING AND ASSESSMENT PROGRAM

PROVISION B.4: WATER QUALITY IMPROVEMENT MONITORING AND ASSESSMENT PROGRAM

Provision	Requirement	Y/N	Location in Plan	Notes	CoPermittee Response
B.4.a	Does the monitoring and assessment program incorporate the monitoring and assessment requirements of Provision D?	N	B.4 SECTION 5; Appendices 5A	**HMP from 2010 permit not clearly identified. Need locations of 2010 and 2010 requirements included in monitoring program in addition to Regional MS4 Permit requirements.**	The hydromodification monitoring sites have been included in a new map (Figure 5-3) and Table 5-4 with lat-long information in Section 5.3.1.3. Added enhanced description of required Hydromodification Monitoring, including requirements of the 2016 SMR HMP and report submittal date which follows from requirements of the 2010 SMR MS4 Permit.
				Monitoring is not representative of WMA (nothing east of lakes). Submittal dates must be specific. San Diego Water Board requested data updates in Annual Report in addition to final report submittal date. See attached comments from Hiram Sirabia, San Diego Water Board. San Diego Water Board is requiring an additional monitoring location east of the lakes. Current proposed location (902USM828) is not representative of the WMA (ie only urban land uses). Long term monitoring station to be selected in in area representative of the rural residential land uses upstream of drinking water reservoirs.	At section 5.3.1: added description of proposed new Receiving Water Monitoring Station to be sited on Wilson Creek or Temecula Creek upstream from Vail Lake. Also revised Figure 5-1 and related tables with a new station accordingly. HMP hydromodification monitoring final report will be submitted October 31, 2019.
				Confirm that no major MS4 outfalls exist in WMA east of drinking water reservoirs. Special studies must be related to the HPWQC.	Confirmed and noted in new Section 1.4--there are no Major Outfalls in the Upper SMR Subwatershed.
				The intercalibration assessment for toxicity does not qualify as a special study for compliance with the Regional MS4 Permit provision D.3. This study should not be referenced for use as a special study per permit term.	Section 5.3.3 (Special Studies) revised to identify the studies specifically required by the Permit Provision D.3 (not the SMC Intercalibration Study), and a category of other special studies.

PROVISION B.4: WATER QUALITY IMPROVEMENT MONITORING AND ASSESSMENT PROGRAM

Provision	Requirement	Y/N	Location in Plan	Notes	CoPermittee Response
B.4.a	If applicable, does the monitoring and assessment program incorporate the specific monitoring and assessment requirements of applicable TMDLs in Attachment E	Y	B.4 SECTION 5; Appendix 4	Rainbow Creek TMDL (Final Compliance for 12/31/21 – N, Total N, and Total P RWLs per Tables 3.1, 3. 2 , 3.3 and 3.4 – Final TMDL Compliance Determination through WQIP requirements in Att. E, 3.b (3) (e) (ii) TMDL Monitoring must be included in WQIP. **Clarify how the structural BMPs can be used to meet the TMDL compliance dates as Table 3-4 in Appendix 4a states as a footnote: *1.The County of San Diego has concerns in that there is no long-term funding source identified to fund structural BMPs and their ongoing operation and maintenance.*** The requirements is to	Rainbow Ceek TMDL Monitoring is described in Section 5.3.1.6, and in Section 5.3.2.4 and has been updated. TMDL Monitoing is also described in Section 4 of WQIP Appendix 5A. Table 3-4 revised to remove the previous Footnote 1.
B.4.a	Did the Copermittees develop and incorporate an integrated monitoring and assessment program into the Water Quality Improvement Plan?	Y	B.4 SECTION 5		
B.4.a	If applicable, does the monitoring and assessment program incorporate the ASBS monitoring requirements in Attachment B to State Water Board Resolution No. 2012-0012?	N/A	N/A	No ASBS monitoring in WMA	

- Provision F.1.a: Water Quality Improvement Plan Development Public Participation Process

PROVISION F.1.A: WATER QUALITY IMPROVEMENT PLAN DEVELOPMENT PUBLIC PARTICIPATION PROCESS				
Provision	**Requirement**	**Y/N**	**Location in Plan**	**Notes**
F.1.a(1)	The Copermittees must implement a public participation process to solicit data, information, and recommendations to be utilized in the development of the Water Quality Improvement Plan. The public participation process must include the following:	Y	N/A	Transparency and communication are two of the four core values of the San Diego Water Board. The Copermittees. The Copermitees addressed the concerns regarding a transparent and adequate public participation process to solicit data, information, and recommendations to be utilized in the development of the Water Quality Improvement Plan.
F.1.a(1)(a)	The Copermittees must develop a publicly available and noticed schedule of the opportunities for the public to participate and provide comments during the development of the Water Quality Improvement Plan. The schedule may be adjusted as necessary by the Copermittees, provided the public is provided timely notification of the changes to the schedule	Y	N/A	The Consultation Panel meetings focused solely on the Plan were noticed via the RCFWCD website for Plan development and participation. Consultation Panel meetings were held after work hours.
F.1.a(1)(b)	The Copermittees must form a Water Quality Improvement Consultation Panel to provide recommendations during the development of the Water Quality Improvement Plan.	Y	N/A	Consultation Panel selected continues to be engaged and continues to be diverse and representative of the WMA stakeholders.
F.1.a(1)(c)	The Copermittees must coordinate the schedules for the public participation process among the Watershed Management Areas to provide the public time and opportunity to participate during the development of the Water Quality Improvement Plans.	Y	N/A	The meetings focused solely on the Plan were scheduled such that the public could participate in the development of other on-going Water Quality Improvement Plans or updates.
F.1.a(2)(a)	The Copermittees must solicit data, information and recommendations from the public to be utilized in the development and identification of the priority water quality conditions and potential water quality improvement strategies for the Watershed Management Area.	Y	NA	The Copermittees included additional data solicited from the public and Consultation Panel members at the request of the San Diego Water Board.
F.1.a(2)(b)	The Copermittees must review the priority water quality conditions the Copermittees plan on including in the Water Quality Improvement Plan with the Water Quality Improvement Consultation Panel to receive recommendations or concurrence	Y	NA	Presented at second Consultation Panel Meeting. Schedule was significantly compressed for Copermittees and CP members to provide meaningful comments.

PROVISION F.1.A: WATER QUALITY IMPROVEMENT PLAN DEVELOPMENT PUBLIC PARTICIPATION PROCESS

Provision	Requirement	Y/N	Location in Plan	Notes
F.1.a(2)(c)	The Copermittees must consider revisions to the priority water quality conditions based on recommendations from the Water Quality Improvement Consultation Panel.	Y	NA	Consultation Panel members input were considered in the selection process of the PWQC and HPWQC.
F.1.a(2)(d)	The Copermittees must include all the potential water quality improvement strategies identified by the public and the Water Quality Improvement Consultation Panel with the submittal of the priority water quality conditions to the San Diego Water Board.	Y	NA	Copermittees included Consultation Panel member and public input on strategies in the selection process of the PWQC and potential water quality improvement strategies developed.
F.1.a(2)(e)	The Copermittees must submit the Water Quality Improvement Plan requirements of Provision B.2 to the San Diego Water Board as early as 6 months and no later than 12 months after the commencement of coverage under this Order.	Y	NA	Received July 7, 2017.
F.1.a(2)(f)	The Copermittees must consider revisions to the priority water quality conditions and potential water quality improvement strategies developed pursuant to Provision B.2 based on public comments received by the close of the comment period.	Y	NA	Copermittees considered Consultation Panel members and public input on strategies in the selection process of the PWQC and potential water quality improvement strategies developed.
F.1.b	Within 24 months after the commencement of coverage under this Order, the Copermittees for each Watershed Management Area must submit a complete Water Quality Improvement Plan in accordance with the requirements of Provision B of this Order to the San Diego Water Board. The San Diego Water Board will issue a public notice and release the Water Quality Improvement Plan for public review and comment for a minimum of 30 days.	Y	NA	Received January 5, 2018 Copermittees considered Consultation Panel members and public input in the development of the complete WQIP.

WMAA Comments and Responses--Additional Responses					
2017 Consultation Committee and Public Comments and Responses - WMAA Comments 12-19-17					
Number	**Name**	**Comment Date**	**Comment**	**January 4, 2018 Response**	**October 9, 2018 Response**
38	Erica Ryan	12/12/2017	Section 4: Figure 4-2 - For the SMR exemption, the Stakeholder Group for the TMDL identified erosion and significant sediment discharge from the watershed (SPAWAR). In addition, erosion has been identified during storm events near the Stuart Mesa fields on Camp Pendleton (San Diego Water Board letter to Camp Pendleton). It does not appear that the cross section assessed is typical of the entire reach to the outfall or that a conclusion can be drawn that there is no issues with this reach or the estuary. Describe why this section is the critical cross section and an adequate location to conclude the river si stable for its entire reach in more detail. Are other cross sections indicative of higher flow velocities downstream?	The District will seek consultant to clarify discussion regarding channel stability. The District will coordinate a meeting with the Regional Board to discuss scope of analysis after the submittal of the WQIP.	An additional field site was evaluated in the lower reach of the SM River on Camp Pendleton Property (see Figure 4-2). The Erosion Potential and Sediment Supply Potential were calculated for the new site. The new analysis in included in Section 4.3.1.
40	Erica Ryan	12/12/2017	Section 4: Explain in more detail the driving factors for the results and statements with regard to the river reach being stable. Merely stating that an x, y z number is less than another number is not transparent and inadequate discussion to support the exemption.	The District will seek consultant to clarify discussion regarding channel stability. The District will coordinate a meeting with the Regional Board to discuss scope of analysis after the submittal of the WQIP.	The explanation of the factors and criteria regarding stability of the SMR Channel has been enhanced in Section 4.3.
59	Erica Ryan	12/12/2017	Attachment C (Now Attachment G): It appears that the medium and high soil loss consist of 90 percent of the potential coarse sediment for the upper WMA. Provide an explanation how this justifies only 9% of the watershed as a CCSY area.	Figure E.1 of Attachment G includes Geologic Groups of the Upper Santa Margarita River Watershed showing the CB, CSI, or CSP geology groups. Based on this analysis it was estimated that 28 percent of the of the SMR study area is a potential coarse sediment yield area and 9 percent of the SMR study area is a potential critical coarse sediment yield area. The majority of the potential critical coarse sediment yield areas were identified to be in the Scrub/Shrub land cover areas with hillslope gradients ranging from 20 to 40 percent.	Staff from the District and WSP Consultants met with Regional Board staff in April 2018 and presented an enhanced analysis of the process to develop the Critical Coarse Sediment Yield Map. The map is now integrated for the entire WMA. A Tech Memo was developed and included in the WMAA Attachments which documents the analysis. Additional "Potential Sediment Source Areas" were added to the CCSY map based on the location of historical sand and gravel deposits in the SMR WMA. In addition, the SMR Ecological Reserve was identified and shown on the CCSY map. The SMRER is the location of ongoing Steelhead Trout habitat restoration efforts. The CCSY Map was included as Attachment G in the updated SMR BMP Manual and requires projects to conduct site-specific analyses and if necessary mitigate any adverse impacts to coarse sediment supply.

SMR WMAA: RESPONSE TO COMMENTS MATRIX

Western Riverside Council of Governments/Riverside County Flood Control & Water Conservation District

Draft Santa Margarita Watershed Management Area Analysis report (SMR WMAA) (Santa Margarita Watershed Management Area Co-Permittees 2018); Draft Upper Santa Margarita River Hydrologic Response Unit and Critical Coarse Sediment Yield Analysis (HRU/CCSY) (WSP 2017)			**CODE**	**A** = Will Incorporate **B** = Disagree, not incorporated **C** = Continue Resolution **N/A** = Not Applicable	
Submitted by: E. Ryan, San Diego Regional Water Quality Control Board					
Comment No.	**Section/Page No.**				
			Code	**By Whom**	**Response**
1	**SMR WMAA/ General**	The San Diego Water Board has made multiple comments over the last year in prior Consultation Committee meetings, comment letters, and e-mails that a WMAA which is not integrated for the entire Watershed Management Area (WMA) cannot be accepted. The CC draft WMAA repeatedly references a web link to the 2015 San Diego WMAA web link without a substantive description in the WMAA on how the Copermitees used this information for the conclusions described for the WMA. In addition, this referral to a web link does not meet the Regional MS4 Permit intent of public transparency.	A	VSS/JM	Links to the 2015 San Diego WMAA were removed and language applicable to the section, from the 2015 SD WMAA, was added to the SMR WMAA. The 2015 San Diego WMAA was also included as an attachment.
2	**SMR WMAA/ General**	Many of the data sets and maps do not reference a year that the information was based on. This information is important to assess how current data sets are used for the conclusions in the WMAA. For example, a generalized reference to “Copermittee General Plans” is used as a basis for the WMAA. This information and other data sets like this need to be accurately described so that the public can provide meaningful comments. What are the years of adoption? Where are these documents? How were the various land uses reconciled for use in the WMAA? One of the concerns of the San Diego Water Board is that current land use is used for the Plan development so that it is consistent with the TMDL development.	A	VSS/JM	A table with Dataset, Source, year and description, similar to 2015 SD WMAA, was added to Section 2.1.1. The Land Use dataset in the 2015 SD WMAA was also added to the SMR WMAA.
3	**SMR WMAA/ SECTION 1**	There are inaccuracies in this section that need to be corrected: The permit does not exempt projects from implementing TCBMPs if they cannot fully implement the pollutant and HMP controls on -site. The portion that cannot be mitigated on site can be mitigated off site through an Alternative Compliance program.	A	JM	Section 1.1 was modified to clarify.

RESPONSE TO COMMENTS MATRIX

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Submitted by: E. Ryan, San Diego Regional Water Quality Control Board					
Comment No.	**Section/Page No.**				
			Code	**By Whom**	**Response**
4	**SMR WMAA/ SECTION 1**	The Water Quality Equivalency has already been accepted in December 2015. See attached. https://www.waterboards.ca.gov/sandiego/water_issues/programs/stormwater/	A	JM	It was noted in the document that Water Quality Equivalency calculations were approved in 2015.
5	**SMR WMAA/ SECTION 1**	HMP exemptions and TCBMPS for water quality and flow control are only applicable to Priority Development Projects.	NA	JM	Thank you for the clarification
6	**SMR WMAA/ SECTION 1**	It is unclear if the information and conclusions in this section are a characterization of the Upper WMA only or of the entire WMA (upper and lower).	A	VSS	Text revised referencing characterization for both the upper and lower SMR watershed.
7	**SMR WMAA/ SECTION 1**	"See web link …for the lower WMA"… is not an adequate description of the data sets and the WMAA is required to be integrated for the ENTIRE WMA.	A	VSS/JM	Links to the 2015 San Diego WMAA were removed and language applicable to the section, from the 2015 SD WMAA, was added to the SMR WMAA. The 2015 San Diego WMAA was also included as an attachment.
8	**SMR WMAA/ SECTION 2**	It would seem logical that information from this section and the technical appendices for the HMP exemption and the 2014 HMP would be a data source for areas susceptible to hydromodification in the Plan (section 2.2). It appears that the CoPs conducted site visits in the WMA for the 2014 HMP Susceptibility Report. This would be especially true of EEM, NEE and NAT facilities listed.	A	JM	The 2014 HMP is included as a data source in section 2.2.1
9	**SMR WMAA/ SECTION 2**	It is unclear how google earth was used in the development of the WMAA.	A	JM	A description was added to the document for the use of google earth.

RESPONSE TO COMMENTS MATRIX

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Submitted by: E. Ryan, San Diego Regional Water Quality Control Board					
Comment No.	**Section/Page No.**				
			Code	**By Whom**	**Response**
10	**SMR WMAA/ SECTION 2**	Intermittent streams are not necessarily ephemeral streams based on the definition used. Provide a description on how locations of ephemeral streams were determined. An ephemeral stream is typically defined as “a stream or portion of a stream which flows briefly in direct response to precipitation in the immediate vicinity and whose channel is at all times above the ground water reservoir.	A	JM	While the specific Regional MS4 Permit language requested classification of perennial or ephemeral, rather than perennial or intermittent, the available data that was referenced in order to classify streams did not include "ephemeral" streams. For reference, the USGS National Hydrography Dataset definition of "ephemeral" is: "contains water only during or after a local rainstorm or heavy snowmelt." None of the stream reaches in the study were classified as ephemeral in the NHD dataset, therefore none are classified as ephemeral in this WMAA.
11	**SMR WMAA/ SECTION 2**	What year are the land uses describing and how were they integrated or modified?	A	JM	Years were added to land use dataset in section 2.3.1
12	**HRU/CCSY**	It is unclear how the conclusion can be made that the majority of the upper WMA does not have CCSY (only 9%???) when the technical appendices map show an indication that trends towards the opposite conclusion. It would be expected that if the majority of the watershed has CB, CSI, or CSP geology, slope, or other factors that it would be more in alignment with the San Diego Portion of the map. In addition, it is unclear how this conclusion was modified by the Copermitees through a review process. Where are the maps of the other contributing factors discussed? (2.4.1)	A	VSS	See Section 2.8 in the SMR WMAA. See Section 3.1.1 - Section 3.1.5 in the Upper SMR Report (WSP 2017). A GLU classified as CB, CSI or CSP were considered as areas that contribute coarse sediment. GLUs rated as CB, CSI or CSP along with a High RUSLE rating were considered as critical coarse sediment yield areas. The result that only 9% of the upper SMR contributes CCSY is attributed to the final RUSLE results. Specifically, the differences along the county border are attributed to the fine resolution of data for the R factor used in the Riverside County portion of the study area, whereas in the San Diego county portion of the study area, only one R data was assigned for each GLU by estimating the area weighted number for the entire study region. For example for the area between 20 and 40 the San Diego study assumed a value of 30. A Memo detailing the differences along the county border is provided in Attachment B of the SMR WMAA.
13	**SMR WMAA/ SECTION 3**	Based on the upper WMA candidate projects it appears that Santa Gertrudis, Bundy Canyon, and French Valley have HMP impacts.	NA	JM	Thank you for the observation.

RESPONSE TO COMMENTS MATRIX

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Submitted by: E. Ryan, San Diego Regional Water Quality Control Board					
Comment No.	**Section/Page No.**				
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14	**SMR WMAA/ SECTION 4**	Provide a more detailed of the change in impervious cover between existing and future development. What years are the data sets? How was this calculated? It would be helpful to provide a summary of the technical information in order to understand the process used and the conclusions.	A	JM	The criteria used to determine the exemptions are appropriate accounts for: (1) hydrology, (2) channel geometry, (3) bed and bank material, and (4) sediment supply. The years of the landuse dataset were added to section 2.3.1. The calculations included in section 4 compare long-term changes in sediment transport capacity, or in-stream work, and sediment supply at specific sections of the creek for the existing and future land use conditions.
15	**SMR WMAA/ SECTION 4**	It is unclear if the sections referred to (ie 2.4) are in the WMAA or the San Diego documents referenced by web links.	A	JM	Links to the 2015 San Diego WMAA were removed and language applicable to the section, from the 2015 SD WMAA, was added to the SMR WMAA. The 2015 San Diego WMAA was also included as an attachment.
16	**SMR WMAA/ SECTION 4**	Explain why the criteria used means that the exemptions are appropriate.	A	JM	The criteria used to determine the exemptions, consistent with the criteria used in the 2015 SD WMAA, are appropriate accounts for: (1) hydrology, (2) channel geometry, (3) bed and bank material, and (4) sediment supply. The selected approach compares long-term changes in sediment transport capacity, or in-stream work, and sediment supply at specific sections of the creek for the existing and future land use conditions.
17	**SMR WMAA/ SECTION 4**	How does the Sp discussion align with the CCSY section? It appears to be contrary to the conclusions and map area in section 2 of the WMAA. Provide a summary explanation as this WMAA should be a standalone document for the entire WMA.	A	JM	Section 4.3.2 refers the reader to Section 4.2.2 which provides an explanation how the Sp analysis was estimated to determine impacts to coarse sediment delivery. The hillslope coarse sediment supply (SYRUSLE) was estimated using the quantitative results. First, the watershed coarse sediment soil loss was estimated for all GLUs producing coarse sediment in the existing condition. Then, the future-condition coarse sediment soil loss was estimated by subtracting the developed parcel soil loss from the existing soil loss. The SMR WMAA includes data and analysis for the entire WMA.

RESPONSE TO COMMENTS MATRIX

Western Riverside Council of Governments/Riverside County Flood Control & Water Conservation District

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Submitted by: E. Ryan, San Diego Regional Water Quality Control Board					
Comment No.	**Section/Page No.**				
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18	**SMR WMAA/ SECTION 4**	Figure 4-2 - For the SMR exemption, the Stakeholder Group for the TMDL identified erosion and significant sediment discharge from the watershed (SPAWAR). In addition, erosion has been identified during storm events near the Stuart Mesa fields on Camp Pendleton (San Diego Water Board letter to Camp Pendleton). It does not appear that the cross section assessed is typical of the entire reach to the outfall or that a conclusion can be drawn that there is no issues with this reach or the estuary. Describe why this section is the critical cross section and an adequate location to conclude the river is stable for its entire reach in more detail. Are other cross sections indicative of higher flow velocities downstream?	C	JM	The District will seek consultant to clarify discussion regarding channel stability. The District will coordinate a meeting with the Regional Board to discuss scope of analysis after the submittal of the WQIP. An additional field site was added--analysis included in Section 4.3.
19	**SMR WMAA/ SECTION 4**	Explain in more detail what the definition of "protected" means with regards to 401 certifications. 401 certifications mitigate impacts and do not necessarily result in avoiding fill conditions in stream systems that are waters of the US and/or State. Describe what NHD Plus channels are and if these are waters of the US and State.	NA	JM	The State Board describes their role under the 401 and Wetlands Programs as follows: This program regulates discharges of fill and dredged material under Clean Water Act Section 401 and the Porter-Cologne Water Quality Control Act. This program protects all waters in its regulatory scope, but has special responsibility for wetlands, riparian areas, and headwaters because these waterbodies have high resource value, are vulnerable to filling, and are not systematically protected by other programs. We are involved with protection of special-status species and regulation of hydromodification impacts. The Program encourages basin-level analysis and protection, because some functions of wetlands, riparian areas, and headwater streams - including pollutant removal, flood water retention, and habitat connectivity - are expressed at the basin or landscape level. In general, channels subject to regulation under Clean Water Act Section 401 would be protected through the Regional Board's review and approval of the regulated activity and compliance with the conditions set forth in the Water Quality Certifications. The NHDPlus channels is GIS stream network developed by USGS. http://www.horizon-systems.com/nhdplus/

RESPONSE TO COMMENTS MATRIX

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20	**SMR WMAA/ SECTION 4**	Explain in more detail the driving factors for the results and statements with regard to the river reach being stable. Merely stating that an x, y z number is less than another number is not transparent and inadequate discussion to support the exemption.	C	JM	The District will seek consultant to clarify discussion regarding channel stability. The District will coordinate a meeting with the Regional Board to discuss scope of analysis after the submittal of the WQIP. Additional details regarding the analysis were added in Section 4.
21	**SMR WMAA/ SECTION 4**	Provide a substantiated numeric based explanation that the SMR exemption will not affect or impair the efforts to restore the beneficial uses to the estuary. The effects the stakeholder group are looking at are hydromodification effects, nutrients, loss of canopy, sediment, toxicity. The group has indicated that potential issues may occur from rising groundwater. Have the Copermittees discussed the analysis of this exemption with the stakeholders (ie Camp Pendleton, SCCWRP) and resolved any comments on the assumptions and conclusions? Other issues may be additional volume, fresh water input, and increased velocity. It does not appear that the analyses looked at this reach as a system that included the estuary. The appropriate technical information from the stakeholder group should be included in this assessment.	A	JM	The wet weather discussion in section 4.3.3 has been revised to provide WASP Model results from the Model Application Report. The Consultation Committee, which includes most of the members from the stakeholder group, San Diego County Co-Permittees, Riverside County Co-Permittees, San Diego Regional Water Quality Control Board, Camp Pendleton, and the Sierra Club all were given the opportunity to express their concerns about the Hydromod Exemptions included in the WMAA.
22	**SMR WMAA/ SECTION 4**	It does not make sense that upstream HMP controls would occur if this reach has exemption from HMP controls. ON what basis is this conclusion made?	A	JM	The wet weather discussion in section 4.3.3 has been revised to better explain the HMP controls.
23	**SMR WMAA/ SECTION 4**	Murrieta creek is stabilized with soil – cement (concrete) and is not “other than concrete”. Hence the on-site concrete batch plant for this project.	A	JM	Materials other than concrete used in Murrieta Creek include: riprap, turf reinforcement or vegetation.
24	**SMR WMAA/ SECTION 4**	It is unclear if the upstream area is 149 or 220 square miles.	A	JM	The following text was deleted from table in Section 4.5.2: (If the areas upstream of the lakes are included the area is 220 sq. miles).
25	**SMR WMAA/ SECTION 4**	It is not clear what the conclusion is if the channel slopes are soil cement and not turf. Is the shear stress greater?	A	JM	Yes, the shear stress for reinforcement mat, soil cement protection, or rip-rap, all of which have critical shear stress greater than or equal to 8 pounds per square foot (lb/ft2), are greater than the value needed to maintain a stable creek. A greater stream shear stress endure/sustains a stronger force.
26	**SMR WMAA/ SECTION 4**	What are the future conditions for Murrieta Creek?	A	JM	The future condition includes the completion of the Murrieta Creek Flood Control, Environmental Restoration and Recreation Project.

RESPONSE TO COMMENTS MATRIX

Western Riverside Council of Governments/Riverside County Flood Control & Water Conservation District

Draft Santa Margarita Watershed Management Area Analysis report (SMR WMAA) (Santa Margarita Watershed Management Area Co-Permittees 2018); Draft Upper Santa Margarita River Hydrologic Response Unit and Critical Coarse Sediment Yield Analysis (HRU/CCSY) (WSP 2017)

Submitted by: E. Ryan, San Diego Regional Water Quality Control Board

CODE

A = Will Incorporate
B = Disagree, not incorporated
C = Continue Resolution
N/A = Not Applicable

Comment No.	Section/Page No.		Code	By Whom	Response
27	SMR WMAA/ SECTION 4	What is a “synthetic record”?	A	JM	In this case, the synthetic record means the modeled or analytically-derived series of hydrology parameters such as flow rate and duration of flow at points or nodes in the system. Available measured parameters such as precipitation, catchment area, catchment slopes, channel conditions, etc., are used as inputs to the model or algorithm; the synthetic record is a model output.
28	SMR WMAA/ SECTION 4	What increase in impervious area is assumed? Would additional increases mean that this reach is not stable?	A	JM	The increased impervious area comes from the future landuse data. Future land use data is used to determine the erosion potential and the sediment supply potential, the calculations used to Evaluate Hydromodification Management Exemptions.
29	SMR WMAA/ SECTION 4	If there is erosion and scour potential of the existing established mitigation area downstream of the project, how is this considered a stable stream reach and a basis for an exemption of flow controls in the drainage area?	A	JM	The occurrences of erosion and scour are expected to be within the range of current conditions. It is anticipated that the larger trees would remain in place once established; however, the smaller trees and shrubs may be washed out during significant storm events. Natural recruitment is expected within areas of scour as has occurred within the Phase I area, where riparian and wetland vegetation within the channel invert has re-established after completion of construction.
30	SMR WMAA/ SECTION 4	Factors of Safety: All projects are required to implement LID in the WMA even if they are exempt from flow controls. Priority development projects must fully implement onsite retention. If the project cannot retain what is required, they must mitigate through off site compliance. Without an AC program, the projects cannot meet the permit requirements.	NA	JM	Thank you for the clarification.
31	SMR WMAA/ SECTION 4	The WQIP is using the likely, unlikely etc potential stressors. Can these reaches be assessed with this information from SCCWRP?	A	JM	The reaches were assessed using the methods described in SCCWRP Technical Report 605, 2010.
32	SMR WMAA/ SECTION 4	How is the WQE guidance used in this assessment?	A	JM	The WMAA combined with the San Diego Water Quality Equivalency guidance can be used to provide flexibility with meeting the Permit’s land development requirements.
33	HRU/CCSY	It is unclear why the national forest was left out when tribal lands were included in the WMA area analyses for the upper WMA.	A	VSS	The entire upper SMR watershed was analyzed; text revised.

RESPONSE TO COMMENTS MATRIX

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34	HRU/CCSY	Provide a summary table of the results (section 2.2.7).	A	VSS	See SMR WQIP, page 593 of 1587; Attachment G, Appendix A
35	HRU/CCSY	It is unclear how “high” RSP is determined – describe.	A	VSS	Additional text has been added to the SMR WMAA to clarify the analysis used.
36	HRU/CCSY	Where are the Qw and Qsu areas in the WMA?	A	VSS	See SMR WQIP, page 603 of 1587; Attachment G, Appendix C. In the Upper SMR Report (WSP 2017) see Appendix C.
37	HRU/CCSY	Is there a summary of the GLUs other than a map (ie by land area or jurisdiction)?	A	VSS	GLUs by map unit are provided in SMR WQIP, page 619 of 1587; Attachment G, Appendix D. GLUs by land area are provided in the SMR WQIP, page 623 of 1587; Attachment G, Appendix E. For the analysis of the Upper SMR, see Appendix D, Table D.1.
38	HRU/CCSY	How were the GLUs assessed or determined to be indicators of CCSY areas??	A	VSS	See Section 3.1.1 - Section 3.1.5 in the Upper SMR Report (WSP 2017). A GLU classified as CB, CSI or CSP were considered as areas that contribute coarse sediment. GLUs rated as CB, CSI or CSP along with a High RUSLE rating were considered as critical coarse sediment yield areas.
39	HRU/CCSY	It appears that the medium and high soil loss consist of 90 percent of the potential coarse sediment for the upper WMA. Provide an explanation how this justifies only 9% of the watershed as a CCSY area.	A	VSS	This is based on the impact of RUSLE. For example, in the northeastern part of the watershed, the R factor in RUSLE decreases going eastward. A Tech Memo, provided as an Attachment in the SMR WMAA, explains the critical coarse sediment result of 9%.
40	HRU/CCSY	The referenced appendices are not provided.	A	VSS	Appendices are provided in Attachment G of the SMR WQIP, beginning on page 593 of 1587
41	HRU/CCSY	Provide technical information regarding how WSP calibrated the CCSY exhibit	A	VSS	Will comply
42	HRU/CCSY	Provide a technical discussion on the differences of approach for calculating RUSLE in San Diego County analysis and Riverside County analysis	A	VSS	Will comply. See Tech Memo in Attachment B.
43	HRU/CCSY	Explain land use interpretations and provide information regarding the role jurisdictions played	A	VSS	Will comply
44	HRU/CCSY	Provide a second line of evidence (i.e. sand and gravel deposit maps) to correlate CCSY results	A	VSS	Will comply. See Tech Memo in Attachment B.

RESPONSE TO COMMENTS MATRIX

Western Riverside Council of Governments/Riverside County Flood Control & Water Conservation District

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Submitted by: E. Ryan, San Diego Regional Water Quality Control Board					
Comment No.	**Section/Page No.**				
			Code	**By Whom**	**Response**
45	**HRU/CCSY**	Discuss border projects and a process for projects that cross from Riverside County into San Diego County. Provide information regarding protection of CCSY and how CCSY would be avoided in protected areas or areas identified as a sand and gravel deposit to confirm if CCSY needs to be avoided (or not) as part of the development planning process.	A	VSS	Will comply. See Tech Memo in Attachment B.

Appendix 2 – Data and Analysis Summary

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October 2018

SANTA MARGARITA RIVER
WATERSHED MANAGEMENT AREA

Appendix 2: Data and Analysis Summary

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List of Acronyms

BP	San Diego Regional Basin Plan
CTR	California Toxics Rule
NTR	National Toxics Rule
SOC	Synthetic Organic Compounds
WQO	Water Quality Objectives
WMA	Watershed Management Area
VOC	Volatile Organic Compound

Table 1. Beneficial Uses by Reach – Upper Santa Margarita Watershed (Regional Water Quality Control Board, San Diego Region, 2011)

Reach			Beneficial Uses												
ID	Name	HU #	MUN	AGR	IND	PROC	GWR	REC-1	REC-2	BIOL	WARM	COLD	WILD	RARE	SPWN
1	Murrieta Creek I	2.31	1	1	1	1	--	2	1	--	1	--	1	--	--
2	Slaughterhouse Canyon	2.31	1	1	1	1	--	2	1	--	1	--	1	--	--
3	Cole Canyon	2.32	1	1	1	1	--	2	1	1	1	--	1	--	--
4	Murrieta Tributary I*	2.32	1	1	1	1	--	2	1	--	1	--	1	--	--
5	Murrieta Creek II	2.32	1	1	1	1	--	2	1	--	1	--	1	--	--
6	Murrieta Creek III	2.32	1	1	1	1	--	2	1	--	1	--	1	--	--
7	Murrieta Tributary II*	2.32	1	1	1	1	--	2	1	--	1	--	1	--	--
8	Warm Springs Canyon	2.33	1	1	1	1	--	2	1	--	1	--	1	--	--
9	French Valley I	2.33	1	1	1	1	--	2	1	--	1	--	1	--	--
10	French Valley II	2.33	1	1	1	1	--	2	1	--	1	--	1	--	--
11	Adobe Creek	2.21	1	1	1	--	--	1	1	--	1	1	1	1	1
12	Sandia Canyon Creek	2.22	1	1	1	--	--	1	1	--	1	1	1	--	--
13	Tucalota Creek I	2.41	1	1	1	1	2	1	1	--	1	--	1	--	--
14	Tucalota Creek II	2.42	1	1	1	1	2	1	1	--	1	--	1	--	--
15	Santa Gertrudis Creek	2.42	1	1	1	1	2	1	1	--	1	--	1	--	--
16	Long Canyon	2.32	1	1	1	1	--	2	1	--	1	--	1	--	--
17	Murrieta Creek IV	2.32	1	1	1	1	--	2	1	--	1	--	1	--	--
18	Empire Canyon*	2.32	1	1	1	1	--	2	1	--	1	--	1	--	--
19	Murrieta Creek V	2.32	1	1	1	1	--	2	1	--	1	--	1	--	--
20	Murrieta Creek VI	2.52	1	1	1	1	1	2	1	--	1	--	1	--	--
21	Temecula Creek I	2.81	1	1	1	1	1	1	1	--	1	1	1	--	1
22	Vail Lake	2.81	1	1	1	1	1	1	1	--	1	--	1	--	--
23	Arroyo Seco Creek	2.81	1	1	1	1	1	1	1	--	1	1	1	--	1
24	Temecula Creek II	2.51	1	1	1	1	1	2	1	--	1	--	1	--	--
25	Redhawk Channel	2.51	1	1	1	1	1	2	1	--	1	--	1	--	--
26	Temecula Creek III	2.52	1	1	1	1	1	2	1	--	1	--	1	--	--
27	Santa Margarita River	2.22	1	1	--	1	--	1	1	--	1	1	1	1	--
28	Pechanga Creek	2.52	1	1	1	1	1	2	1	--	1	--	1	--	--

(1) Existing Beneficial Use
(2) Potential Beneficial Use
*due to tributary rule

Table 2. Beneficial Uses by Reach – Lower Santa Margarita Watershed (Regional Water Quality Control Board, San Diego Region, 2011)

ID	Reach	Beneficial Use															
		MUN	AGR	IND	PROC	GWR	REC1	REC2	BIOL	WARM	COLD	WILD	RARE	SPWN	EST	MAR	MIGR
1	Santa Margarita I	1	1	1	--	--	1	1	--	1	1	1	1	--	--	--	--
2	Temecula Creek I	1	1	1	1	1	2	1	--	1	--	1	--	--	--	--	--
3	Kohler Canyon	1	1	1	1	1	2	1	--	1	1	1	--	--	--	--	--
4	Rattlesnake Creek	1	1	1	1	1	2	1	--	1	1	1	--	--	--	--	--
5	Temecula Creek II	1	1	1	1	1	2	1	--	1	--	1	--	--	--	--	--
6	Chihuahua Creek I	1	1	1	1	1	2	1	--	1	--	1	--	--	--	--	--
7	Chihuahua Creek II	1	1	1	1	1	2	1	--	1	--	1	--	--	--	--	--
8	Cooper Canyon	1	1	1	1	1	2	1	--	1	--	1	--	--	--	--	--
9	Temecula Creek III	1	1	1	1	1	2	1	--	1	--	1	--	--	--	--	--
10	Culp Valley	1	1	1	1	1	2	1	--	1	--	1	--	--	--	--	--
11	Cottonwood Creek I	1	1	1	1	1	1	1	--	1	1	1	--	1	--	--	--
12	Long Canyon	1	1	1	1	1	1	1	--	1	1	1	--	1	--	--	--
13	Arroyo Seco Creek	1	1	1	1	1	1	1	--	1	1	1	--	1	--	--	--
14	Rainbow Creek	1	1	1	--	--	1	1	--	1	1	1	--	1	--	--	--
16	Sandia Canyon	1	1	1	--	--	1	1	--	1	1	1	--	1	--	--	--
17	Santa Margarita II	1	1	1	--	--	1	1	--	1	1	1	1	--	--	--	--
18	DeLuz Creek	1	1	1	--	--	1	1	--	1	1	1	1	1	--	--	--
19	Cottonwood Creek II	1	1	1	--	--	1	1	--	1	1	1	--	--	--	--	--
20	Camps Creek	1	1	1	--	--	1	1	--	1	1	1	--	1	--	--	--
21	Fern Creek	1	1	1	--	--	1	1	--	1	1	1	--	1	--	--	--
22	Roblar Creek	1	1	1	--	--	1	1	--	1	1	1	--		--	--	--
23	Lake O'Neill	1	1	1	1	--	1	1	--	1	1	1	1	--	--	--	--
24	Santa Margarita III	1	1	1	1	--	1	1	--	1	1	1	1	--	--	--	--
25	Wood Canyon	1	1	1	1	--	1	1	--	1	--	1	--	--	--	--	--
26	Santa Margarita IV	1	1	1	1	--	1	1	--	1	1	1	1	--	--	--	--
27	Santa Margarita V	1	1	1	1	--	1	1	--	1	1	1	1	--	--	--	--
29	Newton Canyon	1	1	1	1	--	1	1	--	1	--	1	--	--	--	--	--
30	Santa Margarita Lagoon	--	--	--	--	--	1	1	--	--	--	1	1	1	1	1	1

(1) Existing Beneficial Use
(2) Potential Beneficial Use

Table 3. List of Title 22 Constituents

Inorganics	VOCs	SOCs	Secondary
Aluminum	Benzene	Alachlor	Color
Antimony	Carbon Tetrachloride	Atrazine	Foaming Agents (MBAS)
Arsenic	1,2-Dichlorobenzene	Bentazon	Iron
Asbestos	1,4-Dichlorobenzene	Benzo(a)pyrene	Manganese
Barium	1,1-Dichloroethane	Carbofuran	Odor
Beryllium	1,2-Dichloroethane	Chlordane	Silver
Cadmium	1,1-Dichloroethylene	Dalapon	Thiobencarb
Chromium	Cis-1,2-Dichlorethylene	Dibromochloropropane	Turbidity
Copper	Trans-1,2-Dichloroethylene	Bis(2-ethylhexyl)adipate	Zinc
Cyanide	Dichloromethane	Bis(2-ethylhexyl)phthalate	Total Dissolved Solids
Fluoride	1,3-Dichloropropene	2,4-D	Chloride
Hexavalent Chromium	1,2-Dichloropropane	Dinoseb	Sulfate
Lead	Ethylbenzene	Diquat	
Mercury	Methyl-tert-butyl ether (MTBE)	Endothall	
Nickel	Monochlorobenzene	Endrin	
Nitrate	Styrene	Ethylene Dibromide	
Perchlorate	1,1,2,2-Tetrachloroethane	Glyphosate	
Selenium	Tetrachloroethylene	Heptachlor	
Thallium	Toluene	Heptachlor Epoxide	
	1,2,4 Trichlorobenzene	Hexachlorobenzene	
	1,1,1-Trichloroethane	Hexachlorocyclopentadiene	
	1,1,2-Trichloroethane	Lindane	
	Trichloroethylene	Methoxychlor	
	Trichlorofluoromethane	Molinate	
	1,1,2-Trichloro-1,2,2-Trifluoroethane	Oxamyl	
	Vinyl chloride	Pentachlorophenol	
	Xylenes	Picloram	
		PCBs	
		Simazine	
		Thiobencarb	
		Toxaphene	
		2,3,7,8-TCDD (Dioxin)	
		2,4,5-TP (Silvex)	
		Total Trihalomethanes	

Table 4. Applicable Water Quality Objectives

Constituent	Units	Applicable WQO Wet	Source
% Sodium	%	60	BP
1,1-Dichloroethane	µg/L	5	BP
1,1-Dichloroethylene	µg/L	0.057	NTR
1,1,1-Trichloroethane	µg/L	200	BP
1,1,2-trichloro-1,2,2-trifluoroethane	µg/L	1200	BP
1,1,2-Trichloroethane	µg/L	0.6	NTR
1,1,2,2-Tetrachloroethane	µg/L	0.17	NTR
1,2-Dichlorobenzene	µg/L	600	BP
1,2-Dichloroethane	µg/L	0.38	NTR
1,2-Dichloropropane	µg/L	0.52	CTR
1,2-Diphenylhydrazine	µg/L	0.04	NTR
1,2-Trans-Dichloroethylene	µg/L	10	BP
1,2,4-Trichlorobenzene	µg/L	5	BP
1,3-Dichlorobenzene	µg/L	400	CTR
1,3-Dichloropropene	µg/L	0.5	BP
1,3-Dichloropropylene	µg/L	10	NTR
1,4-Dichlorobenzene	µg/L	5	BP
2-Chloronaphthalene	µg/L	1700	CTR
2-Chlorophenol	µg/L	120	CTR
2-Methyl- 4,6-Dinitrophenol	µg/L	13.4	NTR
2,3,7,8-Tetrachloro-dibenzo-p-dioxin (TCDD, Dioxin)	µg/L	0.000000013	CTR
2,4-D	µg/L	70	BP
2,4-Dichlorophenol	µg/L	93	NTR
2,4-Dimethylphenol	µg/L	540	CTR
2,4-Dinitrophenol	µg/L	70	NTR
2,4-Dinitrotoluene	µg/L	0.11	NTR
2,4,5-TP	µg/L	50	BP
2,4,6-Trichlorophenol	µg/L	2.1	CTR
3,3 Dichlorobenzidine	µg/L	0.04	NTR
4,4'-DDD	µg/L	0.00083	CTR
4,4'-DDE	µg/L	0.00059	CTR
4,4'-DDT	µg/L	1.1	CTR
Acenaphthene	µg/L	1200	CTR

Constituent	Units	Applicable WQO Wet	Source
Acrolein	µg/L	320	NTR
Acrylonitrile	µg/L	0.059	NTR[1]
alachlor	µg/L	2	BP[2]
Aldrin	µg/L	3	CTR[3]
alpha-BHC	µg/L	0.0039	CTR
alpha-Endosulfan	µg/L	0.22	CTR
Aluminum	mg/L	0.2	BP
Anthracene	µg/L	9600	CTR
Antimony	µg/L	6	BP
Arsenic, Dissolved	µg/L	340	CTR
Arsenic, Total	µg/L	50	BP
Asbestos	fibers/L	7000000	NTR
atrazine	µg/L	1	BP
Barium	mg/L	1	BP
bentazon	µg/L	18	BP
Benzene	µg/L	1	BP
Benzidine	µg/L	0.00012	NTR
Benzo(a)Anthracene	µg/L	0.0044	CTR
Benzo(a)Pyrene	µg/L	0.0044	CTR
Benzo(b)Fluoranthene	µg/L	0.0044	CTR
Benzo(k)Fluoranthene	µg/L	0.0044	CTR
Beryllium, Dissolved	µg/L	4	BP
beta-BHC	µg/L	0.014	CTR
beta-Endolsulfan	µg/L	0.22	CTR
Bis(2-Chloroethyl)Ether	µg/L	0.031	NTR
Bis(2-Chloroisopropyl)Ether	µg/L	1400	NTR/CTR
Bis(2-Ethylhexyl)Phthalate	µg/L	1.8	NTR
Boron	mg/L	0.75	BP
Bromoform	µg/L	4.3	CTR
Butylbenzyl Phthalate	µg/L	3000	CTR
Cadmium, Total	µg/L	5	BP
Cadmium, Dissolved	µg/L	10.19	CTR
carbofuran	µg/L	18	BP
Carbon Tetrachloride	µg/L	0.25	NTR
Chlordane	µg/L	2.4	CTR

Constituent	Units	Applicable WQO Wet	Source
Chloride	mg/L	*c [250, 300]*	BP
Chlorobenzene	µg/L	70	BP
Chlorodibromomethane	µg/L	0.401	CTR
Chlorpyrifos	µg/L	0.083	EPA
Chromium (III), Dissolved	µg/L	*a*	CTR
Chromium (VI), Dissolved	µg/L	16.00	CTR
Chromium (VI), Total	µg/L	2	BP
Chromium, Total	µg/L	50	BP
Chrysene	µg/L	0.0044	CTR
cis-1,2-Dichloroethylene	µg/L	6	BP
Color	Units	20	BP
Copper, Dissolved	µg/L	*a*	CTR
Copper, Total	µg/L	1000	BP
Cyanide	µg/L	22	NTR
Dalapon	µg/L	200	BP
Di-n-Butyl Phthalate	µg/L	2700	NTR
Di(2-ethylhexyl)adipate	µg/L	400	BP
Diazinon	µg/L	0.17	EPA
Dibenzo(a,h)Anthracene	µg/L	0.0044	CTR
Dibromochloropropane	µg/L	0.2	BP
Dichlorobromomethane	µg/L	0.56	CTR
Dieldrin	µg/L	0.24	CTR
Diethyl Phthalate	µg/L	23000	NTR
Dimethyl Phthalate	µg/L	313000	NTR
Dinoseb	µg/L	7	BP
Diquat	µg/L	20	BP
Dissolved Oxygen	mg/L	*c [5.0, 6.0]*	BP
E. Coli	MPN/100 mL	126	BP
Endosulfan Sulfate	µg/L	110	CTR
Endothall	µg/L	100	BP
Endrin	µg/L	0.086	CTR
Endrin Aldehyde	µg/L	0.76	CTR
Enterococcus	MPN/100 mL	33	BP
Ethlyene Dibromide	µg/L	0.05	BP

Constituent	Units	Applicable WQO Wet	Source
Ethylbenzene	µg/L	300	BP
Fecal Coliform	MPN/100 mL	400	BP
Fluoranthene	µg/L	300	CTR
Fluorene	µg/L	1300	CTR
Fluoride	mg/L	1	BP
gamma-BHC	µg/L	0.95	CTR
Glyphosate	µg/L	700	BP
Heptachlor	µg/L	0.52	CTR
Heptachlor Epoxide	µg/L	0.52	CTR
Hexachlorobenzene	µg/L	0.00075	CTR
Hexachlorobutadiene	µg/L	0.44	NTR
Hexachlorocyclopentadiene	µg/L	50	BP
Hexachloroethane	µg/L	1.9	NTR
Indeno(1,2,3-cd)Pyrene	µg/L	0.0044	CTR
Iron, Total	mg/L	0.3	BP
Isophorone	µg/L	8.4	NTR
Lead, Dissolved	µg/L	*a*	CTR
Manganese	mg/L	0.05	BP
MBAS	mg/L	0.5	BP
Mercury, Total	µg/L	0.05	CTR
Methly-tert-butyl ether	µg/L	5	BP
Methoxychlor	µg/L	30	BP
Methyl Bromide	µg/L	48	CTR
Methylene Chloride	µg/L	4.7	CTR
Molinate	µg/L	20	BP
N-Nitrosodi-n-Propylamine	µg/L	0.005	CTR
N-Nitrosodimethylamine	µg/L	0.00069	NTR
N-Nitrosodiphenylamine	µg/L	5	NTR
Nickel, Dissolved	µg/L	*a*	CTR
Nickel, Total	µg/L	100	BP
Nitrate as N	mg/L	10	BP
Nitrite as N	mg/L	1	BP
Nitrobenzene	µg/L	17	NTR
Oxamyl	µg/L	50	BP

Constituent	Units	Applicable WQO Wet	Source
Pentachlorophenol	µg/L	*b*	CTR
Perchlorate	µg/L	6	BP
pH		6.5-8.5	BP
Phenol	µg/L	1	NTR/CTR
Picloram	µg/L	500	BP
Polychlorinated biphenyls	µg/L	0.00017	CTR
Pyrene	µg/L	960	CTR
Selenium, Total	µg/L	5.0	CTR
Silver, Dissolved	µg/L	*a*	CTR
Silver, Total	µg/L	100	BP
Simazine	µg/L	4	BP
Styrene	µg/L	100	BP
Sulfate	mg/L	*c [500, 750]*	BP
TDS	mg/L	*c [250, 300]*	BP
Tetrachloroethylene	µg/L	0.8	NTR
Thallium, Total	µg/L	2	BP
Thiobencarb	µg/L	1	BP
Toluene	µg/L	150	BP
Total Coliform	MPN/100 mL	10000	BP
Total Nitrogen	mg/L	1	BP
Total Phosphorus	mg/L	0.1	BP
Toxaphene	µg/L	0.73	CTR
Trichloroethylene	µg/L	2.7	NTR
Trichlorofluoromethane	µg/L	150	BP
Turbidity	NTU	20	BP
Unionized Ammonia as N	mg/L	0.025	BP
Vinyl Chloride	µg/L	0.5	BP
Xylene	µg/L	1750	BP
Zinc, Dissolved	µg/L	*a*	CTR
Zinc, Total	µg/L	5000	BP

[1] National Toxics Rule
[2] San Diego Regional Basin Plan
[3] California Toxics Rule

a Hardness based objective
b pH based objective
c Reach specific objective, values in brackets show possible objectives.

Table 5. Summary of Receiving Water Dry Weather Trend Analysis

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	3-Hydroxycarbofuran	0	13	0.00	Stable
	Acenaphthene	-50	35	0.96	Improving
	Aldicarb Sulfone	0	13	0.00	Stable
	Aldicarb Sulfoxide	3	13	0.28	No trend
	Ammonia as N	-2	52	0.31	Stable
	Antimony, Total	-7	13	0.40	Stable
	Arsenic, Dissolved	16	30	0.17	No trend
	Arsenic, Total	26	34	0.29	No trend
	Atrazine	-28	26	0.37	Improving
	Bifenthrin	25	35	0.91	No trend
	Biochemical Oxygen Demand (BOD)	3	13	0.40	No trend
	bis(2-ethylhexyl)phthalate	0	10	0.00	Stable
	Bromodichloromethane	0	1	0.00	Stable
	Bromoform	0	1	0.00	Stable
	Cadmium, Dissolved	0	20	0.38	Stable
	Cadmium, Total	-21	37	0.26	Stable
De Luz Creek	Calcium, Total	6	44	0.08	No trend
	Carbaryl	0	13	0.00	Stable
	Carbofuran	0	13	0.00	Stable
	Chemical Oxygen Demand	-9	13	0.44	Stable
	chloroform	0	1	0.00	Stable
	Chlorpyrifos	61	66	0.50	Probably declining
	Chromium, Total	-91	71	0.96	Improving
	Chromium, Hexavalent, Dissolved	-6	13	1.31	No trend
	Chromium, Hexavalent, Total	-34	27	1.35	Improving
	Chrysene	-50	35	0.96	Improving
	Color	3	10	0.56	No trend
	Copper, Dissolved	3	29	0.23	No trend
	Copper, Total	35	75	0.60	No trend
	Cyfluthrin	49	35	0.72	Declining
	Cyhalothrin-lambda	15	24	1.00	No trend
	Cypermethrin	61	35	0.70	Declining
De Luz Creek	Danitol	22	30	0.92	No trend

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Deltamethrin	49	35	0.73	Declining
	Diazinon	59	66	0.50	Probably declining
	Dibromochloromethane	0	1	0.00	Stable
	Dichlofenthion	-28	26	0.37	Improving
	Discharge	19	66	1.10	No trend
	Dissolved Organic Carbon	8	13	0.68	No trend
	Dissolved Oxygen	-83	76	0.47	Improving
	E. coli	-18	71	1.67	No trend
	Enterococcus	-4	13	0.91	Stable
	Esfenvalerate	23	21	0.71	Declining
	Event	0	1	0.00	Stable
	Fecal Coliform	-21	71	1.65	No trend
	Fenvalerate	23	21	0.71	Declining
	Flow	5	13	0.69	No trend
	Fluoranthene	-50	35	0.96	Improving
	Fluorene	-50	35	0.96	Improving
	Fluvalinate	0	15	0.00	Stable
	Iron, Dissolved	18	23	0.44	No trend
	Iron, Total	14	41	1.00	No trend
	Lead, Dissolved	-2	20	0.28	Stable
	Lead, Total	-39	50	0.38	Stable
	Magnesium, Total	1	42	0.07	No trend
	Malathion	-15	48	0.39	Stable
	Manganese, Dissolved	10	26	1.56	No trend
	Manganese, Total	16	37	1.07	No trend
	Mercury, Dissolved	1	13	0.05	No trend
	Mercury, Total	0	15	0.00	Stable
	Methylene Blue Active Substance (MBAS)	61	55	0.61	Declining
	Methylene chloride	13	20	0.23	No trend
	Nickel, Dissolved	-18	30	0.35	Stable
	Nickel, Total	-2	74	0.71	Stable
	Nitrate as N	-23	80	2.05	No trend
	Nitrite as N	-9	27	0.60	Stable
De Luz Creek	Nitrogen, Total as N	-23	23	1.42	Probably improving

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Oil & Grease	-19	23	0.33	Stable
	Oxygen Saturation	6	10	0.41	No trend
	Permethrin	3	25	0.77	No trend
	pH, Field	-85	95	0.08	Probably improving
	pH, Lab	34	36	0.02	Probably declining
	Phenols, Field	6	10	1.08	No trend
	Phosphorus, Total as P, Field	5	74	1.29	No trend
	Pyrene, Field	-50	35	0.96	Improving
	Redox Potential, Field	3	13	0.60	No trend
	Selenium, Field	-6	30	0.58	Stable
	Silver, Field	20	20	0.47	Probably declining
	Simazine, Field	-28	26	0.37	Improving
	Specific Conductivity, Field	-85	101	0.27	Probably improving
	Sulfate, Field	-9	20	0.32	Stable
	Temperature, Field	-119	96	0.14	Improving
	Terbufos, Field	-28	26	0.37	Improving
	Thallium, Field	20	20	0.47	Probably declining
	Total Coliform, Field	1	45	0.84	No trend
	Total Dissolved Phosphorus, Field	8	13	0.78	No trend
	Total Dissolved Solids, Field	1	36	0.30	No trend
	Total Hardness, Field	-16	66	0.06	Stable
	Total Kjeldahl Nitrogen, Field	8	76	0.50	No trend
	Total Organic Carbon, Field	10	13	0.69	No trend
	Total Suspended Solids, Field	38	66	0.81	No trend
	Toxicity, Acute Ceriodaphnia (Survival), Field	9	13	1.10	No trend
	Toxicity, Acute Fathead Minnow (Survival), Field	5	13	0.97	No trend
	Toxicity, Acute Hyallela Azteca (Survival), Field	-5	39	0.69	Stable
De Luz Creek	Toxicity, Chronic Hyalella Azteca (Grow), Field	0	13	0.00	Stable

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Toxicity, Chronic Hyalella Azteca (Survival), Field	0	13	0.00	Stable
	Toxicity, Chronic Pimephales(Fathead Minnow) (Survival), Field	0	10	0.00	Stable
	Toxicity, Chronic Pimephales(Fathead Minnow) (Grow), Field	0	10	0.00	Stable
	Toxicity, Chronic PseudoSubcapitata Selenastrum Algae(Grow), Field	0	13	0.00	Stable
	Turbidity, Field	15	76	3.35	No trend
	Zinc, Dissolved	-10	29	0.92	Stable
	Zinc, Total	71	74	2.00	Probably declining
Murrieta and Long Canyon Creek	3-Hydroxycarbofuran	0	13	0.00	Stable
	Acenaphthene	-55	39	0.90	Improving
	Aldicarb Sulfone	0	13	0.00	Stable
	Aldicarb Sulfoxide	0	13	0.00	Stable
	Alkalinity as CaCO3	121	116	0.25	Declining
	Ammonia as N	-211	202	2.16	Improving
	Antimony, Total	7	13	0.21	No trend
	Arsenic, Dissolved	-8	30	0.26	Stable
	Arsenic, Total	-186	182	0.51	Improving
	Atrazine	-28	26	0.37	Improving
	Barium, Total	137	127	0.33	Declining
	Bicarbonate	164	122	0.24	Declining
	Bifenthrin	3	35	0.93	No trend
	Biochemical Oxygen Demand (BOD)	-16	140	1.01	No trend
	bis(2-ethylhexyl)phthalate	0	10	0.00	Stable
	Boron, Total	-15	126	0.46	Stable
	Bromodichloromethane	-1	26	0.87	Stable
	Bromoform	-2	31	2.23	No trend
	Cadmium, Dissolved	-1	20	0.36	Stable
	Cadmium, Total	-831	238	1.32	Improving
	Calcium, Total	97	222	0.24	No trend
	Carbaryl	0	13	0.00	Stable

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Carbofuran	-3	13	0.34	Stable
	Carbon Trioxide	-61	60	1.30	Improving
	Chemical Oxygen Demand	-89	151	0.80	Stable
	Chloride	39	121	0.32	No trend
	chloroform	-1	26	0.49	Stable
	Chlorpyrifos	407	174	1.13	Declining
	Chromium, Total	-777	229	0.70	Improving
	Chromium, Hexavalent, Dissolved	-9	13	1.08	No trend
	Chromium, Hexavalent, Total	-40	26	1.11	Improving
	Chrysene	-55	39	0.90	Improving
	Color	29	144	0.81	No trend
	Copper, Dissolved	-15	30	0.44	Stable
	Copper, Total	-763	242	0.43	Improving
	Cyfluthrin	53	35	0.75	Declining
	Cyhalothrin-lambda	7	24	1.05	No trend
	Cypermethrin	53	35	0.75	Declining
	Danitol	24	35	1.00	No trend
	Deltamethrin	53	35	0.75	Declining
	Diazinon	411	174	1.09	Declining
	Dibromochloromethane	1	26	1.33	No trend
	Dichlofenthion	-28	26	0.37	Improving
	Discharge	-740	370	2.12	Improving
	Dissolved Organic Carbon	10	13	0.66	No trend
	Dissolved Oxygen	-168	286	0.44	Stable
	E. coli	-29	70	2.05	No trend
	Electrochemical Balance	-71	111	-3.51	Stable
	Enterococcus	1	13	1.06	No trend
	Esfenvalerate	23	21	0.71	Declining
	Event	89	116	6.00	No trend
	Fecal Coliform	-24	70	1.89	No trend
	Fenvalerate	23	21	0.71	Declining
Murrieta and Long Canyon Creek	Flourine	-95	108	0.37	Probably improving
	Flow	-30	86	0.44	Stable
	Fluoranthene	-55	39	0.90	Improving

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Fluorene	-55	39	0.90	Improving
	Fluvalinate	-3	18	0.29	Stable
	Iron, Dissolved	-1	23	2.54	No trend
	Iron, Total	41	37	1.86	Declining
	Lead, Dissolved	-2	20	0.40	Stable
	Lead, Total	-742	232	0.79	Improving
	Level	9	18	1.02	No trend
	Magnesium, Total	332	215	0.28	Declining
	Malathion	-27	42	0.38	Stable
	Manganese, Dissolved	-3	27	1.10	No trend
	Manganese, Total	27	34	1.93	No trend
	Mercury, Dissolved	0	13	0.00	Stable
	Mercury, Total	-301	121	0.40	Improving
	Methylene Blue Active Substance (MBAS)	-164	249	0.91	Stable
	Methylene chloride	-13	20	0.07	Stable
	Nickel, Dissolved	-26	30	0.42	Probably improving
	Nickel, Total	-793	237	0.63	Improving
	Nitrate as N	-520	253	1.53	Improving
	Nitrite as N	-142	117	0.34	Improving
	Nitrogen, Total as N	-306	176	0.91	Improving
	Odor	11	50	1.78	No trend
	Oil & Grease	-10	168	0.47	Stable
	Organic Nitrogen	-94	127	0.64	Stable
	Permethrin	-7	26	0.82	Stable
	pH, Field	-147	356	0.08	Stable
	pH, Lab	-28	201	0.04	Stable
	Phenols, Field	-165	94	0.74	Improving
	Phosphorus, Total as P, Field	-351	256	2.22	Improving
	Potassium, Field	64	114	0.35	No trend
	Pyrene, Field	-55	39	0.90	Improving
	Redox Potential, Field	1	27	1.47	No trend
Murrieta and Long Canyon Creek	Salinity, Field	9	33	0.47	No trend
	Selenium, Field	212	187	1.84	Declining
	Silver, Field	205	148	1.43	Declining

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Simazine, Field	-28	26	0.37	Improving
	Sodium, Field	69	116	0.31	No trend
	Specific Conductivity, Field	-151	372	0.31	Stable
	Sulfate, Field	-66	163	0.37	Stable
	Temperature, Field	-122	364	0.56	Stable
	Temperature, Air, Field	20	49	0.13	No trend
	Terbufos, Field	-28	26	0.37	Improving
	Thallium, Field	19	23	0.47	No trend
	Total Anions, Field	40	111	0.31	No trend
	Total Cations, Field	85	117	0.23	No trend
	Total Coliform, Field	-17	45	0.78	Stable
	Total Dissolved Phosphorus, Field	-67	151	1.09	No trend
	Total Dissolved Solids, Field	-79	250	0.26	Stable
	Total Hardness, Field	200	278	0.23	No trend
	Total Inorganic Phosphorus, Field	-8	110	3.20	No trend
	Total Kjeldahl Nitrogen, Field	-206	264	0.69	Stable
	Total Organic Carbon, Field	5	151	0.77	No trend
	Total Petroleum Hydrocarbons, Field	10	77	0.35	No trend
	Total Solids, Field	79	117	0.23	No trend
	Total Suspended Solids, Field	-34	239	1.99	No trend
	Toxicity, Acute Ceriodaphnia (Survival), Field	11	13	1.10	Probably declining
	Toxicity, Acute Fathead Minnow (Survival), Field	6	10	1.33	No trend
	Toxicity, Acute Hyallela Azteca (Survival), Field	-7	39	0.53	Stable
	Toxicity, Chronic Hyalella Azteca (Grow), Field	0	13	0.00	Stable
	Toxicity, Chronic Hyalella Azteca (Survival), Field	0	13	0.00	Stable
Murrieta and Long Canyon Creek	Toxicity, Chronic PseudoSubcapitata Selenastrum Algae (Grow), Field	0	13	0.00	Stable
	Turbidity, Field	-146	372	2.76	No trend
	Zinc, Dissolved	-18	30	0.54	Stable

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Zinc, Total	-628	258	1.20	Improving
Santa Gertrudis Creek	Discharge	-19	57	3.92	No trend
	Dissolved Oxygen	-7	13	0.34	Stable
	Event	0	1	0.00	Stable
	Flow	-6	15	0.94	Stable
	pH, Field	1	15	0.07	No trend
	Redox Potential, Field	-4	10	0.77	Stable
	Specific Conductivity, Field	7	15	0.21	No trend
	Temperature, Field	-1	13	0.07	Stable
	Total Dissolved Solids, Field	2	10	0.22	No trend
	Turbidity, Field	-3	13	0.86	Stable
Temecula Creek and Redhawk Channel	3-Hydroxycarbofuran	0	20	0.00	Stable
	Acenaphthene	-80	50	0.97	Improving
	Aldicarb Sulfone	0	20	0.00	Stable
	Aldicarb Sulfoxide	0	20	0.00	Stable
	Alkalinity as CaCO3	-106	85	0.23	Improving
	Ammonia as N	-414	313	0.92	Improving
	Antimony, Dissolved	-2	15	0.69	Stable
	Antimony, Total	-62	42	1.02	Improving
	Arsenic, Dissolved	-26	53	0.78	Stable
	Arsenic, Total	-365	181	1.49	Improving
	Atrazine	-32	29	0.34	Improving
	Barium, Total	94	95	2.86	Probably declining
	Beryllium, Dissolved	0	15	0.00	Stable
	Beryllium, Total	-49	32	0.94	Improving
	Bicarbonate	-108	85	0.25	Improving
	Bifenthrin	12	60	4.44	No trend
	Biochemical Oxygen Demand (BOD)	93	132	0.98	No trend
	bis(2-ethylhexyl)phthalate	0	10	0.00	Stable
	Boron, Total	50	95	0.44	No trend
	Bromodichloromethane	0	1	0.00	Stable
	Bromoform	0	1	0.00	Stable
	Cadmium, Dissolved	35	61	0.44	No trend
	Cadmium, Total	-932	276	1.62	Improving

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Calcium, Total	179	271	0.44	No trend
	Carbaryl	0	20	0.00	Stable
	Carbofuran	0	20	0.00	Stable
	Carbon Trioxide	5	41	1.99	No trend
	Chemical Oxygen Demand	-36	139	0.79	Stable
	Chloride	103	85	0.35	Declining
	chloroform	0	1	0.00	Stable
	Chlorpyrifos	689	253	0.94	Declining
	Chromium, Total	-865	252	4.69	Improving
	Chromium, Hexavalent, Dissolved	-28	22	2.79	Improving
	Chromium, Hexavalent, Total	-44	28	1.02	Improving
	Chromium, Trivalent, Dissolved	-15	15	1.92	Probably improving
	Chrysene	-80	50	0.97	Improving
	Color	105	182	0.78	No trend
	Copper, Dissolved	-141	101	0.80	Improving
	Copper, Total	-466	343	3.34	Improving
	Cyfluthrin	100	58	4.23	Declining
	Cyhalothrin-lambda	41	35	3.74	Declining
	Cypermethrin	100	58	4.23	Declining
	Danitol	48	57	4.27	Probably declining
	Deltamethrin	100	58	4.23	Declining
	Diazinon	546	253	0.83	Declining
	Dibromochloromethane	0	1	0.00	Stable
	Dichlofenthion	-32	29	0.34	Improving
	Discharge	-162	286	1.51	No trend
	Dissolved Organic Carbon	9	23	0.33	No trend
	Dissolved Oxygen	-90	294	0.46	Stable
	E. coli	-212	169	3.32	Improving
	Electrochemical Balance	-27	80	5.49	No trend
Temecula Creek and Redhawk Channel	Enterococcus	-6	23	1.96	No trend
	Esfenvalerate	45	38	3.76	Declining
	Esfenvalerate:Fenvalerate	0	10	0.00	Stable
	Event	0	1	0.00	Stable
	Fecal Coliform	-242	169	2.91	Improving

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Fenvalerate	45	38	3.76	Declining
	Flourine	59	79	0.42	No trend
	Flow	-24	35	0.61	Stable
	Fluoranthene	-80	50	0.97	Improving
	Fluorene	-80	50	0.97	Improving
	Fluvalinate	1	13	3.13	No trend
	Iron, Dissolved	-29	44	0.49	Stable
	Iron, Total	-71	117	1.28	No trend
	Lead, Dissolved	-29	70	1.91	No trend
	Lead, Total	-877	270	3.48	Improving
	Level	5	10	1.63	No trend
	Magnesium, Total	210	271	0.54	No trend
	Malathion	-21	54	0.33	Stable
	Manganese, Dissolved	-45	53	1.28	Probably improving
	Manganese, Total	-56	106	1.03	No trend
	Mercury, Dissolved	0	20	0.00	Stable
	Mercury, Total	-326	127	0.80	Improving
	Methylene Blue Active Substance (MBAS)	-361	341	2.65	Improving
	Methylene chloride	13	20	0.21	No trend
	Nickel, Dissolved	-60	53	0.42	Improving
	Nickel, Total	-839	252	2.99	Improving
	Nitrate as N	-366	355	0.75	Improving
	Nitrite as N	-114	171	0.71	Stable
	Nitrogen, Total as N	-193	229	0.66	Probably improving
	Odor	13	57	3.69	No trend
	Oil & Grease	-36	230	0.52	Stable
	Organic Nitrogen	53	95	0.89	No trend
	Permethrin	-10	42	3.97	No trend
Temecula Creek and Redhawk Channel	Permethrin, cis-	0	10	0.00	Stable
	Permethrin, trans-	0	10	0.00	Stable
	pH, Field	103	364	0.10	No trend
	pH, Lab	37	228	0.07	No trend
	Phenols, Field	-148	82	0.67	Improving
	Phosphorus, Total as P, Field	-735	348	1.11	Improving

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Potassium, Field	132	85	1.13	Declining
	Pyrene, Field	-80	50	0.97	Improving
	Redox Potential, Field	-27	27	0.65	Probably improving
	Salinity, Field	14	20	0.23	No trend
	Selenium, Field	263	174	1.57	Declining
	Silver, Field	291	154	1.17	Declining
	Simazine, Field	-32	29	0.34	Improving
	Sodium, Field	102	85	0.26	Declining
	Specific Conductivity, Field	860	380	7.68	Declining
	Sulfate, Field	55	151	0.25	No trend
	Temperature, Field	-266	364	0.59	Stable
	Temperature, Air, Field	-20	34	0.15	Stable
	Terbufos, Field	-32	29	0.34	Improving
	Thallium, Field	123	78	0.52	Declining
	Total Anions, Field	8	81	0.28	No trend
	Total Cations, Field	56	85	0.16	No trend
	Total Coliform, Field	-216	111	1.99	Improving
	Total Dissolved Phosphorus, Field	-160	139	0.75	Improving
	Total Dissolved Solids, Field	299	279	0.64	Declining
	Total Hardness, Field	478	355	0.43	Declining
	Total Inorganic Phosphorus, Field	2	85	2.50	No trend
	Total Kjeldahl Nitrogen, Field	-339	347	0.90	Probably improving
	Total Organic Carbon, Field	24	139	1.02	No trend
	Total Petroleum Hydrocarbons, Field	3	50	0.09	No trend
	Total Solids, Field	26	85	1.47	No trend
	Total Suspended Solids, Field	-403	250	5.88	Improving
Temecula Creek and Redhawk Channel	Toxicity, Acute Ceriodaphnia (Survival), Field	19	18	0.83	Declining
	Toxicity, Acute Fathead Minnow (Survival), Field	8	18	0.54	No trend
	Toxicity, Acute Hyallela Azteca (Survival), Field	-5	44	0.49	Stable
	Toxicity, Chronic Hyalella Azteca (Grow), Field	0	15	0.00	Stable

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Toxicity, Chronic Hyalella Azteca (Survival), Field	0	18	0.00	Stable
	Toxicity, Chronic Pimephales(Fathead Minnow) (Survival), Field	0	15	0.00	Stable
	Toxicity, Chronic Pimephales(Fathead Minnow) (Grow), Field	0	15	0.00	Stable
	Toxicity, Chronic PseudoSubcapitata Selenastrum Algae (Grow), Field	0	18	0.00	Stable
	Turbidity, Field	-580	372	5.71	Improving
	Unionized Ammonia as N	-108	355	3.01	No trend
	Zinc, Dissolved	9	53	0.84	No trend
	Zinc, Total	-522	263	4.86	Improving
Upper Murrieta Creek and Tributaries	Alkalinity as CaCO3	56	80	0.22	No trend
	Ammonia as N	7	49	0.51	No trend
	Arsenic, Total	-122	70	0.39	Improving
	Barium, Total	-44	80	0.35	Stable
	Bicarbonate	63	80	0.23	No trend
	Biochemical Oxygen Demand (BOD)	-42	52	0.62	Stable
	Boron, Total	43	76	0.25	No trend
	Cadmium, Total	-112	62	0.98	Improving
	Calcium, Total	52	84	0.28	No trend
	Carbon Trioxide	-21	57	1.64	No trend
	Chemical Oxygen Demand	-34	80	0.46	Stable
	Chloride	67	88	0.24	No trend
	Chlorpyrifos	12	45	0.67	No trend
	Chromium, Total	-24	30	0.21	Stable
	Color	25	78	0.32	No trend
Upper Murrieta Creek and Tributaries	Copper, Total	-46	50	0.33	Probably improving
	Diazinon	-25	45	2.11	No trend
	Discharge	21	124	1.54	No trend
	Dissolved Oxygen	36	49	0.31	No trend
	Electrochemical Balance	-83	76	-2.45	Improving
	Event	0	1	0.00	Stable

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Flourine	-74	66	0.19	Improving
	Flow	-17	26	0.17	Stable
	Lead, Total	-24	30	0.21	Stable
	Level	4	10	0.95	No trend
	Magnesium, Total	95	85	0.21	Declining
	Mercury, Total	-63	46	0.30	Improving
	Methylene Blue Active Substance (MBAS)	-38	79	0.62	Stable
	Nickel, Total	-49	42	0.28	Improving
	Nitrate as N	-13	62	4.54	No trend
	Nitrite as N	-24	30	0.17	Stable
	Nitrogen, Total as N	-31	85	1.08	No trend
	Odor	2	47	2.27	No trend
	Oil & Grease	79	67	0.36	Declining
	Organic Nitrogen	-3	79	0.59	Stable
	pH, Field	-17	75	0.05	Stable
	pH, Lab	54	79	0.03	No trend
	Phenols, Field	-15	29	0.38	Stable
	Phosphorus, Total as P, Field	-25	80	0.53	Stable
	Potassium, Field	26	78	0.34	No trend
	Salinity, Field	1	20	0.24	No trend
	Selenium, Field	-11	78	0.58	Stable
	Silver, Field	0	1	0.00	Stable
	Sodium, Field	140	77	0.15	Declining
	Specific Conductivity, Field	108	85	0.20	Declining
	Sulfate, Field	156	79	0.24	Declining
	Temperature, Field	10	81	0.70	No trend
	Temperature, Air, Field	-5	23	0.15	Stable
Upper Murrieta Creek and Tributaries	Total Anions, Field	80	76	0.29	Declining
	Total Cations, Field	113	80	0.18	Declining
	Total Dissolved Phosphorus, Field	0	80	0.58	Stable
	Total Dissolved Solids, Field	128	80	0.17	Declining
	Total Hardness, Field	94	80	0.21	Declining
	Total Inorganic Phosphorus, Field	-58	57	0.93	Improving

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Total Kjeldahl Nitrogen, Field	28	80	0.50	No trend
	Total Organic Carbon, Field	100	80	0.91	Declining
	Total Petroleum Hydrocarbons, Field	-9	39	0.20	Stable
	Total Solids, Field	56	80	0.26	No trend
	Total Suspended Solids, Field	-20	70	1.44	No trend
	Turbidity, Field	29	80	1.21	No trend
	Zinc, Total	-15	62	1.30	No trend
Upper Santa Margarita River	4,4'-DDE	-18	20	2.74	Probably improving
	4,4'-DDT	-18	20	1.63	Probably improving
	Alkalinity as CaCO3	65	66	0.19	Probably declining
	Aluminum, Total	-9	13	1.34	No trend
	Ammonia as N	-63	168	1.17	No trend
	Antimony, Total	1	13	1.62	No trend
	Arsenic, Dissolved	11	13	0.15	Probably declining
	Arsenic, Total	-169	100	0.63	Improving
	Atrazine	-18	20	1.50	Probably improving
	Barium, Total	29	52	0.25	No trend
	Beryllium, Total	0	13	0.00	Stable
	Bicarbonate	15	57	0.22	No trend
	Bicarbonate Alkalinity as CaCO3	9	15	0.13	No trend
	Bifenthrin	25	21	1.30	Declining
	Biochemical Oxygen Demand (BOD)	39	53	0.47	No trend
	Biological Oxygen Demand	0	1	0.00	Stable
	Boron, Total	-73	85	0.45	Probably improving
	Cadmium, Dissolved	-3	13	1.07	No trend
	Cadmium, Total	-71	48	0.43	Improving
	Calcium, Total	-47	85	0.28	Stable
	Carbon Trioxide	0	1	0.00	Stable
	Chemical Oxygen Demand	27	66	0.64	No trend
	Chlordane-gamma	-16	20	1.98	No trend

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Chloride	-117	90	0.29	Improving
	Chlorophyll	-24	23	2.02	Improving
	Chlorpyrifos	-10	111	2.90	No trend
	Chromium, Dissolved	2	10	0.62	No trend
	Chromium, Total	-54	41	0.41	Improving
	Color	17	50	0.39	No trend
	Copper, Dissolved	-1	10	0.79	Stable
	Copper, Total	-152	92	0.46	Improving
	Cyanide	-6	15	2.65	No trend
	Cyfluthrin	27	21	1.45	Declining
	Cyhalothrin-lambda	19	20	2.55	Probably declining
	Cypermethrin	29	21	1.38	Declining
	Danitol	19	20	2.40	Probably declining
	Deltamethrin	27	21	1.48	Declining
	Diazinon	-59	111	2.81	No trend
	Discharge	15	41	0.78	No trend
	Dissolved Oxygen	-122	117	0.32	Improving
	Electrochemical Balance	2	53	-3.28	No trend
	Endrin Aldehyde	-18	20	1.50	Probably improving
	Esfenvalerate	6	15	2.65	No trend
	Event	0	1	0.00	Stable
	Fecal Coliform	5	23	1.67	No trend
	Fenvalerate	6	15	2.65	No trend
	Flourine	-2	49	0.31	Stable
	Fluoride	-7	15	0.52	Stable
Upper Santa Margarita River	Fluvalinate	0	13	0.00	Stable
	Heptachlor epoxide	-12	18	1.85	No trend
	Iron, Total	-23	23	1.08	Probably improving
	Lead, Dissolved	3	13	1.51	No trend
	Lead, Total	-169	91	0.78	Improving
	Magnesium, Total	62	53	0.18	Declining
	Malathion	9	28	1.79	No trend
	Manganese, Dissolved	-9	13	1.06	No trend

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Manganese, Total	-18	23	0.60	Stable
	Mercury, Total	-125	85	0.61	Improving
	Methylene Blue Active Substance (MBAS)	-136	98	0.91	Improving
	Nickel, Dissolved	1	13	0.78	No trend
	Nickel, Total	-72	48	0.43	Improving
	Nitrate as N	36	175	0.89	No trend
	Nitrite as N	-279	161	0.93	Improving
	Nitrogen, Total as N	-44	66	0.76	Stable
	Odor	13	29	2.23	No trend
	Oil & Grease, Field	0	15	0.00	Stable
	Oil & Grease	-93	53	0.21	Improving
	Organic Nitrogen	-33	53	0.82	Stable
	Orthophosphate as P	-97	61	1.28	Improving
	Permethrin	22	21	1.68	Declining
	pH, Field	-89	176	0.06	Stable
	pH, Lab	-16	53	0.03	Stable
	Phenols, Field	-3	22	0.92	Stable
	Phosphorus, Total as P, Field	-388	170	1.05	Improving
	Potassium, Field	5	53	0.51	No trend
	Prometon, Field	-18	20	1.50	Probably improving
	Salinity, Field	18	23	1.22	No trend
	Selenium, Field	50	80	1.95	No trend
	Silver, Field	-54	104	1.88	No trend
	Simazine, Field	3	20	1.70	No trend
Upper Santa Margarita River	Sodium, Field	-83	85	0.22	Probably improving
	Specific Conductivity, Field	-275	176	0.19	Improving
	Sulfate, Field	102	116	0.22	Probably declining
	Temperature, Field	-11	80	0.68	Stable
	Temperature - Field, Field	73	49	0.19	Declining
	Temperature, Air, Field	14	23	0.13	No trend
	Thallium, Field	23	21	2.10	Declining
	Total Anions, Field	46	53	0.29	Probably declining

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Total Cations, Field	60	53	0.14	Declining
	Total Dissolved Phosphorus, Field	-46	66	1.03	No trend
	Total Dissolved Solids, Field	-75	100	0.18	Stable
	Total Hardness, Field	32	66	0.23	No trend
	Total Inorganic Phosphorus, Field	18	35	0.85	No trend
	Total Kjeldahl Nitrogen, Field	-233	170	0.82	Improving
	Total Organic Carbon, Field	-122	122	0.68	Probably improving
	Total Petroleum Hydrocarbons, Field	-23	29	0.49	Stable
	Total Solids, Field	60	53	0.13	Declining
	Total Suspended Solids, Field	-158	113	2.41	Improving
	Turbidity, Field	-150	117	1.95	Improving
	Zinc, Dissolved	-5	13	0.43	Stable
	Zinc, Total	-38	102	0.82	Stable
Vail Lake and Pechanga Creek	Discharge	0	1	0.00	Stable
	Event	0	1	0.00	Stable
Warm Springs	Discharge	-15	20	4.00	No trend
	Event	0	1	0.00	Stable
	Flow	3	13	0.22	No trend

Table 6. Receiving Water Dry Weather Constituents Without Enough Samples for Trend Assessment

Subarea	Constituent
	4,4'-DDE
	4,4'-DDT
	Alkalinity, Total
	Alkalinity as CaCO3
	Antimony, Dissolved
	Barium, Dissolved
	Barium, Total
	Beryllium, Dissolved
	Beryllium, Total
	Boron, Dissolved
	Boron, Total
	Caffeine, Total
	Chloride
	Chlorophyll a
	Chromium, Dissolved
	Chromium, Trivalent, Dissolved
De Luz Creek	Chromium, Trivalent, Total
	Cyanide
	Endrin Aldehyde
	Esfenvalerate:Fenvalerate
	Heptachlor epoxide
	Magnesium, Dissolved
	Organic Nitrogen
	Orthophosphate as P
	Permethrin, cis-
	Permethrin, trans-
	Phosphorus, Total as P
	Salinity, Field
	Selenium, Total
	Southern California B-IBI score, Field
	Sulfamethoxazole, Field
	Sulfate
	Total Hardness
De Luz Creek	Total Kjeldahl Nitrogen

Subarea	Constituent
	Total Petroleum Hydrocarbons, Field
	Total Suspended Solids
	Toxicity, Chronic Ceriodaphnia - Reproduction, Field
	Toxicity, Chronic Ceriodaphnia (Survival), Field
	Trimethoprim, Field
	4,4'-DDE
	4,4'-DDT
	Alkalinity, Dissolved
	Alkalinity, Total
	Antimony, Dissolved
	Barium, Dissolved
	Beryllium, Dissolved
	Beryllium, Total
	Boron, Dissolved
	Chlorophyll a
	Chromium, Dissolved
	Chromium, Trivalent, Dissolved
	Chromium, Trivalent, Total
	Cyanide
Murrieta and Long Canyon Creek	Endrin Aldehyde
	Esfenvalerate:Fenvalerate
	Heptachlor epoxide
	ICID
	Magnesium, Dissolved
	Orthophosphate as P
	Oxygen Saturation
	Permethrin, cis-
	Permethrin, trans-
	Phosphate as P, Field
	Phosphorus, Total as P
	Selenium, Total
	Southern California B-IBI score, Field
	Sulfate
	Total Hardness
Murrieta and Long Canyon Creek	Total Kjeldahl Nitrogen

Subarea	Constituent
	Total Suspended Solids
	Toxicity, Chronic Ceriodaphnia - Reproduction, Field
	Toxicity, Chronic Ceriodaphnia (Survival), Field
	Toxicity, Chronic Pimephales(Fathead Minnow) (Survival), Field
	Toxicity, Chronic Pimephales(Fathead Minnow) (Grow), Field
Sandia Creek	3-Hydroxycarbofuran
	Aldicarb Sulfone
	Aldicarb Sulfoxide
	Alkalinity, Dissolved
	Alkalinity, Total
	Aluminum, Total
	Ammonia as N
	Arsenic, Dissolved
	Arsenic, Total
	Ash Free Dry Mass
	Bifenthrin
	Biochemical Oxygen Demand (BOD)
	Cadmium, Dissolved
	Cadmium, Total
	Caffeine, Total
	Calcium, Total
	Carbaryl
	Carbofuran
	Chemical Oxygen Demand
	Chloride
	Chlorophyll a
	Chlorpyrifos
	Chromium, Dissolved
	Chromium, Total
	Copper, Dissolved
	Copper, Total
	Cyfluthrin
	Cyhalothrin-lambda
	Cypermethrin

Subarea	Constituent
	Danitol
	Deltamethrin
	Diazinon
	Discharge
	Dissolved Organic Carbon
	Dissolved Oxygen
	E. coli
	Enterococcus
	Esfenvalerate:Fenvalerate
	Fecal Coliform
	Flow
	Iron, Dissolved
	Iron, Total
	Lead, Dissolved
	Lead, Total
	Malathion
	Manganese, Dissolved
	Manganese, Total
	Mercury, Dissolved
	Mercury, Total
	Methylene Blue Active Substance (MBAS)
	Nickel, Dissolved
	Nickel, Total
	Nitrate as N
	Nitrite as N
	Nitrogen, Total as N
	Oil & Grease
	Orthophosphate as P
	Permethrin
	pH, Field
	Phosphorus, Total as P, Field
	Phosphorus, Total as P
	Salinity
Sandia Creek	Selenium, Dissolved
	Selenium, Field

Subarea	Constituent
	Selenium, Total
	Silver, Field
	Silver, Total
	Southern California B-IBI score
	Specific Conductivity, Field
	Sulfate, Field
	Sulfate
	Temperature, Field
	Temperature
	Thallium, Field
	Total Dissolved Phosphorus, Field
	Total Dissolved Solids, Field
	Total Dissolved Solids
	Total Hardness, Field
	Total Hardness
	Total Kjeldahl Nitrogen, Field
	Total Organic Carbon, Field
	Total Suspended Solids, Field
	Total Suspended Solids
	Toxicity, Acute Ceriodaphnia (Survival), Field
	Toxicity, Acute Fathead Minnow (Survival), Field
	Toxicity, Acute Hyallela Azteca (Survival), Field
	Toxicity, Chronic Hyalella Azteca (Grow), Field
	Toxicity, Chronic Hyalella Azteca (Survival), Field
	Toxicity, Chronic Pimephales(Fathead Minnow) (Survival), Field
	Toxicity, Chronic Pimephales(Fathead Minnow) (Grow), Field
	Toxicity, Chronic PseudoSubcapitata Selenastrum Algae (Grow), Field
	Turbidity, Field
	Turbidity, Lab
	Zinc, Dissolved
	Zinc, Total
	Alkalinity, Total
Santa Gertrudis Creek	Ammonia as N
	Antimony, Total

Subarea	Constituent
	Arsenic, Dissolved
	Arsenic, Total
	Beryllium, Total
	Bifenthrin
	Cadmium, Dissolved
	Cadmium, Total
	Calcium, Total
	Chloride
	Chlorophyll a
	Chlorpyrifos
	Chromium, Dissolved
	Color
	Copper, Dissolved
	Copper, Total
	Cyfluthrin
	Cyhalothrin-lambda
	Cypermethrin
	Deltamethrin
	Diazinon
	E. coli
	Fecal Coliform
	Iron, Total
	Lead, Dissolved
	Lead, Total
	Magnesium, Total
	Manganese, Total
	Methylene Blue Active Substance (MBAS)
	Nickel, Dissolved
	Nickel, Total
	Nitrate + Nitrite as N
	Nitrate as N
	Nitrite as N
	Nitrogen, Total as N
Santa Gertrudis Creek	Odor
	Oil & Grease

Subarea	Constituent
	Orthophosphate as P
	Permethrin
	pH, Lab
	Phosphorus, Total as P, Field
	Phosphorus, Total as P
	Selenium, Dissolved
	Selenium, Total
	Sulfate
	Thallium, Field
	Total Coliform, Field
	Total Hardness, Field
	Total Hardness
	Total Kjeldahl Nitrogen, Field
	Total Kjeldahl Nitrogen
	Total Suspended Solids
	Zinc, Dissolved
	Zinc, Total
Temecula Creek and Redhawk Channel	4,4'-DDE
	4,4'-DDT
	Barium, Dissolved
	Boron, Dissolved
	Chlorine Residual
	Chlorophyll a
	Chromium, Dissolved
	Chromium, Trivalent, Total
	Cyanide
	Endrin Aldehyde
	Heptachlor epoxide
	ICID
	Magnesium, Dissolved
	Nitrate + Nitrite as N
	Orthophosphate as P
	Oxygen Saturation
Temecula Creek and Redhawk Channel	Phosphate as P, Field
	Southern California B-IBI score, Field

Subarea	Constituent
	Toxicity, Chronic Ceriodaphnia - Reproduction, Field
	Toxicity, Chronic Ceriodaphnia (Survival), Field
	Turbidity, Lab
Upper Murrieta Creek and Tributaries	Bifenthrin
	Chlorophyll a
	Chromium, Dissolved
	Cyfluthrin
	Cyhalothrin-lambda
	Cypermethrin
	Deltamethrin
	Esfenvalerate:Fenvalerate
	Iron, Total
	Manganese, Total
	Nitrate + Nitrite as N
	Orthophosphate as P
	Oxygen Saturation
	Permethrin
	Phosphorus, Total as P
	Selenium, Total
	Sulfate
	Total Hardness
	Total Kjeldahl Nitrogen
	Total Suspended Solids
Upper Santa Margarita River	3-Hydroxycarbofuran
	Acenaphthene
	Aldicarb Sulfone
	Aldicarb Sulfoxide
	Alkalinity, Dissolved
	Aluminum, Dissolved
	Carbaryl
	Carbofuran
	Chlorophyll a
	Chrysene
Upper Santa Margarita River	Dibenzothiophenes, C1-
	Dibenzothiophenes, C2-

Subarea	Constituent
	Dibenzothiophenes, C3-
	Dichlofenthion
	Dissolved Organic Carbon
	E. coli
	Enterococcus
	Esfenvalerate:Fenvalerate
	Flow
	Fluoranthene
	Fluorene
	Fluorenes, C3-
	Iron, Dissolved
	Level
	Mercury, Dissolved
	Naphthalenes, C3-
	Nitrate + Nitrite as N
	Oxadiazon
	Oxygen Saturation
	Phenanthrene/Anthracene, C1-, Field
	Phosphorus, Total as P
	Pyrene, Field
	Selenium, Total
	Sulfate
	Terbufos, Field
	Total Coliform, Field
	Total Hardness
	Total Kjeldahl Nitrogen
	Total Suspended Solids
	Toxicity, Acute Ceriodaphnia (Survival), Field
	Toxicity, Acute Fathead Minnow (Survival), Field
	Toxicity, Acute Hyallela Azteca (Survival), Field
	Toxicity, Chronic Hyalella Azteca (Grow), Field
	Toxicity, Chronic Hyalella Azteca (Survival), Field
Upper Santa Margarita River	Toxicity, Chronic Pimephales(Fathead Minnow) (Survival), Field
	Toxicity, Chronic Pimephales(Fathead Minnow) (Grow), Field

Subarea	Constituent
	Toxicity, Chronic PseudoSubcapitata Selenastrum Algae (Grow), Field
Vail Lake and Pechanga Creek	Alkalinity as CaCO3
	Ammonia as N
	Chlorophyll a, Particulate
	Chlorophyll a
	Dissolved Oxygen
	Flow
	ICID
	Microcystin-LR, Dissolved
	Microcystin-RR, Dissolved
	Nitrate + Nitrite as N
	Nitrogen, Total as N
	Orthophosphate as P
	Oxygen Saturation
	pH, Field
	Phosphorus, Total as P, Field
	Salinity, Field
	Silica as SiO2, Field
	Specific Conductivity, Field
	Temperature, Field
Warm Springs	Alkalinity, Dissolved
	Ammonia as N
	Antimony, Total
	Arsenic, Total
	Beryllium, Total
	Bicarbonate
	Bifenthrin
	Cadmium, Total
	Calcium, Total
	Chloride
	Chlorophyll a
	Chlorpyrifos
	Chromium, Dissolved
	Color

Subarea	Constituent
	Copper, Dissolved
	Copper, Total
	Cyfluthrin
	Cyhalothrin-lambda
	Cypermethrin
	Deltamethrin
	Diazinon
	Dissolved Oxygen
	E. coli
	Fecal Coliform
	Iron, Total
	Lead, Dissolved
	Lead, Total
	Magnesium, Total
	Manganese, Total
	Methylene Blue Active Substance (MBAS)
	Nickel, Total
	Nitrate + Nitrite as N
	Nitrate as N
	Nitrite as N
	Nitrogen, Total as N
	Odor
	Oil & Grease
	Orthophosphate as P
	Permethrin
	pH, Field
	pH, Lab
	Phosphorus, Total as P, Field
	Phosphorus, Total as P
	Redox Potential, Field
	Selenium, Total
	Specific Conductivity, Field
	Sulfate
Warm Springs	Temperature, Field
	Thallium, Field

Subarea	Constituent
	Total Coliform, Field
	Total Dissolved Solids, Field
	Total Hardness, Field
	Total Hardness
	Total Kjeldahl Nitrogen, Field
	Total Kjeldahl Nitrogen
	Total Suspended Solids
	Turbidity, Field
	Zinc, Total

Table 7. Summary of Receiving Water Wet Weather Trend Analysis

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
De Luz Creek	Discharge	5	18	1.05	No trend
	Flow	13	18	0.24	No trend
Murrieta and Long Canyon Creek	3-Hydroxycarbofuran	0	20	0.00	Stable
	4,4'-DDE	4	21	0.34	No trend
	4,4'-DDT	5	21	0.67	No trend
	Acenaphthene	-69	62	1.22	Improving
	Aldicarb Sulfone	0	20	0.00	Stable
	Aldicarb Sulfoxide	0	20	0.00	Stable
	Alkalinity as CaCO3	2	53	0.70	No trend
	Ammonia as N	-119	249	1.13	No trend
	Antimony, Dissolved	-9	13	0.74	Stable
	Antimony, Total	-76	61	0.81	Improving
	Arsenic, Dissolved	-7	71	0.28	Stable
	Arsenic, Total	-351	185	0.56	Improving
	Atrazine	-40	42	0.49	Probably improving
	Barium, Total	-28	66	0.78	Stable
	Beryllium, Dissolved	0	13	0.00	Stable
	Beryllium, Total	-88	56	1.18	Improving
	Bicarbonate	2	53	0.70	No trend
	Bifenthrin	-41	66	3.19	No trend
	Biochemical Oxygen Demand (BOD)	22	100	0.45	No trend
	bis(2-ethylhexyl)phthalate	-6	28	0.41	Stable
	Boron, Total	42	58	1.22	No trend
	Bromodichloromethane	-3	17	0.59	Stable
	Bromoform	-3	17	3.13	No trend
	Cadmium, Dissolved	-15	52	0.28	Stable
	Cadmium, Total	-791	235	1.53	Improving
	Calcium, Total	216	182	0.57	Declining
	Carbaryl	0	20	0.00	Stable
	Carbofuran	0	20	0.00	Stable
	Carbon Trioxide	0	1	0.00	Stable
	Chemical Oxygen Demand	-9	101	0.33	Stable
	Chloride	12	53	1.21	No trend

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	chloroform	-6	27	0.94	Stable
	Chlorpyrifos	615	227	1.13	Declining
	Chromium, Total	-704	242	1.17	Improving
	Chromium, Hexavalent, Dissolved	-58	41	2.00	Improving
	Chromium, Hexavalent, Total	-110	57	1.52	Improving
	Chromium, Trivalent, Dissolved	-16	22	1.07	No trend
	Chrysene	-70	64	1.21	Improving
	Color	-38	144	0.44	Stable
	Copper, Dissolved	-102	111	0.51	Probably improving
	Copper, Total	-314	264	0.62	Improving
	Cyanide	0	15	0.00	Stable
	Cyfluthrin	5	69	1.36	No trend
	Cyhalothrin-lambda	13	33	1.09	No trend
	Cypermethrin	26	69	1.03	No trend
	Danitol	46	64	1.04	No trend
Murrieta and Long Canyon Creek	Deltamethrin	71	55	1.12	Declining
	Diazinon	343	227	0.90	Declining
	Dibromochloromethane	-3	17	1.68	No trend
	Dichlofenthion	-40	42	0.63	Probably improving
	Discharge	-143	250	1.79	No trend
	Dissolved Organic Carbon	-7	23	0.50	Stable
	Dissolved Oxygen	-86	90	0.33	Probably improving
	E. coli	-72	111	1.18	No trend
	Electrochemical Balance	-22	53	0.88	Stable
	Endrin Aldehyde	5	21	0.67	No trend
	Enterococcus	1	23	2.12	No trend
	Esfenvalerate	21	29	0.69	No trend
	Esfenvalerate:Fenvalerate	-7	17	0.54	Stable
	Event	34	66	0.13	No trend
	Fecal Coliform	-76	117	2.13	No trend
	Fenvalerate	7	29	0.67	No trend
Murrieta and Long Canyon Creek	Flourine	1	48	0.60	No trend
	Flow	-12	36	0.31	Stable

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Fluoranthene	-70	64	1.21	Improving
	Fluorene	-69	62	1.22	Improving
	Fluvalinate	-28	25	0.48	Improving
	Heptachlor epoxide	4	21	0.34	No trend
	Iron, Dissolved	-3	45	0.51	Stable
	Iron, Total	-146	111	1.69	Improving
	Lead, Dissolved	-80	87	2.05	Probably improving
	Lead, Total	-594	240	0.79	Improving
	Magnesium, Total	-13	182	0.54	Stable
	Malathion	-34	80	0.51	Stable
	Manganese, Dissolved	-24	57	1.01	No trend
	Manganese, Total	60	101	0.81	No trend
	Mercury, Dissolved	-3	15	0.03	Stable
	Mercury, Total	-366	137	0.80	Improving
	Methylene Blue Active Substance (MBAS)	462	238	1.28	Declining
	Methylene chloride	-26	30	1.63	Probably improving
	Nickel, Dissolved	-100	71	0.46	Improving
	Nickel, Total	-724	239	0.79	Improving
	Nitrate as N	-259	250	0.56	Improving
	Nitrite as N	67	117	0.29	No trend
	Nitrogen, Total as N	-126	163	0.52	Stable
	Odor	-28	37	1.03	No trend
	Oil & Grease	-244	193	0.79	Improving
	Organic Nitrogen	32	66	0.50	No trend
	Permethrin	-37	48	1.85	No trend
	Permethrin, cis-	2	10	1.87	No trend
	Permethrin, trans-	2	10	1.12	No trend
	pH, Field	-429	208	0.08	Improving
	pH, Lab	-99	149	0.03	Stable
	Phenols, Field	-238	107	1.11	Improving
	Phosphorus, Total as P, Field	-350	250	0.87	Improving
Murrieta and Long Canyon Creek	Potassium, Field	-13	53	0.56	Stable
	Pyrene, Field	-83	66	1.21	Improving

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Selenium, Field	272	181	1.45	Declining
	Silver, Field	251	179	1.14	Declining
	Simazine, Field	-69	50	1.74	Improving
	Sodium, Field	14	53	0.97	No trend
	Specific Conductivity, Field	571	271	0.69	Declining
	Sulfate, Field	168	117	0.85	Declining
	Temperature, Field	-286	229	0.77	Improving
	Temperature, Air, Field	9	20	0.10	No trend
	Terbufos, Field	-40	42	0.49	Probably improving
	Thallium, Field	178	109	0.67	Declining
	Total Anions, Field	13	53	0.95	No trend
	Total Cations, Field	-1	53	0.66	Stable
	Total Coliform, Field	-51	66	1.39	No trend
	Total Dissolved Phosphorus, Field	-125	101	0.61	Improving
	Total Dissolved Solids, Field	135	189	0.56	No trend
	Total Hardness, Field	286	271	0.54	Declining
	Total Inorganic Phosphorus, Field	2	53	1.48	No trend
	Total Kjeldahl Nitrogen, Field	-177	250	0.53	Stable
	Total Organic Carbon, Field	25	101	0.52	No trend
	Total Petroleum Hydrocarbons, Field	0	1	0.00	Stable
	Total Solids, Field	-43	53	0.54	Stable
	Total Suspended Solids, Field	-335	208	1.26	Improving
	Toxicity, Acute Ceriodaphnia (Survival), Field	104	89	0.68	Declining
	Toxicity, Acute Fathead Minnow (Survival), Field	16	20	1.19	No trend
	Toxicity, Acute Hyallela Azteca (Survival), Field	-136	108	1.01	Improving
	Toxicity, Chronic PseudoSubcapitata Selenastrum Algae(Grow), Field	11	36	0.56	No trend
Murrieta and Long Canyon Creek	Turbidity, Field	-484	257	1.22	Improving
	Zinc, Dissolved	-37	71	0.78	Stable
	Zinc, Total	-420	243	0.78	Improving

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
Santa Gertrudis Creek	Ammonia as N	23	45	0.55	No trend
	Antimony, Total	-48	29	0.68	Improving
	Beryllium, Total	-44	29	0.82	Improving
	Bifenthrin	16	18	1.84	Probably declining
	Cadmium, Dissolved	-9	15	0.34	Stable
	Cadmium, Total	-18	18	1.42	Probably improving
	Calcium, Total	-45	45	0.41	Probably improving
	Chlorpyrifos	56	44	1.25	Declining
	Color	24	33	0.63	No trend
	Copper, Dissolved	-24	45	0.43	Stable
	Copper, Total	-59	45	0.46	Improving
	Cyfluthrin	15	20	1.53	No trend
	Cyhalothrin-lambda	5	13	1.11	No trend
	Cypermethrin	-2	20	1.72	No trend
	Danitol	-9	18	0.50	Stable
	Deltamethrin	5	15	1.83	No trend
	Diazinon	36	44	1.17	No trend
	Discharge	-13	53	1.80	No trend
	Dissolved Oxygen	-9	15	0.17	Stable
	E. coli	26	37	0.98	No trend
	Esfenvalerate	4	15	0.94	No trend
	Event	0	1	0.00	Stable
	Fecal Coliform	12	37	2.39	No trend
	Fenvalerate	1	15	0.84	No trend
	Fluvalinate	-11	18	0.68	Stable
	Iron, Total	-86	45	1.67	Improving
	Lead, Dissolved	-31	34	0.49	Probably improving
	Lead, Total	-18	18	0.84	Probably improving
	Magnesium, Total	-70	45	0.69	Improving
	Manganese, Total	-60	41	1.20	Improving
	Methylene Blue Active Substance (MBAS)	28	45	0.65	No trend

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Nitrate as N	2	45	0.48	No trend
	Nitrite as N	3	21	0.59	No trend
	Nitrogen, Total as N	-2	34	0.36	Stable
	Odor	0	1	0.00	Stable
	Oil & Grease	-17	33	0.27	Stable
	Permethrin	5	13	1.59	No trend
	pH, Field	-14	41	0.11	Stable
	pH, Lab	-18	33	0.05	Stable
	Phosphorus, Total as P, Field	-37	45	0.63	Stable
	Specific Conductivity, Field	-1	41	0.53	Stable
	Temperature, Field	10	41	0.22	No trend
	Thallium, Field	7	29	0.56	No trend
	Total Coliform, Field	-7	37	1.33	No trend
	Total Dissolved Solids, Field	-13	34	0.43	Stable
	Total Hardness, Field	-69	57	0.49	Improving
	Total Kjeldahl Nitrogen, Field	-28	45	0.37	Stable
	Turbidity, Field	-55	45	1.46	Improving
	3-Hydroxycarbofuran	0	20	0.00	Stable
	4,4'-DDE	-13	23	0.42	Stable
	4,4'-DDT	-8	23	0.68	Stable
Temecula Creek and Redhawk Channel	Acenaphthene	-64	64	2.54	Probably improving
	Aldicarb Sulfone	0	20	0.00	Stable
	Aldicarb Sulfoxide	0	20	0.00	Stable
	Ammonia as N	-106	138	0.74	Stable
	Antimony, Dissolved	3	13	1.09	No trend
	Antimony, Total	-72	57	0.81	Improving
	Arsenic, Dissolved	-2	75	1.26	No trend
	Arsenic, Total	-124	90	0.35	Improving
Temecula Creek and Redhawk Channel	Atrazine	-40	42	0.49	Probably improving
	Beryllium, Dissolved	1	13	1.39	No trend
	Beryllium, Total	-98	53	0.94	Improving
	Bifenthrin	-68	71	3.03	Probably improving

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Biochemical Oxygen Demand (BOD)	-2	26	0.76	Stable
	bis(2-ethylhexyl)phthalate	-8	25	0.33	Stable
	Bromodichloromethane	0	1	0.00	Stable
	Bromoform	0	1	0.00	Stable
	Cadmium, Dissolved	-3	55	2.31	No trend
	Cadmium, Total	-191	129	0.92	Improving
	Calcium, Total	19	80	0.58	No trend
	Carbaryl	-6	20	0.22	Stable
	Carbofuran	0	20	0.00	Stable
	Chemical Oxygen Demand	10	27	0.52	No trend
	chloroform	-1	17	1.34	No trend
	Chlorpyrifos	217	135	0.77	Declining
	Chromium, Total	-380	134	1.65	Improving
	Chromium, Hexavalent, Dissolved	-80	41	1.88	Improving
	Chromium, Hexavalent, Total	-116	57	1.47	Improving
	Chromium, Trivalent, Dissolved	-10	22	0.96	Stable
	Chrysene	-62	62	2.54	Probably improving
	Color	-8	53	0.58	Stable
	Copper, Dissolved	-63	117	0.59	Stable
	Copper, Total	-286	145	0.56	Improving
	Cyanide	0	15	0.00	Stable
	Cyfluthrin	0	73	2.05	No trend
	Cyhalothrin-lambda	-24	37	1.49	No trend
	Cypermethrin	-24	73	1.52	No trend
	Danitol	33	69	0.77	No trend
	Deltamethrin	60	60	1.87	Probably declining
	Diazinon	205	135	0.75	Declining
	Dibromochloromethane	0	1	0.00	Stable
Temecula Creek and Redhawk Channel	Dichlofenthion	-40	42	0.49	Probably improving
	Discharge	-210	195	2.04	Improving
	Dissolved Organic Carbon	-3	27	0.46	Stable
	Dissolved Oxygen	35	76	0.23	No trend

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	E. coli	-98	117	1.04	Probably improving
	Endrin Aldehyde	0	21	0.33	Stable
	Enterococcus	21	27	1.93	No trend
	Esfenvalerate	16	30	0.66	No trend
	Esfenvalerate:Fenvalerate	0	1	0.00	Stable
	Event	0	1	0.00	Stable
	Fecal Coliform	-144	117	1.08	Improving
	Fenvalerate	3	30	0.73	No trend
	Flow	-16	40	0.66	Stable
	Fluoranthene	-62	62	2.54	Probably improving
	Fluorene	-64	64	2.54	Probably improving
	Fluvalinate	-21	21	0.48	Probably improving
	Heptachlor epoxide	0	21	0.33	Stable
	Iron, Dissolved	-26	49	0.32	Stable
	Iron, Total	-229	117	1.53	Improving
	Lead, Dissolved	-73	97	1.29	No trend
	Lead, Total	-335	134	1.38	Improving
	Magnesium, Total	-31	80	0.69	Stable
	Malathion	-44	77	0.51	Stable
	Manganese, Dissolved	-72	61	1.54	Improving
	Manganese, Total	-29	106	1.16	No trend
	Mercury, Dissolved	0	16	0.02	Stable
	Mercury, Total	15	24	0.29	No trend
	Methylene Blue Active Substance (MBAS)	-35	126	1.65	No trend
	Methylene chloride	-13	23	1.73	No trend
	Nickel, Dissolved	-13	75	0.98	Stable
Temecula Creek and Redhawk Channel	Nickel, Total	-386	134	1.14	Improving
	Nitrate as N	-59	139	0.67	Stable
	Nitrite as N	-23	70	0.28	Stable
	Nitrogen, Total as N	-64	66	0.55	Probably improving
	Odor	0	1	0.00	Stable

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Oil & Grease	-113	95	0.42	Improving
	Permethrin	-70	53	3.10	Improving
	Permethrin, cis-	1	10	1.96	No trend
	Permethrin, trans-	1	10	1.46	No trend
	pH, Field	-35	139	0.07	Stable
	pH, Lab	-29	57	0.03	Stable
	Phenols, Field	20	28	1.27	No trend
	Phosphorus, Total as P, Field	-243	139	0.93	Improving
	Pyrene, Field	-71	65	2.54	Improving
	Selenium, Field	123	90	1.34	Declining
	Silver, Field	143	82	3.47	Declining
	Simazine, Field	-52	44	0.63	Improving
	Specific Conductivity, Field	177	145	0.90	Declining
	Sulfate, Field	9	37	0.74	No trend
	Temperature, Field	58	145	0.56	No trend
	Terbufos, Field	-40	42	0.49	Probably improving
	Thallium, Field	196	106	1.12	Declining
	Total Coliform, Field	-41	62	0.80	Stable
	Total Dissolved Phosphorus, Field	-11	27	0.56	Stable
	Total Dissolved Solids, Field	81	90	0.79	Probably declining
	Total Hardness, Field	104	139	0.87	No trend
	Total Kjeldahl Nitrogen, Field	-143	139	0.60	Improving
	Total Organic Carbon, Field	-2	27	0.44	Stable
	Total Suspended Solids, Field	-233	106	1.78	Improving
	Toxicity, Acute Ceriodaphnia (Survival), Field	121	88	0.80	Declining
	Toxicity, Acute Fathead Minnow (Survival), Field	7	21	2.34	No trend
Temecula Creek and Redhawk Channel	Toxicity, Acute Hyallela Azteca (Survival), Field	-109	99	1.09	Improving
	Toxicity, Chronic PseudoSubcapitata Selenastrum Algae(Grow), Field	13	26	0.20	No trend
	Turbidity, Field	-249	145	1.06	Improving
	Zinc, Dissolved	-50	76	1.36	No trend

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Zinc, Total	-313	134	0.88	Improving
Upper Murrieta Creek and Tributaries	4,4'-DDE	-1	13	0.05	Stable
	4,4'-DDT	-1	13	0.04	Stable
	Acenaphthene	-23	25	1.77	Probably improving
	Alkalinity as CaCO3	-5	71	0.64	Stable
	Ammonia as N	-181	116	0.92	Improving
	Antimony, Total	-15	17	1.45	Probably improving
	Arsenic, Dissolved	-5	18	0.56	Stable
	Arsenic, Total	-146	117	1.02	Improving
	Atrazine	-11	17	0.06	Stable
	Barium, Total	22	71	0.66	No trend
	Beryllium, Total	-11	18	1.39	No trend
	Bicarbonate	-9	71	0.63	Stable
	Biochemical Oxygen Demand (BOD)	-91	71	0.71	Improving
	bis(2-ethylhexyl)phthalate	-7	18	1.71	No trend
	Boron, Total	28	66	0.38	No trend
	Bromodichloromethane	0	20	0.00	Stable
	Bromoform	0	20	0.00	Stable
	Cadmium, Dissolved	0	18	0.00	Stable
	Cadmium, Total	-306	127	1.11	Improving
	Calcium, Total	-135	122	0.70	Improving
	Carbon Trioxide	0	1	0.00	Stable
	Chemical Oxygen Demand	-1	71	0.58	Stable
	Chloride	12	71	0.82	No trend
	chloroform	-4	20	1.53	No trend
	Chlorpyrifos	124	89	1.27	Declining
	Chromium, Total	-184	132	2.62	Improving
	Chromium, Hexavalent, Dissolved	-9	13	1.55	No trend
	Chromium, Hexavalent, Total	6	10	0.72	No trend
	Chromium, Trivalent, Dissolved	-9	13	1.03	No trend
	Chrysene	-23	25	1.77	Probably improving

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Color	106	106	0.64	Probably declining
	Copper, Dissolved	-8	18	0.48	Stable
	Copper, Total	-57	137	2.62	No trend
	Cyanide	0	10	0.00	Stable
	Diazinon	114	89	0.97	Declining
	Dibromochloromethane	0	20	0.00	Stable
	Dichlofenthion	-11	17	0.06	Stable
	Discharge	-1193	382	3.01	Improving
	Dissolved Oxygen	-41	37	0.20	Improving
	E. coli	-26	23	2.06	Improving
	Electrochemical Balance	-2	71	0.87	Stable
	Endrin Aldehyde	-1	13	0.04	Stable
	Event	0	1	0.00	Stable
	Fecal Coliform	-26	23	2.02	Improving
	Flourine	-17	70	0.76	Stable
	Flow	-2	15	0.63	Stable
	Fluoranthene	-23	25	1.77	Probably improving
	Fluorene	-23	25	1.77	Probably improving
	Heptachlor epoxide	-1	13	0.04	Stable
	Iron, Total	-6	18	1.66	No trend
	Lead, Dissolved	-7	18	0.52	Stable
	Lead, Total	-200	136	1.33	Improving
	Level	7	15	2.01	No trend
	Magnesium, Total	-80	122	0.52	Stable
	Malathion	-11	17	0.06	Stable
	Manganese, Total	-5	15	1.40	No trend
	Mercury, Total	-171	85	0.45	Improving
Upper Murrieta Creek and Tributaries	Methylene Blue Active Substance (MBAS)	-3	119	0.98	Stable
	Methylene chloride	-18	20	1.22	Probably improving
	Nickel, Dissolved	-13	18	0.40	Stable
	Nickel, Total	-192	128	1.53	Improving
	Nitrate as N	-9	122	0.63	Stable

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Nitrite as N	30	44	0.00	No trend
	Nitrogen, Total as N	30	85	0.51	No trend
	Odor	-24	48	2.40	No trend
	Oil & Grease	30	85	1.18	No trend
	Organic Nitrogen	44	71	0.58	No trend
	pH, Field	-109	76	0.09	Improving
	pH, Lab	-36	95	0.03	Stable
	Phenols, Field	-171	95	1.02	Improving
	Phosphorus, Total as P, Field	-163	122	0.84	Improving
	Potassium, Field	-7	71	0.48	Stable
	Pyrene, Field	-23	25	1.77	Probably improving
	Selenium, Field	-27	106	3.08	No trend
	Silver, Field	-52	99	1.78	No trend
	Simazine, Field	-11	17	0.06	Stable
	Sodium, Field	5	71	0.70	No trend
	Specific Conductivity, Field	-59	140	0.70	Stable
	Sulfate, Field	9	71	0.85	No trend
	Temperature, Field	-128	90	0.77	Improving
	Temperature, Air, Field	5	23	0.09	No trend
	Terbufos, Field	-11	17	0.06	Stable
	Thallium, Field	12	22	1.58	No trend
	Total Anions, Field	0	71	0.72	Stable
	Total Cations, Field	9	71	0.60	No trend
	Total Coliform, Field	-22	23	1.82	Probably improving
	Total Dissolved Phosphorus, Field	-33	71	0.53	Stable
	Total Dissolved Solids, Field	-28	90	0.55	Stable
Upper Murrieta Creek and Tributaries	Total Hardness, Field	-178	139	0.64	Improving
	Total Inorganic Phosphorus, Field	30	71	0.85	No trend
	Total Kjeldahl Nitrogen, Field	2	122	0.68	No trend
	Total Organic Carbon, Field	91	71	0.41	Declining
	Total Petroleum Hydrocarbons, Field	-11	61	0.57	Stable
	Total Solids, Field	14	71	0.44	No trend

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Total Suspended Solids, Field	-122	122	1.32	Probably improving
	Toxicity, Acute Ceriodaphnia (Survival), Field	27	21	0.92	Declining
	Toxicity, Acute Hyallela Azteca (Survival), Field	27	23	0.72	Declining
	Toxicity, Chronic PseudoSubcapitata Selenastrum Algae(Grow), Field	-3	13	0.17	Stable
	Turbidity, Field	-66	128	1.19	No trend
	Zinc, Dissolved	-14	18	1.03	No trend
	Zinc, Total	-218	139	1.30	Improving
Upper Santa Margarita River	Alkalinity as CaCO3	-15	30	0.41	Stable
	Ammonia as N	-66	57	1.49	Improving
	Arsenic, Total	22	29	0.67	No trend
	Barium, Total	15	27	0.76	No trend
	Bicarbonate	-18	27	0.42	Stable
	Biochemical Oxygen Demand (BOD)	-25	26	1.30	Probably improving
	Biological Oxygen Demand	5	18	2.83	No trend
	Boron, Total	-5	30	0.49	Stable
	Cadmium, Total	10	14	0.40	No trend
	Calcium, Total	-7	30	0.48	Stable
	Carbon Trioxide	0	1	0.00	Stable
	Chemical Oxygen Demand	0	27	0.93	Stable
	Chloride	-6	30	0.74	Stable
	Chlorophyll	6	18	1.49	No trend
	Chlorpyrifos	-27	30	1.02	Probably improving
Upper Santa Margarita River	Chromium, Total	14	26	0.78	No trend
	Color	-2	26	0.49	Stable
	Copper, Total	6	30	0.81	No trend
	Diazinon	-56	34	1.03	Improving
	Discharge	-1	10	0.50	Stable
	Dissolved Oxygen	-11	23	0.10	Stable
	Electrochemical Balance	15	27	0.79	No trend
	Event	0	14	0.33	Stable

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Flourine	-5	23	0.28	Stable
	Lead, Total	-7	27	1.47	No trend
	Magnesium, Total	13	27	0.44	No trend
	Mercury, Total	-1	20	0.50	Stable
	Methylene Blue Active Substance (MBAS)	-21	25	0.79	Probably improving
	Nickel, Total	10	24	0.82	No trend
	Nitrate as N	-32	62	0.67	Stable
	Nitrite as N	-103	54	0.86	Improving
	Nitrogen, Total as N	4	26	1.01	No trend
	Odor	-1	18	2.18	No trend
	Oil & Grease	-4	14	0.92	Stable
	Organic Nitrogen	14	27	1.20	No trend
	Orthophosphate as P	1	20	0.91	No trend
	pH, Field	-34	41	0.07	Stable
	pH, Lab	-13	26	0.03	Stable
	Phenols, Field	-4	14	0.71	Stable
	Phosphorus, Total as P, Field	-86	62	1.28	Improving
	Potassium, Field	8	27	0.56	No trend
	Selenium, Field	4	18	0.45	No trend
	Silver, Field	-1	20	0.52	Stable
	Sodium, Field	-5	30	0.59	Stable
	Specific Conductivity, Field	54	62	0.57	Probably declining
	Sulfate, Field	1	34	0.73	No trend
	Temperature, Field	-6	15	0.59	Stable
	Temperature - Field, Field	-10	18	0.15	Stable
	Total Anions, Field	-17	27	0.50	Stable
Upper Santa Margarita River	Total Cations, Field	-17	27	0.29	Stable
	Total Dissolved Phosphorus, Field	-19	27	0.58	Stable
	Total Dissolved Solids, Field	-8	30	0.36	Stable
	Total Hardness, Field	0	27	0.42	Stable
	Total Inorganic Phosphorus, Field	5	27	1.21	No trend
	Total Kjeldahl Nitrogen, Field	-73	62	1.51	Improving

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Total Organic Carbon, Field	9	30	1.56	No trend
	Total Petroleum Hydrocarbons, Field	0	1	0.00	Stable
	Total Solids, Field	11	27	0.96	No trend
	Total Suspended Solids, Field	-2	34	1.41	No trend
	Turbidity, Field	-1	34	1.23	No trend
	Zinc, Total	5	30	0.82	No trend
	Ammonia as N	-11	57	0.81	Stable
	Antimony, Total	-26	33	0.98	Stable
	Arsenic, Dissolved	3	13	0.21	No trend
	Beryllium, Total	-32	32	1.07	Probably improving
	Bifenthrin	-5	27	2.72	No trend
Warm Springs	Cadmium, Dissolved	-8	19	0.43	Stable
	Cadmium, Total	-14	23	1.37	No trend
	Calcium, Total	-37	45	0.56	Stable
	Chlorpyrifos	80	54	1.03	Declining
	Chromium, Total	-11	13	0.71	Probably improving
	Color	-2	33	0.51	Stable
	Copper, Dissolved	-21	57	0.40	Stable
	Copper, Total	-42	57	0.50	Stable
	Cyfluthrin	6	30	1.82	No trend
	Cyhalothrin-lambda	-3	15	1.68	No trend
	Cypermethrin	1	29	1.97	No trend
	Danitol	-1	26	0.76	Stable
	Deltamethrin	20	22	2.00	Probably declining
	Diazinon	94	54	1.02	Declining
Warm Springs	Discharge	2	66	2.00	No trend
	Dissolved Oxygen	-16	20	0.20	Stable
	E. coli	-33	49	1.56	No trend
	Esfenvalerate	9	18	0.85	No trend
	Event	0	1	0.00	Stable
	Fecal Coliform	-43	49	1.66	Probably improving
	Fenvalerate	4	18	0.76	No trend

Subarea	Analyte	S	S_{crit} 95%	COV	Condition
	Fluvalinate	-9	18	0.50	Stable
	Iron, Dissolved	7	13	0.77	No trend
	Iron, Total	-79	58	1.61	Improving
	Lead, Dissolved	-44	47	0.81	Probably improving
	Lead, Total	-22	27	0.72	Stable
	Magnesium, Total	-47	45	0.59	Improving
	Malathion	0	10	0.00	Stable
	Manganese, Dissolved	-7	15	2.26	No trend
	Manganese, Total	-72	53	1.27	Improving
	Methylene Blue Active Substance (MBAS)	21	49	0.70	No trend
	Nickel, Dissolved	-5	13	0.34	Stable
	Nickel, Total	-12	13	0.55	Probably improving
	Nitrate as N	-22	57	0.42	Stable
	Nitrite as N	-44	34	0.23	Improving
	Nitrogen, Total as N	-30	37	0.43	Stable
	Odor	0	1	0.00	Stable
	Oil & Grease	-12	45	0.33	Stable
	Permethrin	-5	20	0.80	Stable
	pH, Field	-55	49	0.10	Improving
	pH, Lab	-27	37	0.06	Stable
	Phosphorus, Total as P, Field	-50	57	0.65	Probably improving
	Specific Conductivity, Field	6	53	0.76	No trend
	Temperature, Field	15	49	0.21	No trend
	Thallium, Field	56	43	0.48	Declining
Warm Springs	Total Coliform, Field	-40	37	0.66	Improving
	Total Dissolved Solids, Field	-7	45	0.59	Stable
	Total Hardness, Field	-46	62	0.54	Stable
	Total Kjeldahl Nitrogen, Field	-63	57	0.49	Improving
	Total Suspended Solids, Field	-11	13	1.67	Probably improving
	Turbidity, Field	-66	57	1.32	Improving
	Zinc, Dissolved	-1	13	0.82	Stable
	Zinc, Total	-9	13	0.78	Stable

Table 8. Receiving Water Wet Weather Constituents without Enough Samples for Trend Assessment

Subarea	Constituent
	3-Hydroxycarbofuran
	Aldicarb Sulfone
	Aldicarb Sulfoxide
	Ammonia as N
	Arsenic, Dissolved
	Arsenic, Total
	Bifenthrin
	Biochemical Oxygen Demand (BOD)
	Cadmium, Dissolved
	Cadmium, Total
	Carbaryl
	Carbofuran
	Chemical Oxygen Demand
	Chlorpyrifos
	Chromium, Total
	Chromium, Hexavalent, Dissolved
De Luz Creek	Chromium, Hexavalent, Total
	Copper, Dissolved
	Copper, Total
	Cyfluthrin
	Cyhalothrin-lambda
	Cypermethrin
	Danitol
	Deltamethrin
	Diazinon
	Dissolved Organic Carbon
	Dissolved Oxygen
	E. coli
	Enterococcus
	Esfenvalerate:Fenvalerate
	Fecal Coliform
	Gasoline Range Organics
	Hydrocarbons, Diesel Range
De Luz Creek	Iron, Dissolved

Subarea	Constituent
	Iron, Total
	Lead, Dissolved
	Lead, Total
	Malathion
	Manganese, Dissolved
	Manganese, Total
	Mercury, Dissolved
	Mercury, Total
	Methylene Blue Active Substance (MBAS)
	Nickel, Dissolved
	Nickel, Total
	Nitrate as N
	Nitrite as N
	Nitrogen, Total as N
	Oil & Grease
	Permethrin
	pH, Field
	Phosphorus, Total as P, Field
	Selenium, Field
	Silver, Field
	Southern California B-IBI score, Field
	Specific Conductivity, Field
	Sulfate, Field
	Temperature, Field
	Thallium, Field
	Total Dissolved Phosphorus, Field
	Total Dissolved Solids, Field
	Total Hardness, Field
	Total Kjeldahl Nitrogen, Field
	Total Organic Carbon, Field
	Total Suspended Solids, Field
	Toxicity, Acute Ceriodaphnia (Survival), Field
	Toxicity, Acute Fathead Minnow (Survival), Field
	Toxicity, Acute Hyallela Azteca (Survival), Field
	Turbidity, Field

Subarea	Constituent
De Luz Creek	Zinc, Dissolved
	Zinc, Total
Murrieta and Long Canyon Creek	Barium, Dissolved
	Boron, Dissolved
	Chromium, Trivalent, Total
	Gasoline Range Organics
	Hydrocarbons, Diesel Range
	Level
	Magnesium, Dissolved
	Redox Potential, Field
	Salinity, Field
	Southern California B-IBI score, Field
	Total Inorganic Nitrogen, Field
	Toxicity, Acute Hyallela Azteca, Field
	Toxicity, Acute Hyallela Azteca, Field
	Toxicity, Chronic Ceriodaphnia - Reproduction, Field
	Toxicity, Chronic Ceriodaphnia (Survival), Field
Santa Gertrudis Creek	Acenaphthene
	Antimony, Dissolved
	Arsenic, Dissolved
	Atrazine
	Beryllium, Dissolved
	Chromium, Total
	Chromium, Hexavalent, Dissolved
	Chromium, Trivalent, Dissolved
	Chrysene
	Dichlofenthion
	Esfenvalerate:Fenvalerate
	Flow
	Fluoranthene
	Fluorene
	Iron, Dissolved
	Malathion
	Manganese, Dissolved
	Nickel, Dissolved

Subarea	Constituent
Santa Gertrudis Creek	Nickel, Total
	Permethrin, cis-
	Permethrin, trans-
	Pyrene, Field
	Simazine, Field
	Terbufos, Field
	Total Suspended Solids, Field
	Zinc, Dissolved
	Zinc, Total
Temecula Creek and Redhawk Channel	Barium, Dissolved
	Barium, Total
	Boron, Dissolved
	Boron, Total
	Chromium, Trivalent, Total
	Gasoline Range Organics
	Hydrocarbons, Diesel Range
	Magnesium, Dissolved
	Organic Nitrogen
	Redox Potential, Field
	Salinity, Field
	Southern California B-IBI score, Field
	Total Inorganic Nitrogen, Field
	Total Petroleum Hydrocarbons, Field
	Toxicity, Acute Hyallela Azteca, Field
	Toxicity, Acute Hyallela Azteca, Field
	Toxicity, Chronic Ceriodaphnia - Reproduction, Field
	Toxicity, Chronic Ceriodaphnia (Survival), Field
Upper Murrieta Creek and Tributaries	Antimony, Dissolved
	Beryllium, Dissolved
	Bifenthrin
	Cyfluthrin
	Cyhalothrin-lambda
	Cypermethrin
	Danitol

Subarea	Constituent
	Deltamethrin
	Esfenvalerate
	Esfenvalerate:Fenvalerate
	Fenvalerate
Upper Murrieta Creek and Tributaries	Fluvalinate
	Iron, Dissolved
	Manganese, Dissolved
	Mercury, Dissolved
	Permethrin
	Permethrin, cis-
	Permethrin, trans-
	Salinity, Field
	Total Inorganic Nitrogen, Field
Upper Santa Margarita River	4,4'-DDE
	4,4'-DDT
	Aluminum, Total
	Antimony, Total
	Atrazine
	Beryllium, Total
	Bicarbonate Alkalinity as CaCO3
	Bifenthrin
	Chlordane-gamma
	Cyanide
	Cyfluthrin
	Cyhalothrin-lambda
	Cypermethrin
	Danitol
	Deltamethrin
	Dibenzothiophenes, C1-
	Dibenzothiophenes, C2-
	Dibenzothiophenes, C3-
	Endrin Aldehyde
	Esfenvalerate
	Fecal Coliform
	Fenvalerate

Subarea	Constituent
Upper Santa Margarita River	Fluorenes, C3-
	Fluoride
	Fluvalinate
	Heptachlor epoxide
	Iron, Total
	Malathion
	Manganese, Total
	Oil & Grease, Field
	Oxadiazon
	Oxygen Saturation
	Permethrin
	Phenanthrene/Anthracene, C1-, Field
	Prometon, Field
	Salinity, Field
	Simazine, Field
	Temperature, Air, Field
	Thallium, Field
Warm Springs	Acenaphthene
	Antimony, Dissolved
	Arsenic, Total
	Atrazine
	Beryllium, Dissolved
	Biochemical Oxygen Demand (BOD)
	Chemical Oxygen Demand
	Chlorine Residual
	Chromium, Hexavalent, Dissolved
	Chromium, Hexavalent, Total
	Chromium, Trivalent, Dissolved
	Chromium, Trivalent, Total
	Chrysene
	Dichlofenthion
	Dissolved Organic Carbon
	Enterococcus
	Esfenvalerate:Fenvalerate
	Flow

Subarea	Constituent
	Fluoranthene
	Fluorene
	Gasoline Range Organics
	Hydrocarbons, Diesel Range
	Mercury, Dissolved
	Mercury, Total
	Permethrin, cis-
	Permethrin, trans-
Warm Springs	Pyrene, Field
	Selenium, Field
	Silver, Field
	Simazine, Field
	Sulfate, Field
	Terbufos, Field
	Total Dissolved Phosphorus, Field
	Total Organic Carbon, Field
	Total Petroleum Hydrocarbons, Field

Table 9. Active Diversions in the County of San Diego, per eWRI's Database (accessed 12/1/17)

Hydrologic Unit	Face Value Amount	Points of Diversion Unit	Owner
De Luz Creek	1.7	Gallons per Day	Individual
De Luz Creek	18	Gallons per Day	Individual
De Luz Creek	200	Cubic Feet per Second	Individual
De Luz Creek	100	Gallons per Day	Individual
O'Neill Lake-Santa Margarita River	173,000	Gallons per Day	U.S. Department of the Navy
Sandia Canyon	20,000	Gallons per Day	U.S. Department of the Navy Marine Corps Base Camp Pendleton

Appendix 3A – Other Types of Data Reviewed as Part of Source Identification Efforts

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Table 1. Other Types of Data Reviewed as Part of Source Identification Efforts

Special Study Title	Type of Data	Notes
Eutrophication and Nutrient Cycling in Santa Margarita River Estuary: A Summary of Baseline Studies for Monitoring Order R9-2006-0076	Algal biomass and percent cover, dissolved oxygen, total nitrogen and total phosphorus concentrations and fluxes between water and sediment.	SMRNIG Study, See Section **Error! Reference source not found.**.
Status of Eutrophication over a Two Year Period (2015-2016) in Lower Santa Margarita River, San Diego, California (SMRNIG Phase I data report)	Benthic algal abundance, benthic organic carbon, dissolved oxygen, pH, total nitrogen and total phosphorus concentrations, stream velocity, depth, discharge, channel substrate and riparian canopy cover.	SMRNIG Study, See Section **Error! Reference source not found.**. Two year study in three portions of river.
Santa Margarita River Watershed Phase II-Sediment and Nutrient Calibration Memorandum	Results of Watershed Loading Model calibration for nitrogen and phosphorus.	SMRNIG Study, See Section **Error! Reference source not found.**.
Calibration of Linked Hydrodynamic and Water Quality Model for Santa Margarita Lagoon	Results of estuary model calibration for algae, dissolved oxygen, nitrogen and phosphorus.	SMRNIG Study, See Section **Error! Reference source not found.**.
Application of watershed loading and estuary water quality models to inform nutrient management in the Santa Margarita River Watershed.	Results of using the watershed loading model and estuary model to inform major science objectives for the SMRNIG, including understanding the major pathways that supply nutrients to the SMR Estuary, estimate the range of allowable loads to the SMR Estuary, evaluate potential numeric targets, identify preliminary scenarios for evaluating nutrient management, and estimate sources of nutrients to SMR Estuary.	SMRNIG Study, See Section **Error! Reference source not found.**.
Agricultural, Federal, Tribal, and State Input Special Study, 2014 Annual Progress Report	Monitoring data for the following parameters: physical chemistry, bacteriological, conventionals, nutrients and hydrocarbons, pesticides, and total and dissolved metals.	Source information for agricultural, federal and tribal land uses.

Special Study Title	Type of Data	Notes
Hydromodification Monitoring Project	Channel and bank conditions (gradient, particle size, channel width), location of discharge points, habitat integrity (individual CRAM attribute scores and selected parameters from SWAMP stream physical habitat characterization), quantification of bank eroded areas, and vertical and lateral susceptibility ratings.	Three monitoring locations. Not directly relevant to the identification of sources/stressors related to nutrients.
Sediment Toxicity Special Study, Santa Margarita Region, 2013-2014 Final Report	Analytical results for particle size, general chemistry, trace metals, organochlorine pesticides, and synthetic pyrethroids. Acute and chronic solid phase toxicity bioassay results, rapid stream bioassessment results (including IBI scores for 4 reaches).	Not directly relevant to the identification of sources/stressors related to nutrients.
Source Assessment of Iron and Manganese for the Santa Margarita Region	Summary statistics for the following: iron and manganese concentrations in groundwater, SMR reference streams, atmospheric deposition mass loads from wet weather monitoring data, and TSS and TDS concentrations in SMR urban receiving waters.	Not directly relevant to the identification of sources/stressors related to nutrients.
Trash and Litter Investigation Special Study	Number and type of trash items for two wet and two dry events. Rapid trash assessment overall scores and ratings. Evaluations of trash and litter BMPs currently in place.	Not directly relevant to the identification of sources/stressors related to nutrients.
Pharmaceuticals and Personal Care Products in the Streams and Rivers within the San Diego Region, Pilot Study, California Regional Water Quality Control Board, San Diego Region, May 10, 2016.	The study was designed to investigate the presence of Pharmaceuticals and Personal Care Products (PPCPs) in the region and monitored discharges from POTWs and several sites in surface waters focusing on PPCPs.	The study monitored discharges from POTWs and surface waters. The results do not provide useful information related to sources of pollutants entering or discharging from the MS4. Further, the study focuses on PPCPs and does not include monitoring of constituents related to eutrophication or nutrients. The study does identify caffeine as a potential surrogate for detecting human waste, which can

Special Study Title	Type of Data	Notes
		contribute nutrient loads, but concludes that caffeine alone should not be used as the only tracer for leaking sewer lines or septic tank systems.
Cost Benefit Analysis - San Diego Region Bacteria Total Maximum Daily Loads	Information on potential sources of bacteria and human waste to receiving waters in the San Diego Region and potential BMPs.	Multiple sources of human waste are identified which could contribute nutrients to receiving waters. Potential sources include sanitary sewer collections systems, OWTS, and homeless encampments. The study did not include the Santa Margarita River Watershed.
Bioassessment of Perennial Streams in Southern California: A Report on the First Five Years of the Stormwater Monitoring Coalition's Regional Stream Survey	CSCI scores, diatom index (D18), soft algae index (S2), and CRAM scores. Summary statistics for water chemistry, toxicity, physical habitat, and stress prioritization.	Dataset utilized by this report has been incorporated into the receiving water condition assessment. Data is not directly relevant to the identification of sources/stressors related to nutrients
Santa Margarita River Lagoon Monitoring Project	Monitoring data for the following parameters: ammonia, nitrate/nitrite as N, nitrite as N, total nitrogen, and total phosphorus.	One monitoring location in the SMR Estuary. Not directly relevant to the identification of sources/stressors related to nutrients
2011 Long-Term Effectiveness Assessment (LTEA), San Diego Copermittees	Watershed priority constituents determined by Water Quality Assessment Monitoring Program; trends assessments; source attribution,	The 2011 LTEA characterized the source loading potential for various areas and activities across the San Diego Region.
Transitional Monitoring and Assessment Program Report for the Santa Margarita River Watershed Management Area (2014 - 2015)	Dry and wet weather receiving water trends.	One monitoring location
Monitoring Reports submitted under Agricultural Waiver, Upper SMR Irrigated Lands Group	General chemistry, wet and dry events.	Supplemented by loading estimates as characterized through SMRNIG modeling efforts. See Section **Error! Reference source not found.**.
Caltrans Public Education Litter Monitoring Study 2001-2002	Summary of results from storm water litter monitoring study conducted during the	Not directly relevant to the identification of sources/stressors related to nutrients.

Special Study Title	Type of Data	Notes
	2000 to 2001 storm season in Caltrans District 7.	
Caltrans Stormwater Monitoring and Research Program, Annual Data Summary Report 2002, 2008	Summary of all data generated from the Caltrans Stormwater Monitoring and Research Program during the 2006 to 2007 storm season for the following constituents: conventionals, nutrients, metals, hydrocarbons, and microbiologicals.	Supplemented by loading estimates as characterized through SMRNIG modeling efforts. See Section **Error! Reference source not found.**.
Caltrans Discharge Characterization Study Report (November, 2003)	Summary statistics of the following monitored constituents: conventional parameters (pH, temperature, TSS, TDS, conductivity, hardness, total organic carbon, and dissolved organic carbon), nutrients (nitrate, total kjeldahl nitrogen (TKN), orthophosphate-P, and TP), and total and dissolved metals (arsenic, cadmium, chromium, copper, lead, nickel, and zinc).	Supplemented by loading estimates as characterized through SMRNIG modeling efforts. See Section **Error! Reference source not found.**.
Caltrans Construction Sites Runoff Characterization Study Monitoring Seasons 1998-2002	Seasonal mean values of total and dissolved metals, and nutrients, conventional pollutants.	Supplemented by loading estimates as characterized through SMRNIG modeling efforts. See Section **Error! Reference source not found.**.
Geotracker Site 1120 T10000004268 (Camp Pendleton Marine Corps Base Site – 1120 Stuart Mesa)	Pesticides and metals analysis.	Data obtained from Geotracker Site did not include any nutrient data to evaluate this location as a source of nutrients. However, as shown in **Error! Reference source not found.**, modeling work performed as part of the SMRNIG demonstrates that this site may be a significant source of nutrients in the Lower SMR Subwatershed.

Appendix 3B – Potential Strategies to Address the HPWQC

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Appendix 3B.
Potential Water Quality Improvement Strategies

Permit Provision B.2.e requires Copermittees to identify potential strategies that can result in improvements to water quality in MS4 discharges and/ or receiving waters. The Permit stipulates that structural and non-structural BMPs, including incentive or other programs, may be implemented within the SMR WMA to address the HPWQC; retrofits may be implemented to reduce MS4 sources of pollutants or stressors, and rehabilitation may be implemented to protect and/or improve conditions in receiving waters.

It is expected that a phased approach to implementation will be based primarily on non-structural solutions, with structural solutions considered where non-structural approaches are not demonstrating achievement of goals.

Considering that some strategies can address similar sources, the sources were grouped into the following land use categories:

- Residential areas and activities;
- Commercial/Industrial;
- Parks and recreation;
- Orchards, Vineyards, Nurseries, and other Agriculture; and
- Horse Ranches.

RESIDENTIAL AREAS AND ACTIVITIES

Residential land uses make up approximately 35% of the land uses in the SMR watershed. Coupled with approximately 20-70% of the dry weather loading to the MS4, depending on the jurisdiction, these areas will be one of the key sources addressed by the implementation strategies ultimately selected by the Copermittees. Sources of nutrients within residential areas generally focus on landscape maintenance (e.g., fertilizer application) and irrigation, with irrigation return flows being the main transport mechanism for nutrients. In the areas of the watershed where there is a predominance of residential sources, eutrophication and nutrient loading are a dry weather issue, so strategies are generally focused on areas and activities under the dry condition. While the potential strategies have been developed to address eutrophication and nutrients, many of them will directly address sources of dry weather flow, thereby providing reductions for constituents affecting priority water quality conditions as well (e.g., bacteria reductions will benefit recreational uses). Key potential strategies to address eutrophication and nutrient loading from residential areas during dry weather are included in **Table 1**.

COMMERCIAL/INDUSTRIAL

Commercial land uses make up only 1% of the land uses in the SMR watershed but these areas have the potential to contribute approximately 1-13% of the nutrient loads in the watershed during dry weather. Although not as prevalent as residential areas, these areas are one of the more significant sources in several jurisdictions and will be addressed by implementation strategies. (Of note, commercial and industrial sources are not inclusive of commercial nurseries for the purposes of the source characterization and strategy selection.) Sources of nutrients within commercial areas generally focus on landscape maintenance (e.g., fertilizer application) and irrigation, with irrigation return flows being the main transport mechanism for nutrients. However depending on the type of commercial or industrial facilities, other outdoor areas and activities have the potential to contribute to nutrient loading. Examples include materials storage (e.g., fertilizers, compost), waste storage (e.g., trash, grease areas), illegal washing (e.g., restaurant mats), and illegal dumping (e.g., mop water). In the areas of the watershed where there are many commercial sources, eutrophication and nutrient loading are a dry weather issue, so strategies are generally focused on areas and activities under the dry condition. While the potential strategies have been developed to address eutrophication and nutrients, many of them will directly address sources of dry weather flow, thereby providing reductions for constituents affecting priority water quality conditions as well. Key potential strategies to address eutrophication and nutrient loading from commercial and industrial areas during dry weather are included in **Table 1**.

PARKS AND RECREATION

Parks and recreation land uses make up only 1% of the land uses in the SMR watershed. These areas also have relatively low estimated dry weather loads (0-2.5%) but are often owned and maintained directly by Copermittees within the watershed. Therefore, where parks and recreation areas are significant contributors, jurisdictions will implement strategies to address these sources. Sources of nutrients within parks and recreation areas are similar to residential areas, and generally focus on landscape maintenance (e.g., fertilizer application) and irrigation, with irrigation return flows being the main transport mechanism for nutrients. In the areas of the watershed where there are parks and recreation related sources, eutrophication and nutrient loading are a dry weather issue, so strategies are generally focused on areas and activities under the dry condition. While the

potential strategies have been developed to address eutrophication and nutrients, many of them will directly address sources of dry weather flow, thereby providing reductions for constituents affecting priority water quality conditions as well. Key potential strategies to address eutrophication and nutrient loading from parks and recreation areas during dry weather are included in **Table 1**.

ORCHARDS, VINEYARDS, NURSERIES, AND OTHER AGRICULTURE

Agricultural land uses comprise approximately 7% of the land uses in the SMR watershed. Orchards, vineyards, nurseries, and other agriculture discharging to the MS4 may be subset of the 7% but can also fall within residential areas of the watershed. Estimates are that these uses contribute as little as 0% of the loading in some jurisdictions but as much as 56% in others, depending on the distribution of these sources. Where orchards, vineyards, nurseries, and other agricultural areas are significant contributors of nutrient loading to the MS4, jurisdictions will implement strategies to address these sources. In area such as Rainbow Creek, strategies focusing on commercial nurseries will be significant in addressing nutrient loads. Sources of nutrients within orchards, vineyards, nurseries, and other agricultural areas generally focus on irrigation return flows being the main transport mechanism for nutrients. However, in Rainbow Creek, these sources have been show to contribute nutrient loads in wet weather as well. While nutrient loading from these areas will generally be addressed by strategies focused on dry weather, strategies in Rainbow Creek will address both dry and wet conditions. Many of the strategies will directly address sources of nutrient loading under dry and wet conditions (e.g., flow and materials storage, respectively), but will also provide reductions for constituents affecting priority water quality conditions (e.g., bacteria in dry weather flow, transport of trash or pesticides in wet weather). Key potential strategies to address eutrophication and nutrient loading from orchards, vineyards, nurseries, and other agricultural areas during dry and wet weather are included in **Table 1**.

HORSE RANCHES

Horse ranches are a unique land use that may fall under the general umbrella of agricultural land uses (7% of the land uses in the SMR watershed) or under residential land uses. Loading estimates during dry weather range from 0 – 10% depending on their prevalence within the jurisdiction. Where horse ranches are significant contributors of nutrient loading to the MS4, jurisdictions will implement strategies to address these sources. Nutrients coming from horse ranches could be from a variety of sources, but in dry weather would most likely focus on irrigation return flows being the main transport mechanism for nutrients. Other sources could include material storage (e.g., manure storage or compost) and illegal washing within facilities. Many of the strategies will directly address sources of nutrient loading under dry conditions (e.g., irrigation flows, illegal washing), but may also provide benefits in wet weather (e.g., material storage), and will provide reductions for constituents affecting priority water quality conditions (e.g., bacteria in dry weather flow). Key potential strategies to address eutrophication and nutrient loading from horse ranches during dry weather are included in **Table 1**.

Table 1. Key Potential Strategies to Address Eutrophication and Nutrient Loading from Source Categories

Potential Strategy	Source Categories				
	Residential	Commercial/ Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries, and other Agriculture	Horse Ranches
Illicit Discharge, Detection, and Elimination (IDDE) Program (Prov D.2, E.2)					
Maintain storm water conveyance system map to facilitate IDDE program.	X	X	X	X	
Utilize municipal personnel and contractors to identify and report Illicit Connections and Discharges.	X	X	X	X	X
Updated focused training for municipal field staff.	X	X	X		
Address septic system failures where observed.	X	X	X	X	
Facilitate public reporting of incidental observation of Illicit Connections and Illicit Discharges (e.g., via email).	X	X	X	X	X
Bilingual hotline to provide better customer service.	X	X	X	X	X
Implement practices and procedures to address spills with the potential to enter the storm drain system.	X	X	X	X	X
Utilize municipal personnel and contractors to monitor storm water outfalls for discharges of potential Illicit Connections and Illicit Discharges.	X	X	X	X	X
Develop and implement a strategy for investigating and addressing Illicit Connections and Illicit Discharges.	X	X	X	X	X
Implement an inspection and enforcement program to ensure compliance with regulation and IDDE requirements.	X	X	X	X	X
Refer homeless issue complaints to law enforcement or appropriate jurisdictions.	X	X	X	X	X
Respond to homeless issue complaints with law enforcement and other agencies to remove trash and debris.	X	X	X	X	X
Responsible Compassion for the Homeless Program to address homeless problems throughout the jurisdiction, thereby reducing their impacts on water quality through trash, illegal dumping, and direct discharge of human waste.	X	X	X	X	X

Potential Strategy	Source Categories				
	Residential	Commercial/ Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries, and other Agriculture	Horse Ranches
Plot IDDE incidents in GIS to identify clusters where targeted education, community outreach, or workshops may be effective in eliminating dry weather flows.	X	X	X	X	X
Update ordinances to reflect current illicit discharge and connections requirements and strategies.	X	X	X	X	X
Develop a standardized approach to allow staff to more efficiently identify and report IDDE incidents.	X	X	X	X	X
Enhanced municipal training programs and curriculum targeting key field staff. Programs will focus on the water quality improvement plan, HPWQCs, NNE requirements as related to illicit discharges and elimination of dry weather flows.	X				
Implement a District right-of-way inspection program to identify and report Illicit Connections and Discharges.	X	X			
Respond, educate and require mitigation on septic system failures where observed. Coordinate investigations with regulatory agency for septic systems. Focus on elimination of nutrient loading from phosphorus sources and bacteria loading to MS4 from septic failure. Educate property owners on proper septic maintenance and the importance of eliminating discharges to the MS4.	X	X	X	X	
Post signage adjacent to open channels providing information to report any observed illicit discharges. Signage will focus on sources of non-stormwater discharges such as illegal dumping and over-irrigation.	X	X	X	X	
Development Planning (Prov D.2)					
Priority Development Projects (PDPs): In addition to requirement for all development projects, implement or require implementation of onsite structural BMPs to control pollutants and manage hydromodification for PDPs.	X	X	X	X	X
Update BMP Design Manual procedures to specify storm water requirements applicable to development and redevelopment projects, identify and design appropriate BMPs, establish maintenance criteria, and establish where implemented alternative compliance options.	X	X	X	X	X

Potential Strategy	Source Categories				
	Residential	Commercial/ Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries, and other Agriculture	Horse Ranches
Conduct internal (staff) training on the updated BMP Manual.	X	X	X	X	X
Impose legal authority to ensure all development and redevelopment projects are in compliance with all post construction requirements.	X	X	X	X	X
Update codes, ordinances, and storm water design standards consistent with the permit and the updated BMP Manual.	X	X	X	X	X
For all development projects, administer a program to ensure implementation of source control BMPs to minimize pollutant generation at each project and implement LID BMPs to maintain or restore hydrology of the area, where applicable and feasible.	X	X	X	X	X
Smart Irrigation Conditions of Approval	X	X			
Revised post-construction guidelines to eliminate dry weather discharges from new and redevelopment	X	X			
Require new development projects to develop and submit a Storm Water Quality Training Manual for employees.		X			
Delineate Jurisdictional Areas on Development Plans	X	X	X	X	X
Update BMP Design Manual to include soil mix specifications for Bioretention BMPs to retain nutrients.	X	X	X	X	X
Prepare drought tolerant Guidelines and Standards for new development and BMP retrofits (e.g. water smart irrigation controllers, turf replacements programs, residential landscape evaluation program).	X	X	X	X	X
Develop a NPDES DATA FORM for Design Teams to identify project-related NPDES data to facilitate: identification of HPWQC and PWQP sources, analyze HPWQC and PWQP source reduction in CEQA/NEPA document, and design of post-construction BMPs to address HPWQC and PWQPs loading reduction and hydromodification.	X	X	X	X	X

Potential Strategy	Source Categories				
	Residential	Commercial/ Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries, and other Agriculture	Horse Ranches
Modified Low Impact Development requirements for new and redevelopment to specifically address nutrients during dry and wet weather through increased use of disconnected impervious surfaces, on-site retention of dry weather flows, and treatment of stormwater prior to discharge.	X	X	X	X	X
Construction Management (Prov E.4)					
Require implementation of BMPs that are site specific, seasonally appropriate and appropriate to the construction phase, year round.	X	X	X	X	X
Impose legal authority to ensure inventoried construction projects are in compliance with all requirements.	X	X	X	X	X
Provide internal staff training related to construction storm water management.	X	X	X	X	X
Administer a program to oversee implementation of BMPs during the construction phase of land development. Includes inspections at an appropriate frequency and enforcement of requirements.	X	X	X	X	X
Implement, or require the implementation of, enhanced construction BMPs on specific projects.	X	X	X	X	X
Provide enhanced focus on specific items during construction inspections.	X	X	X	X	X
Delineate Jurisdictional Areas on Project Sites	X	X	X	X	X
Make updates to ordinances related to construction; reference to existing grading ordinance and requirement to implement enhanced BMPs to mitigate erosion and dry weather flows to MS4 and receiving waters in the SMR.	X	X	X	X	X
Ensure grading activities are classified as HIGH priority if land is surrounded by or was previously used for agricultural operations.				X	
Existing Development Management (Prov E.5)					
Maintain and update a watershed-based inventory of existing development (i.e. commercial, industrial, municipal and residential areas).	X	X	X		

Potential Strategy	Source Categories				
	Residential	Commercial/ Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries, and other Agriculture	Horse Ranches
Improve the tracking of watershed based inventories via consolidated database.	X	X	X	X	X
Designate a minimum set of BMPs required for all existing development inventories, including special event venues. The designated minimum BMPs must be specific to facility or area types and pollutant generating activities, as appropriate.	X	X	X	X	X
Pet waste management and outreach.	X		X		
Implement a schedule or operation and maintenance activities for the storm water conveyance system and related structures.	X	X	X	X	X
Implement a schedule of operation and maintenance for paved and unpaved roads.	X	X	X	X	X
Promote and encourage implementation of designated BMPs in residential areas.	X				
Conduct inspections of inventoried existing development to ensure compliance.	X	X	X	X	X
Conduct focused residential inspections based on strategic assessments.	X				
Develop a residential inspection tracking program via mobile platform - miles, violations, etc.	X				
Improve inspections data tracking through mobile phone applications.	X	X	X	X	X
Enforce legal authority established for all inventoried existing development to achieve compliance.	X	X	X	X	X
Promote incentive program for BMP retrofits (e.g. water smart irrigation controllers, turf replacements programs, residential landscape evaluation program).	X	X	X	X	X
Turf replacement in parks.			X		
Promote the implementation of equestrian BMPs and distribute outreach material.					X
Notify Regional Board of industrial businesses subject to the Industrial General Permit so that the businesses may obtain coverage as required.		X			

Potential Strategy	Source Categories				
	Residential	Commercial/ Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries, and other Agriculture	Horse Ranches
Adjustments to street sweeping frequencies and routes, as determined by jurisdiction.	X	X			
Enhanced municipal training programs and curriculum targeting key field staff. Programs will focus on the water quality improvement plan, HPWQCs, NNE requirements as related to illicit discharges and elimination of dry weather flows.	X	X	X	X	X
Install weather based irrigation controllers in public landscaped areas.			X		
Enhance commercial/industrial/municipal inspections programs to focus on irrigation systems.		X			
Enhance residential inspections programs to focus on over-irrigation.	X				
Increase inspection frequencies at facilities identified on Copermittee inventories to be sources of nutrients	X	X		X	
Maintain the as-built capacity/lines and grades of existing flood control facilities. Maintenance activities include sediment and debris removal, slope and erosion repairs, side-slope tracking and/or reshaping, vegetation maintenance, structure rehabilitation and/or replacement, rip-rap and grout repair, removal and replacement of concrete channel linings, and washout backfill and repair.	X	X	X	X	X
Inspection and outreach program to eliminate dry weather flows from target areas	X	X	X	X	X
HAZMAT Response Program support	X	X	X	X	X
Enhance the Business Registration Program by educating owners on Nutrient and other PWQP source reduction.		X			
Require implementation of BMPs to address application, storage, and disposal of pesticides, herbicides, and fertilizers on commercial, industrial, agricultural (e.g., large commercial nurseries), residential, and municipal properties. Includes education, verifying permits and certifications.	X	X	X	X	

Potential Strategy	Source Categories				
	Residential	Commercial/ Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries, and other Agriculture	Horse Ranches
Enforcement Response Plans (Prov E.6)					
Implement escalating enforcement responses to compel compliance with ordinances, permits, contracts, orders, and other requirements for IDDE, development planning, construction management, industrial/commercial, municipal, and residential development (including residential equestrian and livestock activities)	X	X	X	X	X
Enforce Legal Authority on development projects to ensure that projects comply with post-construction BMP requirements.	X	X			
Implement Enforcement Response Plan, per JRMP, to address IDDE incidents.	X	X			
Require the use of BMPs to prevent or reduce the discharge of Pollutants into the MS4 from Stormwater	X	X	X	X	X
Ensure that private construction activities comply with the Construction General Permit and Copermittees' Stormwater Ordinances.	X	X	X	X	X
Enforce escalating legal authority established for all inventoried existing development, including residential and agricultural, to conserve water and eliminate dry weather flows. Verbal warnings shall be tracked along with written escalating enforcement.	X	X	X	X	X
Report suspected agriculture operation "non-filers" to the Regional Board promptly. Maintain database of reported "non-filers".				X	X
Public Education and Participation (Prov E.7)					
Implement a public education and participation program to promote and encourage development of programs, management practices and behaviors that reduce the discharge of pollutants in storm water prioritized by high risk behaviors, pollutants of concern, and target audiences.	X	X		X	
Educational Workshops on Integrated Pest Management, manure management and others as needed.	X	X	X	X	X
Collaborate with watershed partners to develop consistent messaging to targeted audiences, such as	X	X			

Potential Strategy	Source Categories				
	Residential	Commercial/ Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries, and other Agriculture	Horse Ranches
commercial residents to conserve water and reduce dry weather flows.					
Outreach to mobile landscaping service providers.	X	X			
Give outreach presentations to elementary, middle, and high school students.	X				
Provide municipal staff training.	X	X	X	X	X
Enhanced outreach programs targeting nurseries				X	
Enhanced outreach programs targeting animal facilities				X	X
Enhanced outreach programs targeting homeowner's associations/residential communities.	X				
Coordinate/develop outreach materials in support of Co-Permittee enhanced inspection, outreach & enforcement programs	X	X	X	X	X
Develop a webpage	X	X	X	X	X
Private Property Watercourse Management Fact Sheet	X	X	X	X	X
Implement pet waste management outreach in parks for resident pet owners.	X		X		
Stock public counters at municipal offices with Pollution Prevention Public Education brochures. Brochures should highlight the importance of proper fertilizer use/application and over irrigation. Other brochures should include emphasis on proper septic maintenance and other good practices to prevent nutrient and other PWQP loading to the MS4 and receiving waters. Provide brochures to other agencies for their public counters as well (e.g., School Administration Buildings).	X	X	X	X	X
Facilitate public reporting, through outreach and public education, of Illicit Connections and Illicit Discharges, including over-irrigation.	X	X	X	X	X
Enhanced outreach materials focused on sources of nutrients (e.g., door hangers, pamphlets, other media). Outreach materials will focus on non-stormwater discharges to the storm drain system (e.g., outdoor water	X	X	X	X	X

Potential Strategy	Source Categories				
	Residential	Commercial/ Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries, and other Agriculture	Horse Ranches
usage, the effects of over-irrigation, and specific BMPs they can implement to reduce runoff from over-irrigation).					
Other Potential Strategies					
Implement dry weather infiltration, diversion to sanitary sewer, or treatment at outfalls to eliminate non-stormwater discharges to the MS4.	X	X	X	X	X
Promote Incentive Programs: Rain Barrel, Live Turf Replacement & Outdoor Water Efficiency. Promote Incentive Programs for BMP Retrofits.	X	X	X	X	X
Implement a program that provides rebates or incentives for pumping onsite wastewater treatment systems.	X	X	X	X	X
Implement a Green Streets Retrofits Program.	X	X	X		
Flood Control Channel Rehabilitation Projects (e.g., removal of impervious lining in flood control channel and replacement with earthen or vegetated surface).				X	
Identify candidate areas of existing development for stream, channel, and/or habitat rehabilitation projects and facilitate implementation of such projects.	X	X	X	X	X
Develop and implement a residential inspections program. Areas covered would include mainly rural residential and some urban residential.	X				
Enhance public education and outreach for residents.	X	X	X	X	X
Increase inspection frequency for highest nutrient pollutant potential businesses within the Santa Margarita Watershed.		X			
Coordinate with Riverside County Transportation during review of an encroachment permit to support an integrated mitigation project.	X	X	X	X	X

Potential Strategy	Source Categories				
	Residential	Commercial/ Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries, and other Agriculture	Horse Ranches
Coordination with Water Districts to pinpoint and address problem sources of dry weather flows; potential implementation actions could include rebate/incentive programs, irrigation retrofits, or other programs as appropriate and effective.	X	X			
Coordination with Water Districts on inspection and enforcement efforts.	X	X			
Coordination with Riverside County Flood Control and Water Conservation District to install waste receptacles at or around channels with public access roads/trails.			X		
Establish semiannual meetings among Engineering and Community Services District to evaluate opportunities for improving water quality at MS4s, streets, parking lots, parks and other landscaped areas.			X		
Establish semiannual meetings to discuss potential ordinance changes.	X	X	X	X	X
Establish semiannual meetings among CIP staff to identify opportunities to rehabilitate channels or habitats.	X	X	X	X	X
Regional inspector to inspect areas watershed-wide for anthropogenic sources of dry weather flows.	X	X	X	X	X
Streambed protection and critical area planting	X	X	X	X	X
Provide funding and support for future phases of the Murrieta Creek Army Corp of Engineers project	X	X	X	X	X
Infiltration Testing at District Basins and/or outfalls private basin sites to provide data to assess the feasibility of regional recharge facilities or individual infiltration BMPs	X	X	X	X	X
Education and reporting to reduce yard waste dumping	X	X	X	X	X
A private partnership to engage the public, promote educational programs and a community cleanup.	X	X	X	X	X
Detention Basin located upstream of I-15. Requires an evaluation for basin suitability.	X	X	X	X	X

Potential Strategy	Source Categories				
	Residential	Commercial/ Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries, and other Agriculture	Horse Ranches
Construct and manage the Integrated Mitigated Project This project will result in the creation of over 1,500 linear feet of new intermittent channel and seasonal wetlands. The 75-acre site is located south of Scott Road and west of Briggs road in the County of Riverside. The project will preserve, restore and enhance the existing un-named creek (which is tributary to Warm Springs Creek), ephemeral drainages, and associated wetland habitats. This project provided the required 2.3 acres mitigation for 3 capital projects, but is planned to have approximately 71.6 acres of surplus mitigation in the form of Habitat Enhancement, Created Habitat, Preserved Habitat or Restored Habitat for this un-named creek. In total the project is planned to install approximately 2,800 plants, including Oak trees, Sycamore riparian, Southern Willow Scrub, existing channel, and wetland species. Storm water run-on containing Nutrients and other PWQPs would be treated through infiltration and biofiltration.	X			X	X
Implement a Partnering Rebate Program for septic system maintenance, with a focus in Target Areas.	X	X	X	X	
Implement a Partnering Program with Sewering Agencies to identify where sewer and storm water infrastructure are in close proximity and subsequently, confirm the absence of flow at nearby major outfall during dry weather for high risk areas.	X	X	X		
Implement a program for on-site wastewater treatment (septic) systems. May include mapping and risk assessment, inspection, or maintenance practices.	X	X	X	X	
Hold external land development workshops targeting the development community (developers and their engineers).	X	X	X	X	X
Implement outreach program for land owners of equestrian/livestock, and other agricultural operations.				X	X
Develop inspection data tracking through GIS applications.	X	X	X	X	X
Implement a turf replacement program in parks.			X		
Collaborate with partner agencies and groups to promote non-sponsored incentive programs for BMP retrofits, for example, smart controllers, soil sensors, turf replacement, etc.	X	X	X	X	X

Potential Strategy	Source Categories				
	Residential	Commercial/ Industrial	Parks and Recreation	Orchards, Vineyards, Nurseries, and other Agriculture	Horse Ranches
Implement Parks Improvement Program that will provide landscaping, irrigation, and on-site drainage improvements that will reduce the potential for pollutant discharges (e.g., irrigation runoff, fertilizer) from municipal parks.			X		

Appendix 4A – Rainbow Creek Watershed Modeling and Compliance Analysis

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Appendix 4A

Rainbow Creek Compliance Analysis

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1.0 INTRODUCTION

This technical appendix presents the Rainbow Creek Compliance Analysis conducted by Tetra Tech Inc., to support development of the Santa Margarita River Watershed Water Quality Improvement Plan (WQIP). Numeric water quality targets were identified to demonstrate compliance with the Rainbow Creek nutrient TMDL and the County of San Diego's (County's) Municipal Separate Storm Sewer Permit (Permit). A compliance analysis was then conducted to determine the extent of subwatershed-scale strategies needed to achieve the numeric water quality targets.

1.1 SANTA MARGARITA RIVER WATERSHED MANAGEMENT AREA WQIP

A WQIP is currently being developed for the Santa Margarita River Watershed Management Area (WMA) to meet the applicable MS4 permit requirements. To guide and prioritize implementation efforts, the WQIP established a process for identifying the Highest Priority Water Quality Conditions (HPWQCs) in the WMA. This process ranked Rainbow Creek as a HPWQC because Rainbow Creek is the only 303(d) listed water body with an adopted Total Maximum Daily Load (TMDL) in the Santa Margarita River watershed. To address the Rainbow Creek nutrient impairments, a compliance analysis was conducted to identify the recommended water quality improvement strategies and associated planning-level costs.

1.2 COMPLIANCE ANALYSIS SCOPE

Nutrient impairments in Rainbow Creek were identified as the HPWQC for the Santa Margarita River WQIP. A compliance analysis was conducted to demonstrate how the County can comply with the MS4 permit by implementing strategies to achieve the nutrient load reductions necessary to support water quality improvements, especially from developed areas within the County. Baseline nutrient loads, allowable loads, and required load reductions were estimated using the recently updated Santa Margarita HSPF watershed model, which includes the Rainbow Creek watershed. Strategies specifically identified to address nutrient loading in the Rainbow Creek watershed were modeled to demonstrate compliance with the calculated numeric targets. This analysis provides reasonable assurance that the strategies identified will result in the necessary reductions in nutrient loading in the watershed.

The compliance analysis focused first on actionable projects to address runoff both into and from the County's MS4 drainage area. Within each outfall catchment, all areas including residential urban land uses, nurseries, Caltrans and other land uses were identified. To inform comprehensive, watershed-scale decision making, the compliance analysis also identified strategies to address nutrient loading which the County can pursue to improve overall watershed health and meet compliance.

2.0 WATER QUALITY CONDITIONS AND NUMERIC TARGETS

2.1 WATERSHED PROFILE

Rainbow Creek is a tributary to the Santa Margarita River and is located near the unincorporated community of Fallbrook in northern San Diego County (**Figure 2-1**). The Rainbow Creek watershed is designated in the Basin Plan as hydrologic unit subareas (HSAs) 902.22 and 902.23, and encompasses 7,085 acres (San Diego Regional Water Quality Control Board 2005).

Rainbow Creek runs through the middle of Rainbow Valley and the community of Rainbow. Rainbow is the most developed part of the watershed, including residential areas, commercial and private nurseries, and other agricultural operations. While the majority of the watershed is located in San Diego County, a 1,514-acre portion of Riverside County also drains to the creek.

The key sources of nutrients in Rainbow Creek are state highways, agricultural fields and orchards, commercial nurseries, residential and urban areas, and septic tank disposal systems (Figure 2-2). These sources contribute nutrients via stormwater runoff, irrigation return flows, and groundwater contributions to the creek (San Diego Regional Water Quality Control Board 2005).

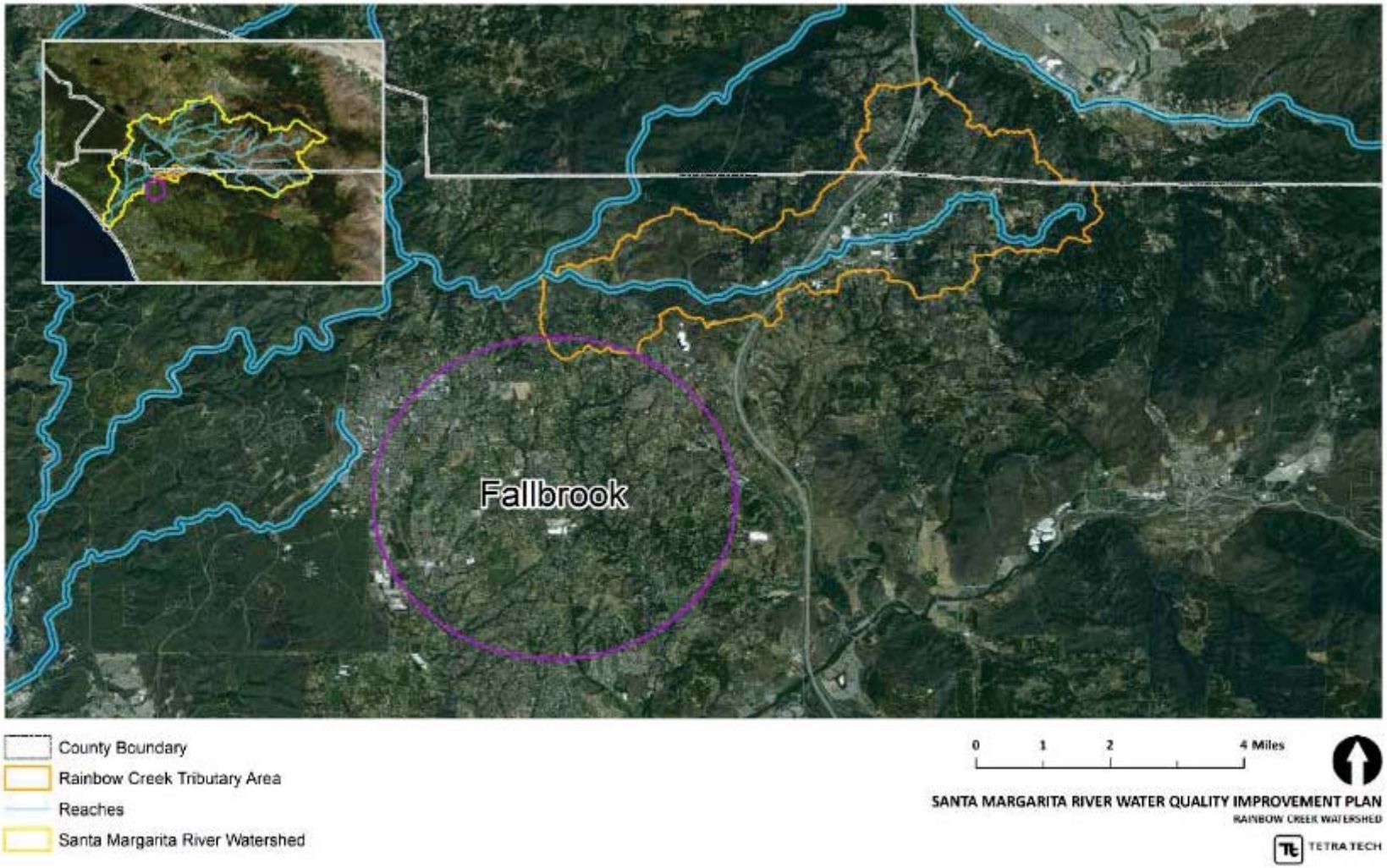

Figure 2-1. Rainbow Creek watershed

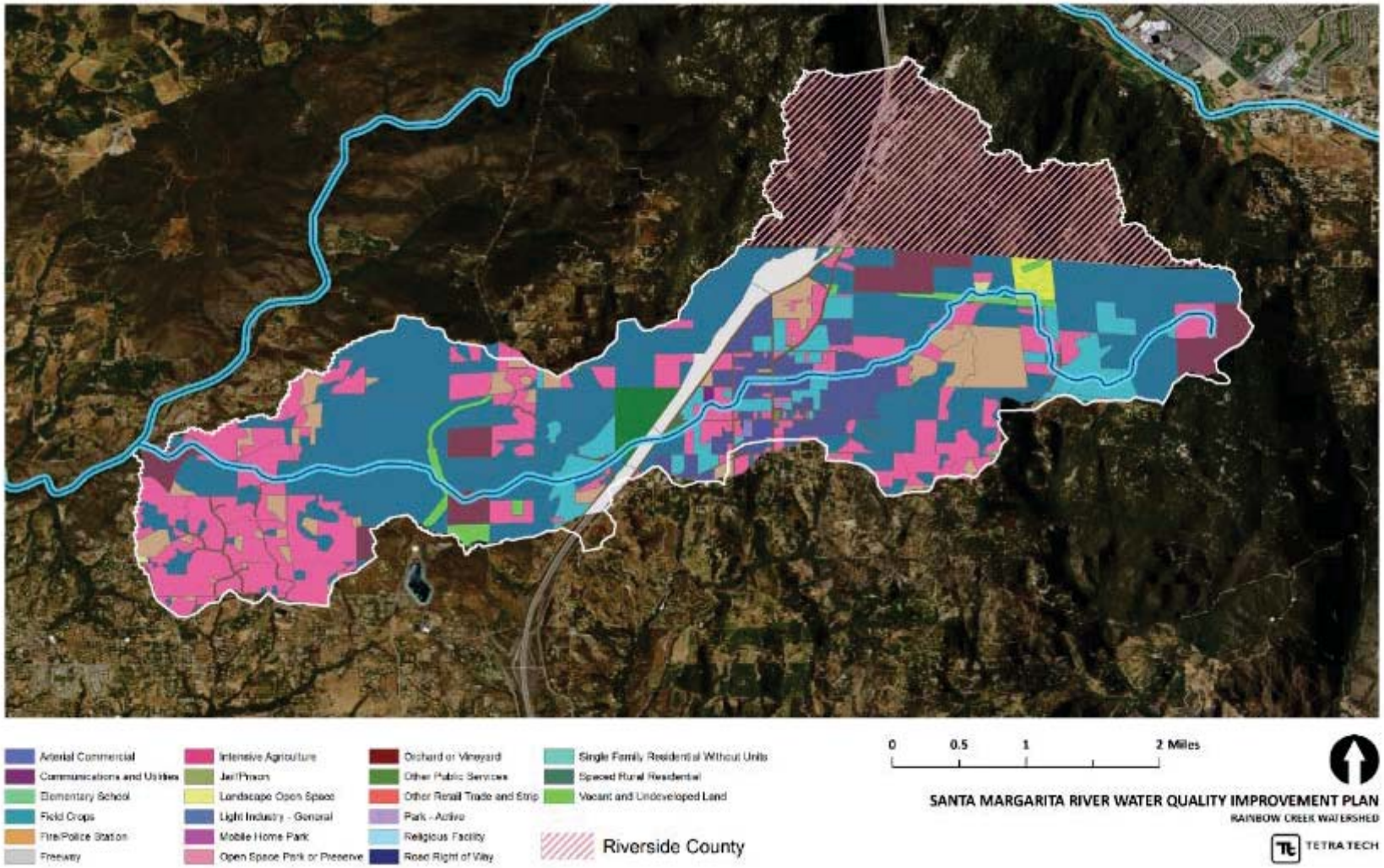

Figure 2-2. Rainbow Creek watershed land uses (Source: SANDAG 2016)

2.2 REGULATORY BACKGROUND

This section provides a brief background on the regulations that affect Rainbow Creek and provide the foundation for calculating the WQIP numeric targets. Note that waste load allocations referenced in the MS4 Permit and TMDL, which were established on the basis land use loading data available at the time, are presented for reference only. Updated waste load allocations (and numeric targets) were calculated to support the compliance analysis using the Rainbow Creek output from the recently updated Santa Margarita River watershed model (discussed further in Section 2.3).

2.2.1 Rainbow Creek Watershed TMDL

On February 9, 2005, the San Diego Water Board adopted Resolution No. R9-2005-0036, A Resolution Adopting An Amendment To The Water Quality Control Plan For The San Diego Region (9) To Incorporate Total Maximum Daily Loads (TMDLs) For Total Nitrogen and Total Phosphorus In The Rainbow Creek Watershed, San Diego County (Rainbow Creek TMDL). The affected beneficial uses identified in the TMDL include municipal water supply (MUN), contact and non-contact water recreation (REC-1 and REC-2), warm and cold freshwater habitat (WARM and COLD), and wildlife habitat (WILD). The TMDL numeric targets for nitrate, total nitrogen (TN), and total phosphorus (TP) were set equal to the water quality objectives for municipal water supply (nitrate) and biostimulatory substances (TN and TP) as defined in the Basin Plan (**Table 2-1**).

The Rainbow Creek TMDL indicates that 79% of TN loading and 70% of TP loading are attributable to controllable sources, which include certain land use activities (commercial nurseries, agricultural fields, orchards, residential areas, urban areas, and park areas), septic tank disposal systems (TN only), and Interstate 15 (I-15) (San Diego Regional Water Quality Control Board 2005; **Table 2-2**).

Table 2-1. Rainbow Creek TMDL numeric targets

Constituent	Water quality objective (WQO) = Numeric Target	Note
Nitrate as nitrogen (NO_3-N) [1]	10mg/L	Inorganic nitrate WQO for municipal water supply
Total nitrogen (TN)	1.0mg/L	Numeric goals in the Basin Plan
Total phosphorus (TP)	0.1mg/L	Numeric goals in the Basin Plan

[1] Although the numeric targets are included in the TMDL, LAs and WLAs were not developed for nitrate.

Table 2-2. Rainbow Creek TMDL source assessment

Source	TN Mass Load (kg N/yr)	Percent Contribution (% N)	TP Mass Load (kg P/yr)	Percent Contribution (% P)
Land Uses Runoff	2,662	69	262	66
Background	779	20	116	29
Septic Tank	200	5	0	0
I-15 Runoff (Caltrans)	153	4	14	4
Direct Atmospheric Deposition	40	1	2	1
Combined Sources	3,834	100	394	100

The Rainbow Creek TMDL represents the "amount of a pollutant that a waterbody can receive without violating applicable water quality standards. It is the sum of the allowable loads of a pollutant from all contributing point and nonpoint sources plus a margin of safety" (p. 32 of the Final Technical Report). The TMDL includes the following equations:

- TMDL/load capacity = Margin of safety (MOS) + Background load + ∑(WLA) + ∑(LA)
- Allowable load = TMDL – MOS

The Rainbow Creek nutrient TMDLs were not calculated based on modeling results, rather they were estimated based on a variety of data sources as summarized below (Appendix E to the Final Technical Report includes details on the TMDL technical approach):

- Annual flow volumes were calculated using daily median flow rates from U.S. Geological Service (USGS) records (1989 – 2000; however only data of 8 years were used) for Rainbow Creek near sampling station Willow Glen-4 (Gage No. 11044250)
- 3 flow rate tiers and associated annual flow volumes were developed (**Table 2-3**)
- TMDLs were calculated based on the flow tier results and various nutrient data sources (reference stream monitoring data and land use loading coefficients).

Table 2-3. TN and TP TMDL/load capacity calculation (modified Tables E-3 and E-4 in Appendix E)

Flow tier	Corresponding flow rate (cfs)	Total No. of days (for 8 years)	% of total days	Mean daily flow volume for Tier (cfd)	Avg. No. of days per year	Annual flow volume (cf)	TN TMDL/load capacity[1] (kg/yr)	TP TMDL/load capacity[1] (kg/yr)
Low flow	0-2.9	2,475	86	56,575	314	17,764,622	503	50
Moderate-high flow	3-39	365	12.7	880,546	46	40,775,379	1155	115
Very high flow	>40	37	1.3	9,971,027	5	46,805,255	See footnote[2]	See footnote[2]
Total					365		1,658	165

[1] Numeric target x annual flow volume
[2] Excluded in the TMDL calculation because this flow tier was considered to represent extreme weather conditions

Background loads were estimated via the flow tier approach and reference stream data (Appendix D to the Final Technical Report).

- Calculated based on reference concentrations in San Diego streams and Rainbow Creek annual flow volumes (using the flow tier approach)
- City of San Diego monitoring data from 2001 to mid-2003 at 12 streams and 1997-1998 San Vicente Reservoir study data
- Ammonia, nitrite, nitrate, total Kjeldahl nitrogen, ortho-phosphate, TN, and TP; TN and TP are available only in 2003. For the rest of the years, TN = nitrate + nitrite +TKN
- Average TN concentration = 0.47 mg/L
- Average TP concentration = 0.07 mg/L

Table 2-4. Rainbow Creek TMDL background load calculation

Flow Tier	Annual flow volume (cf)	TN background load (kg/yr)	TP background load (kg/yr)
Low flow	17,764,622	236	35
Moderate-high flow	40,775,379	543	81
Very high flow	46,805,255	See footnote[1]	See footnote[1]
Total		779	116

[1] Excluded in the TMDL calculation because this flow tier was considered to represent extreme weather conditions

Table 2-5. Calculated annual TN/TP surface water loads to Rainbow Creek from various land uses (Tables 4-1 and 4-3 of the Final Technical Report)

Land use	Area (acres [ha])	N-export coefficient (kg/ha/yr)	Annual TN load (kg/yr)	P-export coefficient (kg/ha/yr)	Annual TP load (kg/yr)
Commercial nurseries	339 (137)	3.7	507	0.2	27.4
Agricultural fields	436 (177)	3.7	655	0.2	35.4
Orchards	781 (316)	2.5	790	0.2	63.2
Park	5 (2)	3.4	7	0.1	0.2
Residential	618 (250)	2.6	650	0.5	125
Urban	34 (14)	3.8	53	0.8	11.2
Total	6,591 (2,668)		2,662		262

The Rainbow Creek TMDL includes discussion of the calculation of existing loads in the source assessment section and Appendix F to the Final Technical Report.

- Load Allocations (LAs)
  - Commercial nurseries, agricultural fields, orchards, park, residential areas, and urban areas: using TN/TP export coefficient values from the literature (**Table 2-5**)
  - Septic tank disposal systems: equal to groundwater load (calculated using nitrogen concentration and flow data during dry weather conditions from the Oak Crest-3 Station)
  - Air deposition: TN 40 kg/yr and TP 2 kg/yr; an atmospheric deposition rates of 10 kg N/ha/yr and 0.6 kg P/ha/yr (USEPA 1994) were applied to approximately 4 hectares of the surface area of Rainbow Creek (15 mile length and an average width of 5 ft)
- Waste Load Allocations (WLAs)
  - Caltrans highway runoff: TN and TP concentrations from Caltrans 2003, CTSW-RT-03-065 (3.13 mg N/L; 0.29 mg P/L)
  - Also includes UFPS: 2% of the TMDL – not existing load by the definition

The Rainbow Creek TMDL existing loads, load allocations, and percent reductions are summarized in Table 2-6.

Table 2-6. 2005 Rainbow Creek TMDL existing loads, load allocations, and percent load reductions for TN and TP

	TN				TP			
	Existing load (kg/yr)	*Percent contribution (%)*	Load allocation (kg/yr)	Load reduction (%)	Existing load (kg/yr)	Percent contribution (%)	Load allocation (kg/yr)	Load reduction (%)
WLAs								
Caltrans	153	*4*	49	*68*	14	*4*	5	*64*
UFPS	-	-	33	-	-	-	3	-
LAs								
Commercial nurseries	507	*13*	116	*77*	27.4	*7*	3	*90*
Agricultural fields	655	*17*	151	*77*	35.4	*9*	4	*90*
Orchards	790	*21*	182	*77*	63.2	*16*	6	*90*
Park	7	*0*	3	*50*	0.2	*0*	0.1	*50*
Residential areas	650	*17*	149	*77*	125	*32*	12	*90*
Urban areas	53	*1*	27	*50*	11.2	*3*	6	*50*
Septic tank disposal systems	200	*5*	46	*77*	0	*0*	0	*0*
Air deposition	40	*1*	40	*0*	2	*1*	2	*0*
WLAs + LAs			796				41	
Background load	779	*20*	779	-	116	*29*	116	-
MOS	-	-	83				8	
TMDL			1,658				165	
Combined sources	3,834	*100*			394	*100*		

Sources: Tables 4-B, 4-D.1, and 4-D.2 (San Diego Water Board 2005)

2.2.2 MS4 Permit Appendix E

On May 8, 2013, the San Diego Water Board adopted Order No. R9-2013-0001; NPDES No. CAS 0109266, National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems Draining the Watersheds within the San Diego Region (MS4 Permit). Appendix E to the MS4 Permit outlines the TMDL compliance requirements (San Diego Regional Water Quality Control Board 2015), which include receiving water and effluent limitations. The TMDL concentrations are the same as the numeric targets in **Table 2-1**. Final effluent limitations were also expressed as annuals loads in MS4 discharges to Rainbow Creek (Table 2-7).

Table 2-7. Final effluent limitations expressed as annual loads in MS4 discharges to Rainbow Creek

Land use	TN (kg/yr)	TP (kg/yr)
Commercial nurseries	116	3
Park	3	0.1
Residential areas	149	12
Urban areas	27	6

Source, Table 3.3 of Attachment E to the MS4 Permit

Compliance with the final WQBELs can be demonstrated via one of the following:

(a) No direct or indirect discharge
(b) No exceedance of the final receiving water limitations (**Table 2-1**) in the receiving water or downstream of MS4 outfalls
(c) No exceedance of the final concentration-based effluent limitations (**Table 2-1**) at the MS4 outfalls
(d) No exceedance of the final load-based effluent limitations (**Table 2-4**) at the MS4 outfalls
(e) WQIP implementation: Demonstrate that implementation of BMPs achieves (a), (b), (c), “and/or” (d) above

2.3 ESTABLISHING NUMERIC COMPLIANCE TARGETS

Since establishment of the Rainbow Creek TMDL, additional water quality monitoring data have been collected to inform the establishment of baseline loading and load reduction targets for areas draining into and from the MS4 in the watershed. This section discusses how the recently updated Santa Margarita River watershed model was used to establish new waste load allocations and numeric targets for the Rainbow Creek compliance analysis. This analysis provides a reasonable assurance that the remedies to be proposed in the Water Quality Improvement Plan will result in satisfying the requirements of the Rainbow Creek Nutrient TMDL.

2.3.1 Updated Watershed Model and Allocations

As part of a stakeholder-led nutrient investigation for the Santa Margarita estuary and river, the HSPF watershed model was recently updated and recalibrated. SCCWRP and Tetra Tech developed a model application report in 2016 that documents the model updates that were completed at the time (Sutula et al. 2016). Since that time, additional model updates were completed to better represent land uses within San Diego County, updated surface water/ground water exchanges based on the Camp Pendleton MODFLOW model, and enhanced weather data to drive the model simulation (Tetra Tech 2017a; Tetra Tech 2017b; Tetra Tech 2017c). This effort included additional calibration of the Rainbow Creek watershed to support the WQIP compliance analysis and future updates to the TMDL. The updated model was used to calculate numeric targets for the Rainbow Creek compliance analysis, rather than using the previously calculated TMDL and MS4 permit nutrient loads and allocations.

Baseline at-source and delivered nutrient loads within the Rainbow Creek watershed were tabulated from the HSPF time-series modeling results. The analysis focused on Water Year (WY) 2003, which is considered to be an "average" or representative water year, consistent with other San Diego Region WQIP compliance analyses. WQIP compliance was determined based on reducing baseline (existing) nutrient loads to meet the estimated allowable loading. Nutrient compliance targets were established based on the receiving water and effluent limitations specified in the TMDL, MS4 permit, and Basin Plan water quality objectives: 1 mg/L for TN and 0.1 mg/L for TP. These limits were tabulated with respect to total hourly flow from the MS4 outfalls to calculate the total allowable loading for WY 2003, and likewise the required reduction.

Numeric compliance targets for the County were, therefore, established by tabulating net at-source (surface runoff) loading and reduction targets, calculated as the difference between modeled loading and hourly sums of allowable loads, given modeled flow rates.

2.3.2 Baseline Loading, Allowable Loads, and Load Reduction Targets

The model and methodology described above were used to generate the baseline loads, allowable loads, and load reduction targets reported in **Table 2-8**, which includes the baseline surface nutrient loading by source from the HSPF model. These data suggest that the majority of at-source loading within the Rainbow Creek watershed stems from non-point sources or areas outside outfall catchments, indicating that nurseries and non-point sources contribute significantly to the total nutrient loading in the Rainbow Creek watershed.

The loads were parsed between outfalls and all other remaining area within the Rainbow Creek watershed (also generically referenced as non-point source loading).

For all areas, only *at-source* surface loading was considered because these loads represent runoff and nutrient contributions that are discharged as "effluent" to receiving waters. The at-source loads also enable equitable comparison between strategies modeled in the following compliance analysis; whereas, the analysis would be confounded if it considered the delivered loads to the watershed outlet (which are influenced by groundwater and surface water loads that originate from point and non-point sources). Furthermore, given the resolution of the modeling system, it was assumed that all at-source surface flow within any catchment area drains to Rainbow Creek, even if the outfall is located upstream.

Table 2-8. Baseline Nutrient Loading, Calculated Allowable Loads, and Load Reduction Targets

Rainbow Creek Area	Area (ac)	Modeled Loading and Numeric Target Summary for WY 2003[1]					
		TN			TP		
		Baseline TN Load (lb)	Allowable TN Load (lb)	Reduction Target (lb and %)	Baseline TP Load (lb)	Allowable TP Load (lb)	Reduction Target (lb and %)
	5,970	5,596	1,421	4,175 (75%)	2,374	153	2,221 (94%)

[1] Metrics represent modeled at-source, surface loading allocated by hydrologic response unit area

In general, the estimated percent load reduction for TN and TP between the current model-based analysis and the Rainbow Creek TMDL (Attachment E to the MS4 Permit) were similar. For example, Table 2-8 shows the TN percent reduction for the outfall catchment area was 65%; whereas, the TMDL percent load reduction for MS4 areas ranged from 50-77% depending on land use type (Table 3.3 in Attachment E of the MS4 permit). TP showed a similar trend, although the current analysis indicated a higher required percent load reduction (92% versus 50-90% in Table 3.3 of Attachment E to the MS4 permit). As expected, estimated baseline loads, allowable loads, and required load reductions are very different between the current model-based analysis and the Rainbow Creek TMDL for various reasons, as discussed in the sections above. Loading estimates based on the recently updated and calibrated HSPF model for Rainbow Creek are expected to be more accurate and appropriate for the WQIP compliance analysis (similar to other WQIPs developed in the San Diego region).

3.0 WATER QUALITY STRATEGIES AND COMPLIANCE ANALYSIS

This section describes the methodology that was used to select, customize, and simulate strategies to achieve the required nutrient load reductions.

3.1 CUSTOMIZED STRATEGIES

A screening-level assessment of the watershed was performed to determine which strategies are most appropriate to address local conditions. This section discusses the recommended strategies and how they were represented in the compliance analysis.

3.1.1 Assessment of Watershed Constraints, Conditions, and Opportunities

To provide a robust and reasonable assurance of compliance, it is essential that the compliance analysis be founded on the basis of opportunities that are actually feasible within the watershed (i.e., instead of allowing the modeling tools to prescribe project types that may not necessarily be appropriate). A desktop assessment was performed to establish this foundation. Soil characteristics, groundwater depth, land use and transportation

typologies, public land availability, and environmental constraints were reviewed to inform the selection of strategies customized to local conditions.

A literature review was also conducted to understand past recommendations for nutrient management in Rainbow Creek. The findings were incorporated into the recommendations in the following subsections. Reviewed references included:

- Rainbow Creek Nutrient Reduction and Management Plan (NRMP): County of San Diego
- Basin Plan Amendment and Final Technical Report for Total Nitrogen and Total Phosphorous Total Maximum Daily Loads for Rainbow Creek
- Santa Margarita River Watershed Management Area Water Quality Improvement Plan, Provision B.2 Submittal: Priority Water Quality Conditions
- San Diego County MS4 Permit Attachment E.3: Specific Provisions for Total Maximum Daily Loads, Total Maximum Daily Loads for Total Nitrogen and Total Phosphorus in Rainbow Creek Watershed

The screening-level assessment revealed that opportunities to improve water quality using public parcels are sparse, with most public land being located in the downstream, less developed areas of the watershed (**Figure 3-1**). This finding implies that non-structural strategies may be essential to address nutrient loads and that distributed, linear control measures within the road rights-of-way may be needed to capture runoff before it discharges to Rainbow Creek (vis-a-vis regional capture strategies, which are not as feasible due to the absence of public parcels in strategic locations to intercept outfall discharges).

Furthermore, soils with poor permeability and high groundwater nutrient concentrations are generally present throughout the watershed indicating that infiltration-based strategies are generally unsuitable (**Figure 3-2**). As a result, infiltration-based strategies were avoided in this particular watershed to protect groundwater supplies from increased nutrient inputs. This means that flow-through and filtration strategies incorporating nutrient-sensitive design elements may be most effective.

Finally, it was observed that the creek itself has been heavily modified and denuded of riparian vegetation in the upper watershed; whereas, the reach downstream from the I-15 freeway remains heavily vegetated. This implies that despite the prevalence of public land in the downstream reach, restoration and in- or near-channel improvements to the upper reaches would likely make progress towards restoring the beneficial uses of Rainbow Creek and were considered important watershed-scale strategies in the compliance analysis.

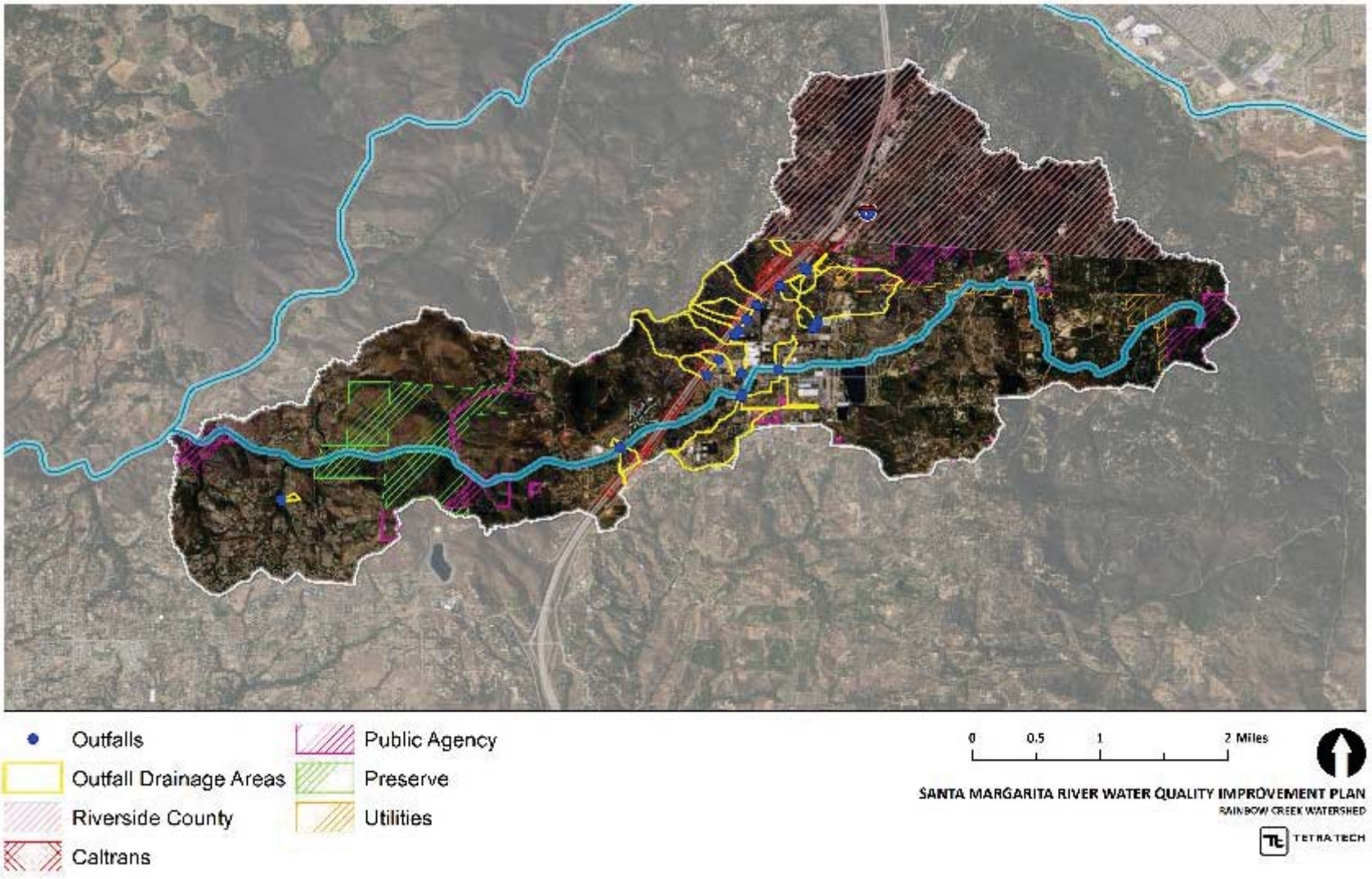

Figure 3-1. Overview of Rainbow Creek watershed strategy areas

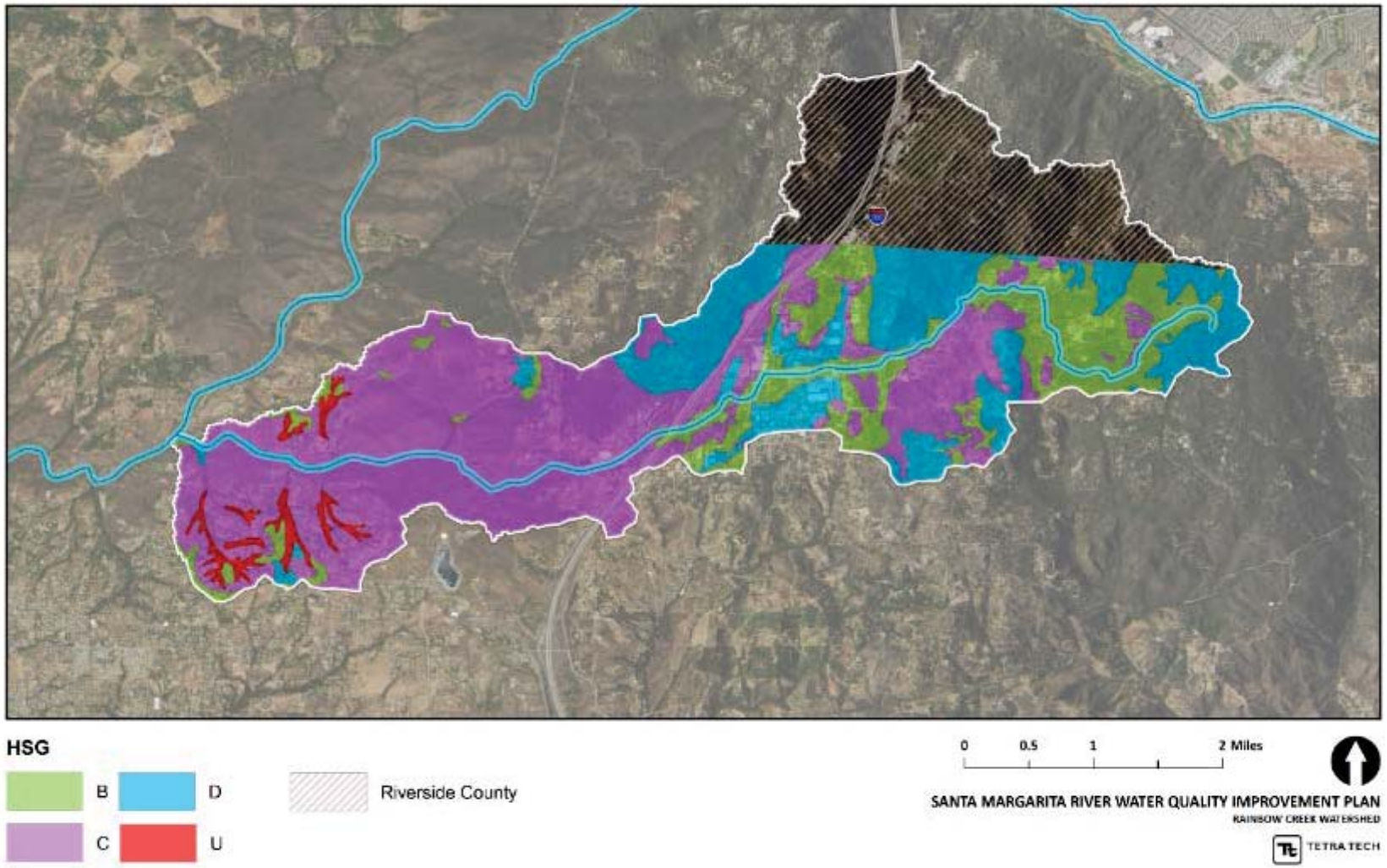

Figure 3-2. Hydrologic Soil Groups (HSG) in the San Diego County portion of Rainbow Creek watershed

3.1.2 Non-Structural Strategies

Non-structural strategies represent the first line of defense for management of stormwater pollutants. These institutional programs tend to be the most cost-effective options for water quality improvement because they focus on controlling the sources of pollution throughout the landscape before pollutants can be washed downstream by stormwater runoff. Maintenance and enhancement of non-structural strategies has been acknowledged by the San Diego Water Board to reduce pollutant loads by approximately 10% during development of previous WQIPs throughout the San Diego region (San Diego Regional Water Quality Control Board 2016b).

Non-structural strategies for Rainbow Creek should focus on source-control activities to reduce fertilizer runoff from private and public parcels (by means of enhanced education and enforcement; Figure 3-3), as well as channel maintenance to directly remove nutrient-laden sediment and organic matter. Together, these non-structural strategies were attributed a 10% reduction of TN and TP loading from the land surface (San Diego Regional Water Quality Control Board 2016b).

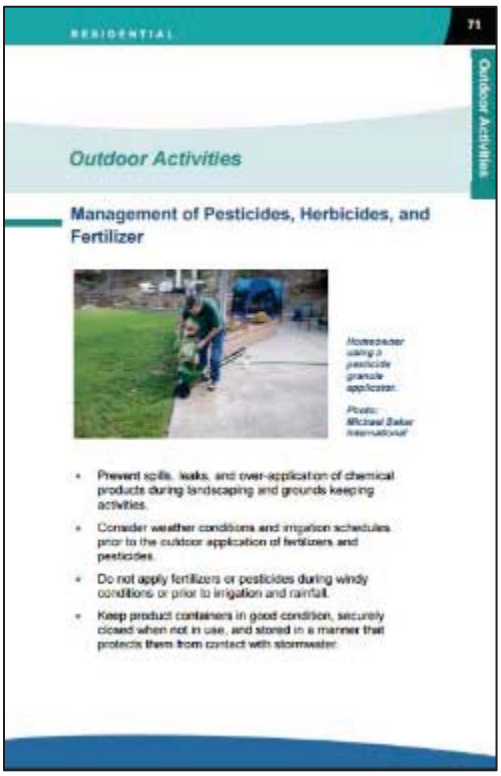

Figure 3-3. The County of San Diego has developed numerous pollution prevention education and outreach materials

The structural strategies proposed below were developed to supplement ongoing pollution prevention efforts. The NRMP outlines several waste control and cleaning practices for sources. Additionally, management practices for irrigation, nutrient control, and erosion and runoff are recommended for agricultural operations. The County's Department of Agriculture, Weights, and Measures (AWM) is authorized to respond to stormwater complaints and inspect commercial nurseries and greenhouse facilities to follow up that violations have been addressed and resolved.

3.1.3 Structural Strategies

Structural strategies are needed to assist with the reduction in nutrient loading to meet the requirements of the Rainbow Creek Nutrient TMDL. As described in the NRMP, these practices "serve to supplement source control and site design [best management practices]" (Michael Baker International 2016). The County of San Diego's Best Management Practice Design Manual (BMPDM) describes which structural strategies can be effective at targeting nutrient reduction, including vegetated filter strips, detention basins, wet ponds, and biofiltration (when designed with nutrient-sensitive media) (County of San Diego Department of Public Works 2016). An extensive body of peer-reviewed research agrees with the recommendations of the BMPDM, and also identifies stormwater wetlands, wetland swales, and stream restoration as effective nutrient management practices.

Given the constraints and conditions of the watershed discussed above in Section 3.1.1, nutrient-sensitive biofiltration was deemed the most appropriate strategy to address outfalls located upstream from Rainbow Creek; whereas, wetland channels are most appropriate for outfalls that discharge directly to Rainbow Creek and can be sited in the public right-of-way to intercept stormwater runoff. Stream restoration and near-channel improvements can also provide nutrient removal at a regional scale, albeit these projects would be located downstream of outfalls.

Table 3-1 provides a high-level summary of the recommended structural strategies. The following subsections describe additional details regarding nutrient removal mechanisms and model representation. Note that although the screening-level assessment deemed these appropriate strategies for this watershed, site-specific siting, sizing, and design specifications will be provided in the subsequent implementation plan.

Table 3-1. Summary of recommended structural strategies

	Recommended Structural Strategies		
	Nutrient-Sensitive Biofiltration	**Wetland Channels**	**Stream Restoration and Channel Improvements**
Type	Distributed	Distributed	Regional
Description	Shallow vegetated basins with engineered soil media and underdrains.	Vegetated areas that mimic natural physical and biological processes for capturing, storing, and treating runoff.	Augmentation or replacement of impacted habitat with equal or enhanced value to stream ecology.
Siting	At outfalls upgradient from receiving water	Along rights-of-way upstream from outfalls discharging to receiving water	Reaches of receiving water with impaired beneficial uses
Nutrient-Specific Design Components	Soil media must include minimal organic matter and residual nutrients. Underdrains should be upturned to create an anaerobic sump for denitrification	Saturated, anaerobic zones, dense vegetation, and long residence time should be provided to promote denitrification and phosphorus capture	Stream restoration should promote hyporheic exchanges and sediment capture.
Average Effluent Concentration or Efficiency	0.92 mg/L TN 0.089 mg/L TP	1.2 mg/L TN 0.092 mg/L TP	0.075 lb/yr TN and 0.068 lb/yr TP reduced per linear feet of restoration
References	Hunt et al., 2012; Leisenring et al., 2014; County of San Diego Department of Public Works 2014; County of San Diego Department of Public Works 2016	Caltrans 2010; Leisenring et al., 2014; CASQA 2003; Winston et al., 2012	Chesapeake Stormwater Network and Center for Watershed Protection 2014; County of San Diego Department of Public Works 2017

3.1.3.1 Nutrient-Sensitive Biofiltration

Nutrient-sensitive biofiltration is recommended to manage outfalls that are located upstream and do not directly discharge to Rainbow Creek because these areas tend to provide adequate relief to daylight the underdrain to the surface (preventing lengthy plumbing from the facilities to downstream conveyances). The Rainbow Creek watershed is conducive to biofiltration because soils have poor permeability and the groundwater table is generally shallow (which both tend to rule out infiltrating bioretention facilities).

Nutrient-sensitive biofiltration (BF-2 in the County BMP Design Handbook) applies principles of typical biofiltration BMPs by filtering stormwater through an engineered media, but the concept ensures that minimal fertilizer is applied to vegetation, includes very low concentrations of compost in soil media, and includes internal water storage (IWS) to promote a saturated, anaerobic zone for denitrification. Phosphorus is typically reduced via sediment capture and sorption to soil media. Vegetation within the basin can also uptake nutrients, although the intensity of uptake is not well understood. The IWS also enables a shallower invert depth such that the underdrain can be more easily tied into nearby infrastructure or daylighted to the ground surface. A typical cross section of biofiltration with IWS is shown in Figure 3-4 and photos are shown in **Figure 3-5**.

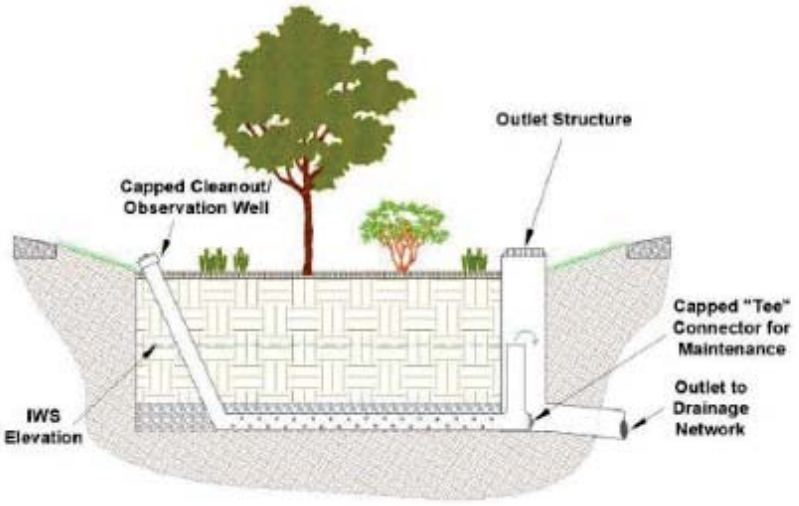

Figure 3-4. Typical biofiltration cross section, including IWS (from the San Diego County LID Handbook)



Figure 3-5. A biofiltration outlet structure showing upturned underdrains to create IWS (left) and biofiltration facility with cobbled surface cover in San Diego County (right). Source: Tetra Tech

3.1.3.2 Wetland Channel

Constructed wetlands have long been used to improve water quality. The Rainbow Creek watershed is well-suited for linear wetland channels (also known as wetland swales, wet swales, or vegetated rock filters depending on the design) along roadways because the high groundwater table will help sustain wetland vegetation and maintain saturated, anaerobic conditions for denitrification. The existing roadside ditches and concrete swales throughout the watershed could be retrofitted into constructed wetlands to capture nutrients while still conveying higher flows to Rainbow Creek.

Constructed wetlands function similar to biofiltration, in that they provide sedimentation, filtration, and biological transformations of pollutants; however, whereas biofiltration tends to provide *aerobic* soil near the ground surface to sustain upland vegetation, wetlands tend to maintain fully anaerobic soils to sustain wetland vegetation. System design can take on many forms depending on site constraints, including dividing the system into cells using baffles to control hydraulics and improve maintenance. To provide vector control, the systems can be designed such that captured stormwater flows laterally through subsurface gravel substrate and standing water is only present during wet weather (**Figure 3-6**). **Figure 3-7** shows example photographs of constructed wetland channels.

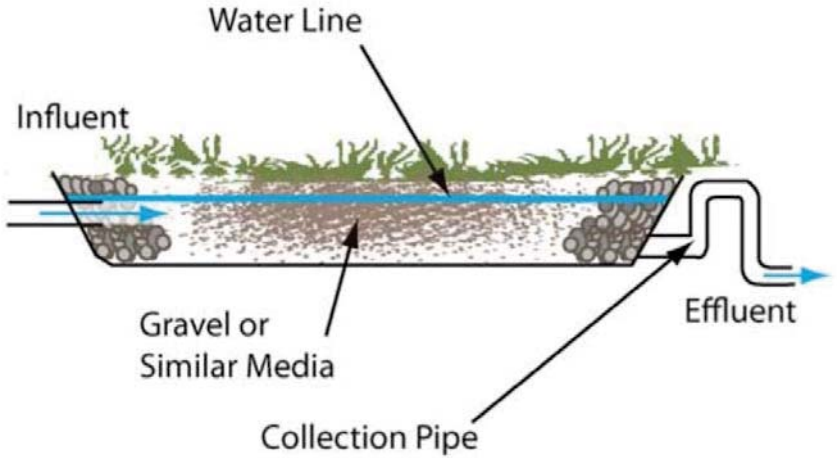

Figure 3-6. Example cross section of a subsurface gravel wetland for improved vector control (also called a vegetated rock filter) Source: Caltrans



Figure 3-7. A Southern California wetland channel (left) and a roadside wetland swale. Source: Tetra Tech

3.1.3.3 Stream Restoration and Channel Improvements

Rainbow Creek and its tributaries have been heavily impacted and degraded by development, including the removal of riparian vegetation and channelization of the creek. Stream restoration can be an effective strategy to help restore beneficial uses to degraded creeks and enhance nutrient capture and assimilation. Typical restoration projects include reshaping of the channel, installation of features to enhance fluvial processes, and replanting of riparian vegetation. For nutrient management, it is particularly important that the project attempt to restore the exchange of water in the hyporheic zone (the interface between surface water and groundwater in the bed of the channel, as shown in **Figure 3-8**) and include design elements to trap and immobilize sediment-born phosphorus. Projects can also include near-channel improvements to provide additional water quality and hydraulic benefits, such as construction of offline wetlands and basins to mimic historical floodplain functions.

Stream restoration is an accepted strategy for nutrient management in the Chesapeake Bay watershed, where an expert panel has developed a guidance document for attributing nutrient load reductions to restoration projects (Chesapeake Stormwater Network and Center for Watershed Protection 2014). Planning-level studies in Southern California substantiate the potential for stream restoration and near-channel features to provide comprehensive pollutant removal benefits (San Diego County 2017). While this strategy is inherently applied downstream from the outfall, the strategy strives to directly restore the beneficial uses of the receiving water while simultaneously reducing nutrient loads contributed by the outfall.

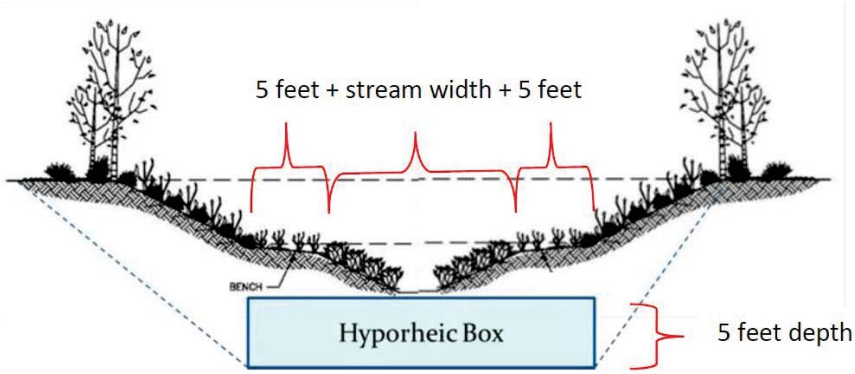

Figure 3-8. Cross section of a restored stream showing the hyporheic zone where biogeochemical reactions denitrify surface water and groundwater. Source: Chesapeake Stormwater Network and Center for Watershed Protection



Figure 3-9. Example photographs of a stream in a nutrient-sensitive watershed before (left) and after (right) restoration.

3.2 COMPLIANCE APPROACH

The goal of the WQIP is to demonstrate compliance with the MS4 Permit; therefore, the modeling approach first prioritized upstream strategies to address loads originating from outfalls (19 total in the watershed), then evaluated downstream strategies to address remaining excess loads contributed by other remaining areas. This approach provides permittees and regulators with information useful for decision making at the watershed-scale. The strategies discussed in the previous section were evaluated and customized to the conditions and scale of the treated areas so that cost-effective and actionable solutions could be recommended.

Consistent with other San Diego region WQIPs (San Diego Regional Water Quality Control Board 2016b), the compliance analysis was conducted using a customized version of EPA's System for Urban Stormwater Treatment and Analysis INtegration (SUSTAIN) to simulate long-term surface runoff capture and nutrient load reduction by strategies. Simulations were driven by the same baseline HSPF land surface loading data used to calculate the numeric targets. The customized version of SUSTAIN enabled simulation of average effluent concentrations from structural strategies to better represent water quality performance. In lieu of a one-size-fits-all sizing approach (which could result in overspending), SUSTAIN's optimization algorithms were used to guide selection of the level of implementation with the least cost to achieve the targets. Areas were optimized sequentially to prioritize upstream treatment. **Figure 3-10** depicts example results from the optimization process for one outfall; the chart shows how the most efficient green infrastructure size for TN reduction was selected from the cost-effectiveness curve. Despite the need for higher relative reductions of TP, the optimization was driven by TN load reduction because green infrastructure is more efficient at removing TP than TN. In other words, TN was considered the "limiting" pollutant for green infrastructure sizing.

The design of distributed green infrastructure was optimized with respect to the drainage area associated with each outfall selected for treatment resulting in cost-effective sizing recommendations for all outfall catchment areas. Once the optimum green infrastructure sizes were identified for the outfall areas, the analysis shifted to downstream opportunities. The compliance approach is shown conceptually in **Figure 3-11**.

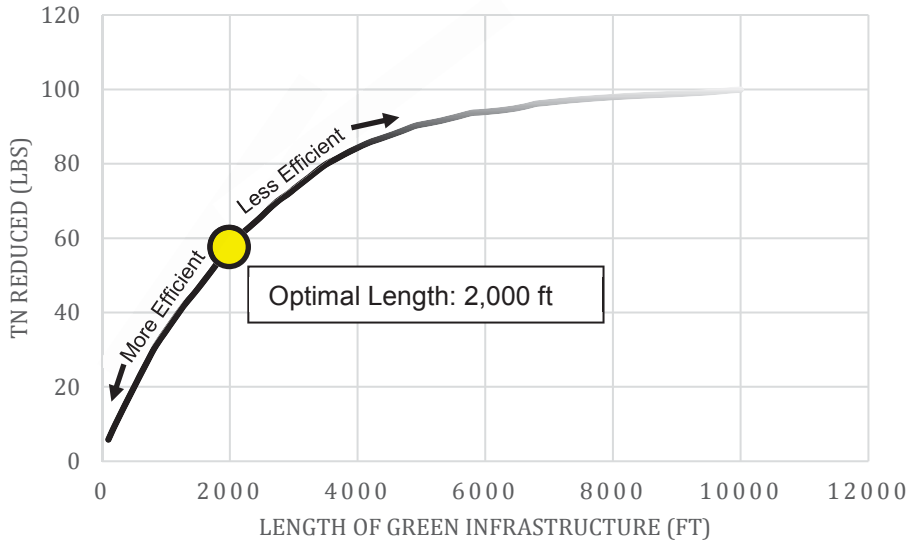

Figure 3-10. Example cost-effectiveness curve used to identify optimum sizing for one of the outfalls

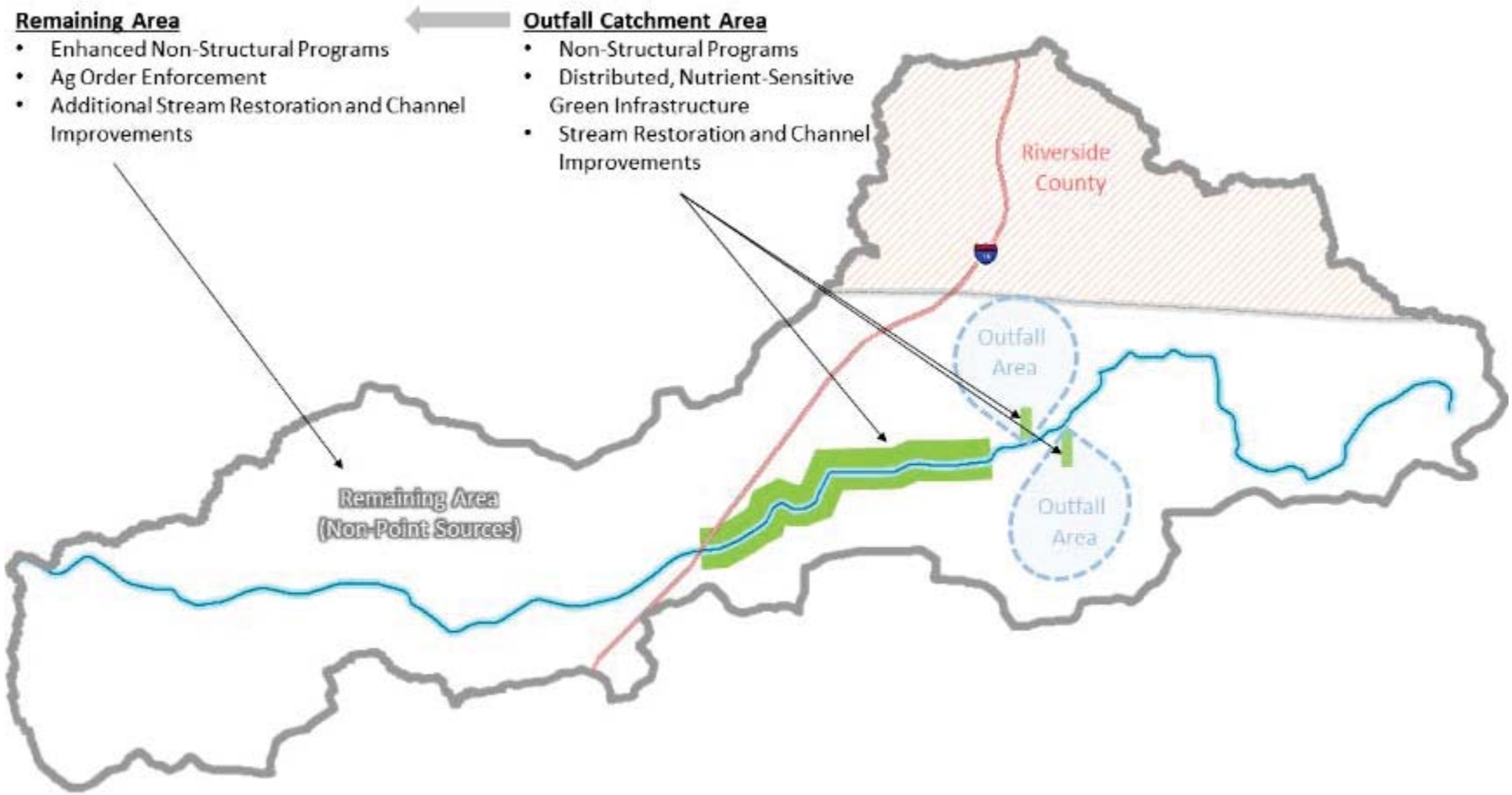

Figure 3-11. Conceptual figure showing modeling approach.

3.3 COMPLIANCE ANALYSIS RESULTS AND RECOMMENDATIONS

Treatment of the top 6 priority outfalls was targeted in the compliance analysis to support a cost-effective strategy, as discussed below. Furthermore, green infrastructure was optimized for load reduction at the outfall scale.

To demonstrate compliance, the following methodology was used to distribute the load reduction "credit":

1. Load reductions achieved by County-implemented non-structural programs and distributed green infrastructure were first attributed.
2. Stream restoration and channel improvements were then sized to capture the remaining targeted at-source loading.

Note that the recommended strategies below exceed the total load reduction targets for TP because the strategies are more efficient for TP capture. In other words, TN was the "limiting pollutant" despite TP having a higher relative reduction target in **Table 2-8**.

Table 3-2. Modeled Load Captured to Meet Compliance

Compliance Area	Strategy	Modeled TN Captured (lb/yr)	Modeled TP Captured (lb/yr)
Six Priority Outfalls	Non-Structural Programs	56	26
	Distributed Green Infrastructure or equivalent (Treating 6 Priority Outfalls)	150	96
	Stream Restoration and Channel Improvements or equivalent (Public-Private Partnerships)	161	156
	Subtotal	**367**	**278**
Stream	Stream Restoration	3,808	1,980
	Total	**4,175 (Target = 4,175)**	**2,258 (Target = 2,221)**

Table 3-3 shows the modeled nutrient reduction achieved with green infrastructure installed at every outfall, as well as installed only at the outfalls with the top 6 nutrient loadings (**Figure 3-13**), which comprise 77% of the total loading from all 19 outfalls. These 6 outfalls were prioritized for green infrastructure implementation to address nutrient loading from outfall catchment areas (as shown in **Figure 3-11**). Focusing on the top 6 outfalls contributing the largest nutrient loads significantly saves mobilization costs, relative to installing green infrastructure at every outfall that would result in only small additional load reductions (**Figure 3-12**). The remaining reduction requirements will be addressed through stream restoration.

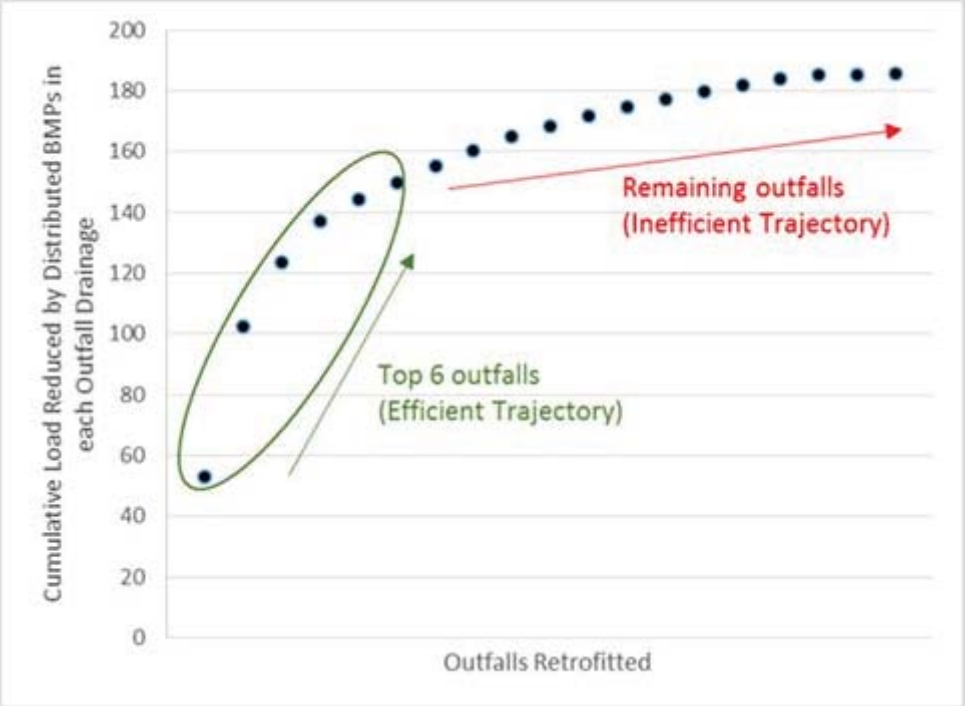

Figure 3-12. Cumulative load reduced by distributed BMPs, based on the number of outfalls retrofitted.

Table 3-3. Modeled Reduction from All Outfalls Compared with Prioritization of the Top 6 Outfalls

Outfall Extent	Optimum GI Area: Drainage Area Ratio [1]	TN				
		Outfall Target Reduction (lb)	Non-Structural Reduction (lb)	Reduction from Green Infrastructure (lb)	Total Reduction (lb)	% of Outfall Target Achieved
All Outfalls	0.267%	367	56	186	242	65.9%
Top 6 Outfalls	0.183%			150	206	56.1%

Outfall Extent	Optimum GI Area: Drainage Area Ratio [i]	TP				
		Outfall Target Reduction (lb)	Non-Structural Reduction (lb)	Reduction from Green Infrastructure (lb)	Total Reduction (lb)	% of Outfall Target Achieved
All Outfalls	0.267%	241	26	120	146	60.6%
Top 6 Outfalls	0.183%			96	122	50.6%

[1] Aggregate of all green infrastructure area over total outfall drainage area

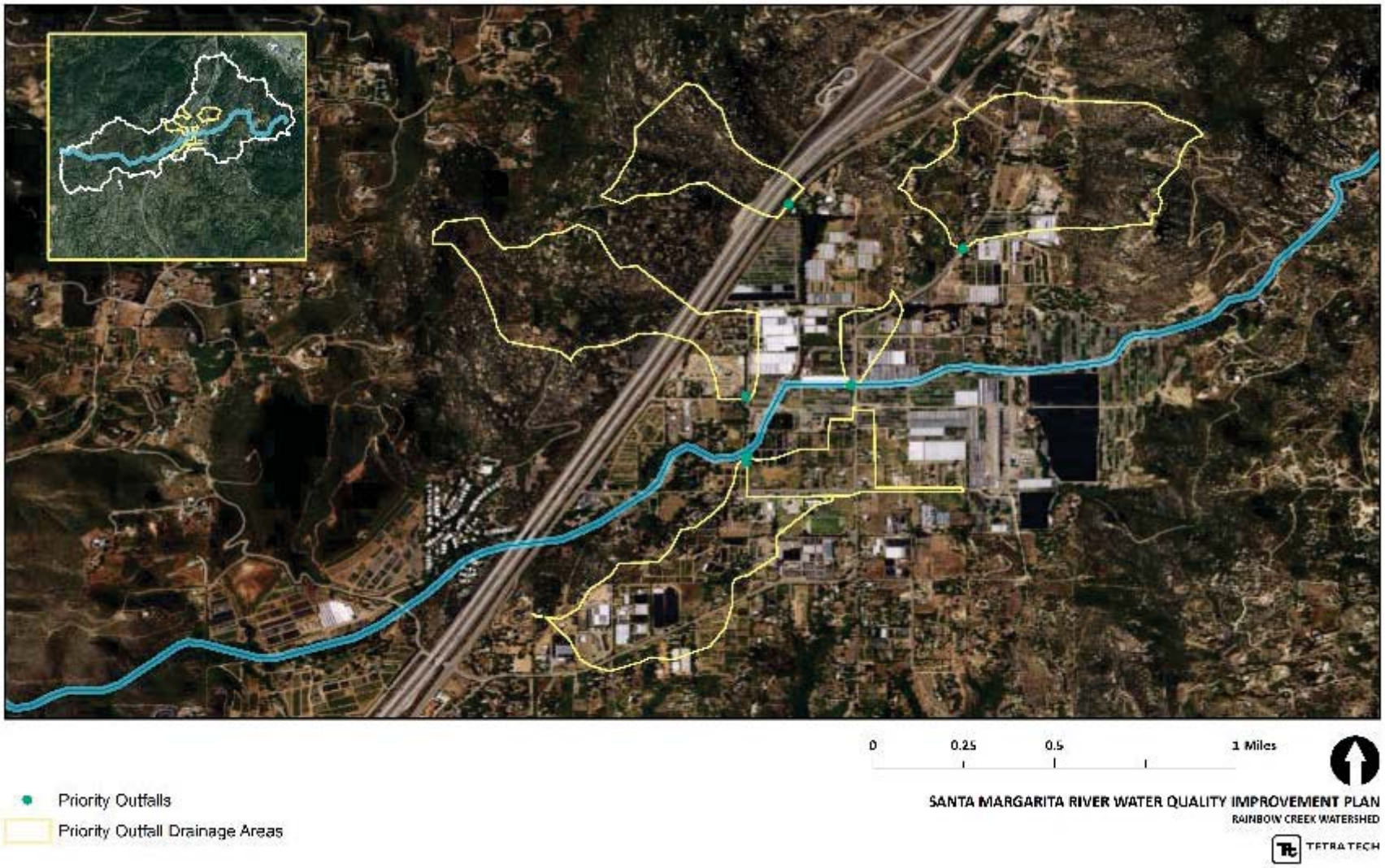

Figure 3-13. Outfalls Prioritized for Distributed Green Infrastructure

The modeling results indicate that a substantial portion of the nutrient loading from outfall catchment areas can be captured by strategically applying distributed green infrastructure at the outfalls. Stream restoration downstream of the outfall catchment areas can thus be sized primarily to capture the remaining at-source loading from these areas not captured by the distributed green infrastructure at the outfalls.

Table 3-2 lists the recommended strategies to manage excess loads based on the results of the compliance analysis. Note that these estimates will be updated during the adaptive management process. **Table 3-4** proposes the strategies needed to meet the TMDL compliance requirements of Attachment E.3, Table 3.3 of the MS4 Permit (San Diego Regional Water Quality Control Board 2015).

Table 3-4. Proposed Structural Strategies to Meet Compliance with Rainbow Creek TMDL

Strategy	Quantity[1]	Units	Scheduled Compliance
Nutrient-Sensitive Biofiltration (Based on six priority outfalls) or equivalent	0.21	acres	12/31/21
Wetland Channels (Based on six priority outfalls) or equivalent	0.39	acres	12/31/21
Stream Restoration and Channel Improvements or equivalent (Public-Private Partnerships)	2,143 [2]	linear feet	12/31/21

1. Note that quantities are based on planning-level, desktop analyses. Actual quantities will vary during implementation on the basis of site-specific designs, conditions, and constraints.
2. Sized based on rate of 0.075 lbs/ft/yr removed of TN (Chesapeake Stormwater Network and Center for Watershed Protection 2014)

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Appendix 4B – Watershed Management Area Analysis

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Santa Margarita Watershed Management Area Analysis

October 2018



Murrieta Creek downstream of 1st Street

Prepared by the Santa Margarita
Watershed Management Area
Co-Permittees

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1 Introduction

1.1 Background

On May 8, 2013 the California Regional Water Quality Control Board, San Diego Region (San Diego Water Board) adopted Order No. R9-2013-0001; NPDES No. CAS 0109266, National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds within the San Diego Region (Regional MS4 Permit). Order No. R9-2015-0001 extended the permit to Orange County Region 9 Co-Permittees on February 11, 2015 and Order No. R9-2015-0100 extended the permit to Riverside County Region 9 Co-Permittees. The Regional MS4 Permit, which became effective on June 27, 2013, replaces the previous MS4 Permits that covered portions of the Counties of San Diego, Orange, and Riverside within the San Diego Region. There were two main goals for the Regional MS4 Permit:

- To have more consistent implementation, as well as improve inter-agency communication (particularly in the case of watersheds that cross jurisdictional boundaries), and minimize resources spent on the permit renewal process.
- To establish requirements that focused on the achievement of water quality improvement goals and outcomes rather than completing specific actions, thereby giving the Co-Permittees more control over how their water quality programs are implemented.

To achieve the second goal, the Regional MS4 Permit requires that a Water Quality Improvement Plan (WQIP) be developed for each Watershed Management Area (WMA) within the San Diego Region. As part of the development of WQIPs, the Regional MS4 Permit provides Co-Permittees an option to perform a Watershed Management Area Analysis (WMAA) through which watershed-specific requirements for structural BMP implementation for Priority Development Projects can be developed for each WMA. This report presents the Co-Permittees' approach and results for the regional elements of the WMAA developed for the Santa Margarita River within the San Diego County area and the results of additional analysis that was developed for the Middle and Upper Santa Margarita River Watershed within the Riverside County area.

This Santa Margarita WMAA builds upon the work completed in the 2015 San Diego County Regional WMAA (Geosyntec Consultants and Rick Engineering Company, 2015). The regional analysis developed the tools for the Santa Margarita Region (SMR) Watershed Management Area (WMA) and began the mapping effort in the lower SMR. Figure 1-1 shows and overall map of the SMR. San Diego County's mapping elements can be found in the 2015 San Diego County Regional WMAA located in Attachment I.

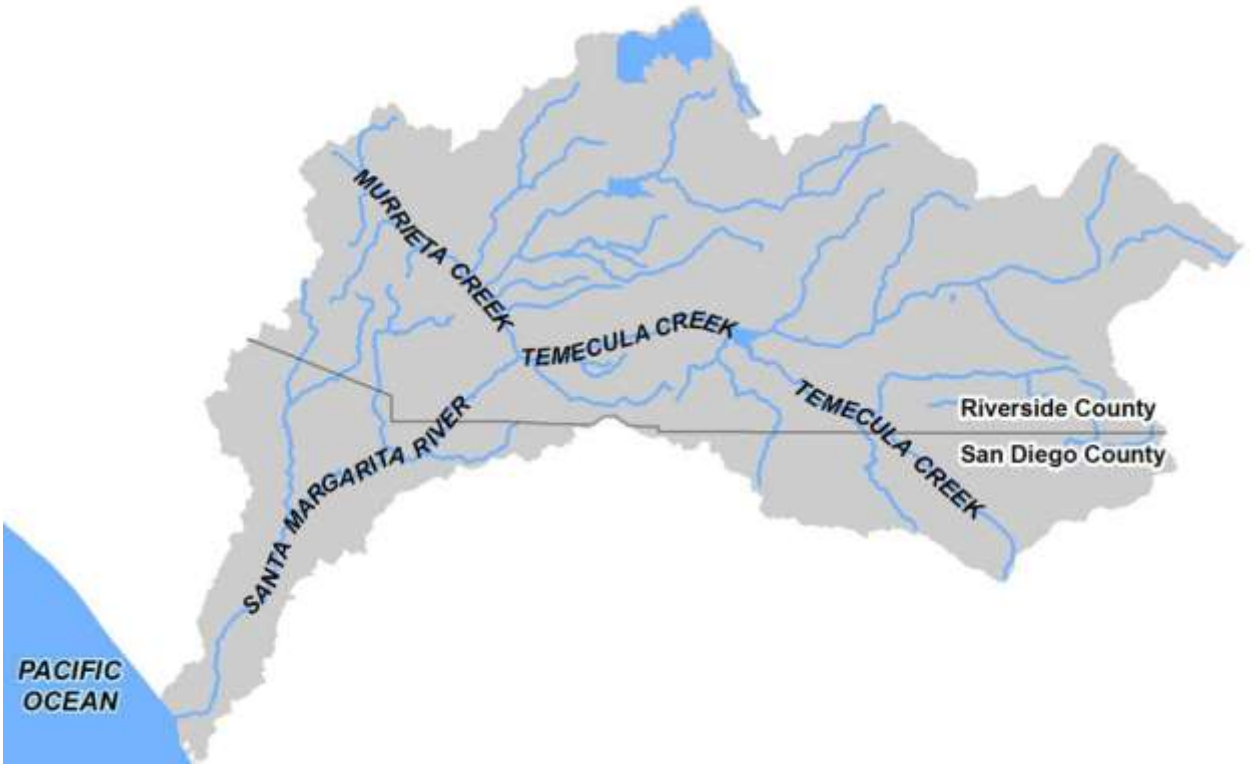


Figure 1-1. Santa Margarita River Watershed Management Area

1.2 Watershed Management Area Analysis

The Regional MS4 Permit, through inclusion of the WMAA, provides an optional pathway for Co-Permittees to develop an integrated approach for their land development programs by promoting evaluation of multiple strategies for water quality improvement and development of watershed-scale solutions for improving overall water quality in the watershed. The WMAA comprises the following three components as indicated in the Regional MS4 Permit:

- Perform analysis and develop Geographic Information System (GIS) layers (maps) by gathering information pertaining to the physical characteristics of the WMA (referred to herein as WMA Characterization). This includes, for example, identifying potential areas of coarse sediment supply, present and anticipated future land uses, and locations of physical structures within receiving streams and upland areas that affect the watershed hydrology (such as bridges, culverts, and flood management basins).
- Additionally, using the WMA Characterization maps, identify areas within the watershed management area where it is appropriate to allow for exemptions from hydromodification management requirements that are in addition to those already allowed by the Regional MS4 Permit for Priority Development Projects (PDP). The Co-Permittees shall identify such cases on a watershed basis and include them in the WMAA with supporting rationale to support claims for exemptions.
- Using the WMA Characterization results, compile a list of candidate projects that could potentially be used as alternative compliance options for Priority Development Projects.

Priority Development Projects (PDPs), at the discretion of the Co-Permittees, may participate in an alternative compliance program to provide greater overall water quality benefit to the watershed management area and offset Stormwater Pollutant Control Impacts and Hydromodification Control Impacts associated with the PDP. A PDP may be allowed to utilize alternative compliance in lieu of complying with the storm water pollutant control BMP performance requirements. The PDP must mitigate for the portion of the pollutant load in the design capture volume not retained onsite. If a PDP can utilize alternative compliance, flow-thru treatment control BMPs must be implemented to treat the portion of the design capture volume that is not reliably retained onsite.

For projects to participate in an Alternative Compliance Program, the WQIP must include the optional WMAA; and Water Quality Equivalency calculations must have been accepted by the San Diego Water Board's Executive Officer. The San Diego Water Board accepted the Water Quality Equivalency Guidance Document in December 2015. Furthermore, a fee structure program is required to complete the Alternative Compliance Program.

On December 17, 2015 the California Regional Water Quality Control Board accepted the Water Quality Equivalency Guidance Document and Water Quality Equivalency Automated Calculation Worksheets (WQE Guidance Documents). The effective date of the WQE Guidance Documents is the date of the acceptance letter and serves as the single, region-wide, applicable date after which Co-Permittee-approved alternative compliance projects may begin generating credits for potential future banking, tracking, trading, and selling. The WQE Guidance Documents form the regional and technical basis to determine the water quality benefits associated with BMPs implemented as part of an alternative compliance program. Since approval of the WQE Guidance documents, the Co-Permittees have convened a Technical Advisory Group of regional stakeholders to develop a credit framework for facilitating the use of alternative compliance in those jurisdictions. The current status of the credit framework is as follows:

1. Technical working group was established in 2016 to develop an Alternative Compliance Program for the subregion and gather input from Co-Permittees and the private sector.
2. Western Riverside Council of Governments (WRCOG) met with San Diego Regional Water Quality Control Board in August 2017 to introduce the technical working group, its findings, and plan to develop program.
3. Technical working group has developed a Draft Credit System Policy Manual handbook that will provide details on eligible project type, credits, credit eligibility, bank, and roles.
4. WRCOG has sent a request to Regional Board staff to present program and details to San Diego Regional Water Quality Control Board and acquire feedback.

1.3 Scope of Work for Regional WMAA and Middle and Upper Santa Margarita River Watershed (within Riverside County)

In July 2013, the Co-Permittees elected to fund a regional effort to develop elements of the regional WMAA for the nine San Diego-area WMAs within the County of San Diego that are currently subject to the Regional MS4 Permit, which include:

- Santa Margarita River (for portion in San Diego County)

- San Luis Rey River
- Carlsbad
- San Dieguito River
- Los Peñasquitos
- Mission Bay & La Jolla Watershed
- San Diego River
- San Diego Bay
- Tijuana River (for portion in San Diego County)

The regional-level information developed is intended to provide consistency across WMAs and serve as the foundation for developing watershed-specific information for each WMA to be developed through the WQIP process. The regional effort excluded the middle and upper portion of the Santa Margarita Watershed within Riverside County. Therefore, the scope of this WMAA will combine watershed specific information from the regional effort with additional studies performed on the Middle and Upper Santa Margarita Watershed within Riverside County. The regional WMAA will be used as a guide for developing information within Riverside County. This effort included:

- Development of GIS map layers that characterize the WMA using data previously collected, readily available, and provided by the Co-permittees, including:
- Description of dominant hydrologic processes, such as areas where infiltration or overland flow likely dominates;
- Description of existing streams in the watershed, including bed material and composition, and if they are perennial or ephemeral;
- Current and anticipated future land uses;
- Potential coarse sediment yield areas;
- Locations of existing flood control structures and channel structures, such as stream armoring, constrictions, grade control structures, and hydromodification or flood management basins;
- Development of a list of candidate projects for an optional alternative compliance program; and
- Development of additional criteria and analyses to support proposed exemptions that were originally developed in the approved 2013 Santa Margarita Region Hydromodification Management Plan.

The scope of work for the Middle and Upper Santa Margarita Watershed effort and the regional effort within San Diego County excluded performing analysis within the following areas unless data was readily available, as Co-Permittees do not have jurisdiction over these areas:

1. State Lands;
2. U.S. Departments of Defense land;
3. U.S. National Forest land;
4. U.S. Department of Interior land; and
5. Tribal lands.

1.4 Report Organization

This report references the regional WMAA for San Diego County for the Lower Santa Margarita River Watershed within San Diego County. Additional supporting information has been developed for the Middle and Upper Santa Margarita River Watershed to supplement the regional WMAA and provide a complete data set that covers the entire Santa Margarita River WMA. This report is organized as follows:

- Chapter 1 provides the project background and purpose.
- Chapter 2 describes the technical basis for characterizing the WMA.
- Chapter 3 describes potential candidate projects for the Middle and Lower Santa Margarita Watershed.
- Chapter 4 summarizes the analyses performed to support reinstating select exemptions from hydromodification control requirements for PDPs.
- Chapter 5 presents the WMAA conclusions.
- Chapter 6 presents the references used for the WMAA.
- Chapter 6 presents the Glossary used for the WMAA.
- Attachments A-F presents the exhibits for watershed management area characterization within the Santa Margarita River Watershed.
- Attachment G presents the supporting information for Hydrologic Response Unit and Critical Course Sediment Yield Analysis for the Middle and Upper Santa Margarita Watershed within Riverside County.
- Attachment H presents the supporting information for Hydromodification Exemptions on Santa Margarita Rivers and Murrieta Creek.
- Attachment I provides the San Diego County Regional Watershed Management Area Analysis.
- Attachment J presents the Candidate Projects for the Middle Santa Margarita Subwatershed.

Table 1.1 summarizes the Permit sections that identify specific WMAA requirements and the corresponding sections in this WMAA that comply with the Permit.

Table 1-1. WMAA corresponding Permit requirements

Corresponding Permit Section	WMAA Section
Provision B.3.b.(4).a.i	2.1. Dominant Hydrologic Processes
Provision B.3.b.(4).a.ii **Provision B.3.b.(4).a.v**	2.2. Existing Streams in the Watershed and Locations of Existing Flood Control Structures
Provision B.3.b.(4).a.iii	2.3. Current and Anticipated Land Uses
Provision B.3.b.(4).a.v	2.4. Potential Coarse Sediment Yield Analysis
Provision B.3.b.(4).b	3. Potential Candidate Projects
Provision B.3.b.(4).c	4. Hydromodification Exempt Areas

2 Watershed Management Area Characterization

2.1 Dominant Hydrologic Processes

The Regional MS4 Permit requires that the WMAA include a description of dominant hydrologic processes, such as areas where groundwater recharge, interflow, or overland flow likely dominate (San Diego RWQCB, 2015). Figure 2-1 displays the screening level analysis used to define the hydrologic response unit (HRU) and to then associate the HRU to a final dominant hydrologic process endpoint (e.g., overland flow; interflow; or groundwater recharge). The evaluation of dominant hydrologic processes in the SMR, however, should also consider evapotranspiration (ET). ET is the quantity of water transpired by plants, retained in plant tissues, and evaporated from plant tissues and surrounding soil surfaces (Department of Water Resources, 2005). A comparison of the estimated mean annual precipitation (4 – 10 inches) with the estimated fraction of precipitation lost to ET (90 – 99%) over a thirty year timespan in the Riverside-area watersheds suggests that ET is the dominant hydrologic process (Sanford and Selnick, 2013). Therefore, theoretically, if all the annual precipitation for Riverside County watersheds remained stationary where it fell and did not infiltrate or flow downstream to receiving waterbodies, then the precipitation would be loss to ET. Rain events, however, do not remain stationary and often produce runoff in these watersheds, especially in the urbanized areas, where the topography and land cover tend to accelerate the runoff rate downstream. Furthermore, this analysis focuses on developing information and mapping to gain an understanding of the macro-scale opportunities for locating projects that take advantage of either capturing overland flow for treatment or for supplementing the groundwater regime. Therefore, this analysis is based on the methodology illustrated in Figure 2-1 and described in Technical Report 605 titled *Hydromodification Screening Tools: GIS-Based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge* (Booth et al. 2010). After considering the effects of ET (see Section 2.1.4), and an intermediate category of infiltration, the predicted fate of runoff within the Santa Margarita watershed management area was evaluated based on the hydrologic process endpoints - overland flow, interflow, or groundwater recharge.

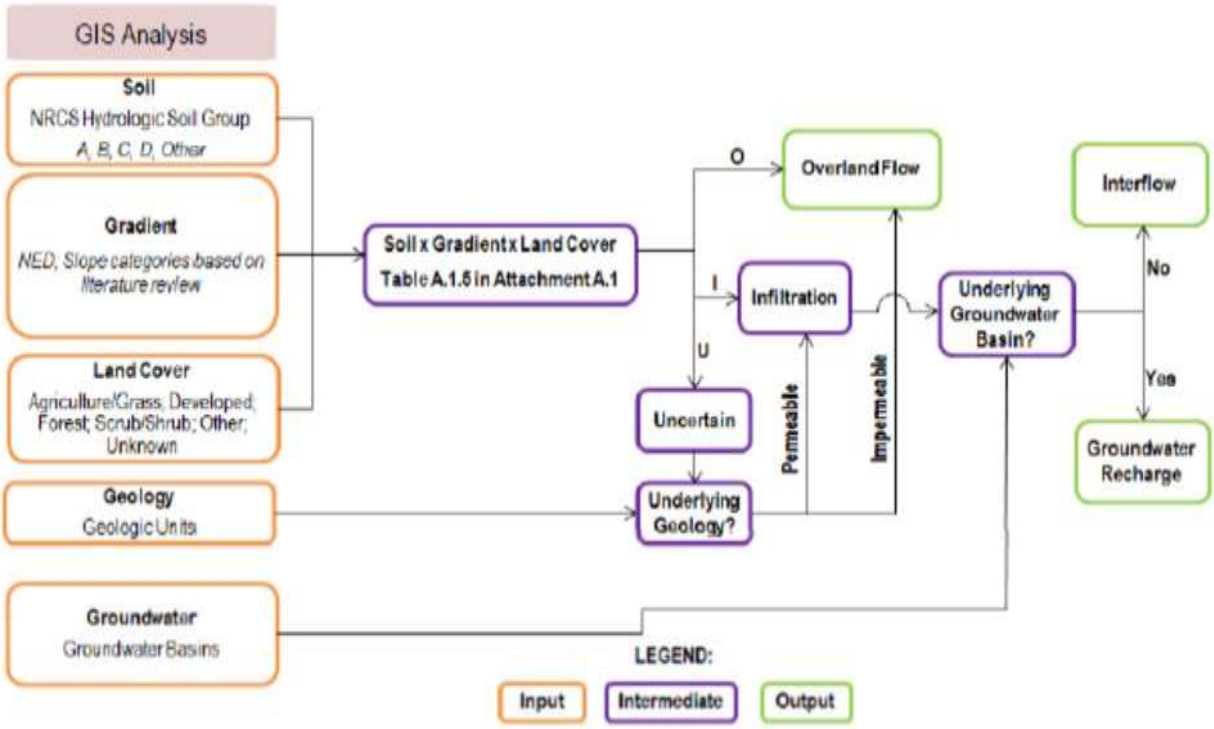


Figure 2-1. Hydrologic Response Unit and Hydrologic Process Flow Chart

2.1.1 Hydrologic Response Unit

The hydrologic process endpoint (e.g., overland flow, interflow, or groundwater recharge) was derived by first integrating soil, gradient, and land cover datasets into hydrologic response units (HRUs) using a geographic information system (GIS). HRUs are regions within a watershed which are presumed to have similar hydrologic attributes based on the combination of soil, gradient, and land cover. The GIS data acquired from public-domain sources are listed in Table 2.1.

Table 2-1. Hydrologic Response Unit Data Types and Source

GIS	Dataset	Source	Year	Description
Gradient	Elevation	USGS	2013	1/3 Arc Second (~10 meter cells) digital elevation model for San Diego County
		USGS	2016	1/3 Arc-Second digital elevation model digital elevation model for Riverside County
Soils	Hydrologic Soils Group	SanGIS	2013	NRCS (SSURGO) Database for San Diego County downloaded from SanGIS

GIS	Dataset	Source	Year	Description
		USDA/ NRCS	2017	(USDA/NRCS) Web Soil Survey and Digital General Soil Map of the United States for Riverside County https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
Land Cover	Vegetation Type	SanGIS	2013	Ecology-Vegetation layer for San Diego County downloaded from SanGIS
		Riverside County GIS	1994	*https://gis.countyofriverside.us/arcgis_public/rest/services/OpenData/NaturalFeaturesAndHazards/MapServer/4*

Source: Geosyntec Consultants and Rick Engineering Company, 2015 and Riverside County Flood Control and Water Conservation District, 2017

Soil Categories

Soil categories were based on United States Department of Agriculture/National Resources Conservation Service (USDA/NRCS) Hydrologic Soil Group (HSG) classifications, which are commonly used to describe runoff/infiltration potential of soils on a regional scale. There are four HSGs: A, B, C, and D and three dual groups: A/D, B/D and C/D. HSGs are based on the rate of water infiltration, with Group A having the highest rates and Group D having the lowest rates. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas. The following describes the methodology used to assign a single HSG rating for each of the dual groups identified in the Middle and Upper SMR Watershed.

Over two hundred polygons, equating to an area of approximately 7,000 acres in the Riverside County portion of the SMR WMA GIS were rated with a dual HSG. Dual HSG ratings were evaluated based on the mapped geologic unit as determined by published geologic mapping information, a desktop evaluation, and soils laboratory results. Specifically, the mapped geologic units were compiled into similar categories and then referenced with a geologic unit name. Geologic units were then categorized as either "coarse" or "fine" based on typical weathering characteristics for the bedrock unit or primary grain size of the sedimentary unit. For example, some geologic units weather to a coarse material such as silty sand and were therefore classified as "coarse". Geologic units that weather to a sandy clay were classified as "fine". Regarding sedimentary formations that are usually associated with variable amounts of coarse and fine units, the final classification was based on the predominating composition, i.e., sandstone/silty sand versus claystone. Finally, given that silty sands drain very quickly, any geologic unit identified as coarse was considered drained and was identified as either HSG A, B, or C. Whereas, geologic units classified as "fine" were considered undrained and were rated as HSG D in the GIS database.

HSG data were not available for some of the areas of the SMR WMA. These areas are designated as Uncertain (U) in the GIS. For HRUs considered uncertain (U), the underlying regional geology was used to evaluate whether overland flow or infiltration were dominant. This analysis was performed using GIS and is discussed further in Section 2.1.5.

Gradient Categories

The hillslope digital elevation model (DEM) for San Diego County and Riverside County was analyzed to produce a grid of slope values, which were subsequently classified into discrete categories: 0 - 2%; 2 - 6%; 6 - 10%; and greater than 10%. The greater than 10% slope category was considered the maximum limit given that slopes steeper than 10% are assumed to be dominated by overland flow. This limit is also consistent with Technical Report 605 (Booth et al. 2010).

Land Cover

Land cover categories for the Riverside County portion of the Santa Margarita WMA were defined using the ecology vegetation GIS map layers developed for Western Riverside County in the SMR (Riverside County GIS, 2014). For the San Diego County portion of the Santa Margarita watershed management area, land cover categories were defined using the Ecology Vegetation GIS map layer developed for the City of San Diego, the County of San Diego and SANDAG. This GIS map layer was downloaded from SanGIS (2013). The vegetation categories in the GIS layers were grouped to match the following land cover categories: Agriculture/Grass; Developed; Forest; Scrub/Shrub, Other and Other (Water) (see Tables A.1 and A.2, Attachment A). Land cover categories for Agriculture/Grass, Forest, Scrub/Shrub, Unknown Other and Other (Water) were then related to land use categories using Table A.3 in Attachment A. A land use category for the Developed land cover category was not determined because this land cover was assumed to have overland flow as its dominant hydrologic endpoint. Table A.4 in Attachment A displays the results showing how the land cover categories related to land use.

2.1.2 Geology and Groundwater Basins

As indicated in Figure 2-1, the intermediate process is implemented after the HRUs are defined. This process entails identifying the geologic units and groundwater basins in the Santa Margarita WMA. The GIS data acquired from public-domain sources for identifying geologic units and groundwater basins are listed in Table 2.2.

Table 2-2. Geologic Unit and Groundwater Basin Data Type and Source

GIS	Dataset	Source	Year	Description
Geologic Unit	Geology	Kennedy, M.P. and Tan, S.S.	2002	Geologic Map of the Oceanside 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 2, 1:100,000 scale for San Diego County
		Kennedy, M.P. and Tan, S.S.	2008	Geologic Map of the Oceanside 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 2, 1:100,000 scale for San Diego County
		Todd, V.R.	2004	Preliminary Geologic Map of the El Cajon 30'x60' Quadrangle, Southern California, United States Geological Survey, Southern California Aerial Mapping Project (SCAMP), Open File Report 2004-1361, 1:100,000 scale for San Diego County

GIS	Dataset	Source	Year	Description
		Jennings et al.	2010	"Geologic Map of California," California Geological Survey, Map No. 2 – Geologic Map of California, 1:750,000 scale for San Diego County
		Department of Conservation	2015	Geology layer for Riverside County, California Geological Survey, Geologic Atlas of California, Map No. 019, 1:250,000 scale, Compilation 1965. *http://www.conservation.ca.gov/cgs/information/geologic_mapping*
Groundwater Basin	Ground water Basin	SanGIS	2013	Groundwater Basins in San Diego County downloaded from SanGIS
	Ground water	Metropolitan Water District of Southern California	2007	Groundwater assessment study was used to determine the Dominant Hydrologic Process

Source: Geosyntec Consultants and Rick Engineering Company, 2015 and Riverside County Flood Control and Water Conservation District, 2017

Geologic Unit

The geology layer was categorized based on rock types, the predominant sediment size generated upon erosion, and their associated erodibility (Booth, et al., 2010). The attribution (and thus the naming) of the geology classes included the following categories:

- Coarse Bedrock (CB):
- Coarse Sedimentary Impermeable (CSI):
- Coarse Sedimentary Permeable (CSP):
- Fine Bedrock (FB):
- Fine Sedimentary Impermeable (FSI):
- Fine Sedimentary Permeable (FSP): and
- Other (O).

The underlying geology was then evaluated to determine if it was permeable or impermeable. This determination was based on a desktop evaluation using the best professional judgment of a Certified Engineering Geologist. All geologic units identified as permeable were considered to have infiltration as the hydrologic process endpoint, whereas all impermeable layers were considered to have overland flow as the hydrologic process endpoint. The Certified Engineering Geologist also performed a desktop evaluation of any HRUs that were identified as uncertain. Again, if the underlying geology was considered permeable, then these uncertain areas were presumed to be dominated by infiltration. Likewise, if the underlying geology was considered impermeable, then these uncertain areas were categorized as overland flow.

2.1.3 Groundwater Basins

For HRUs with relatively high infiltration the presence or absence of a regional groundwater basin underlying these areas determined whether the dominant hydrologic process was designated as interflow or groundwater recharge. The groundwater recharge hydrologic process was assigned as dominant for those applicable areas which have an underlying groundwater basin. The interflow hydrologic process was assigned as dominant for those applicable areas which did not have an underlying groundwater basin.

2.1.4 Hydrologic Characteristics and Evapotranspiration (ET)

For each of the land cover/land use categories the ratio of precipitation lost to evapotranspiration (i.e. an evapotranspiration coefficient) was estimated using the process described by Geosyntec Consultants and Rick Engineering Company (2015) as indicated below as Equation 1 (Eq 1). Since precipitation is the sum of the resulting runoff, infiltration, and evapotranspiration, the coefficients for these three hydrologic pathways sum to one using Equation (Eq) 1.

Runoff Coefficient + Infiltration Coefficient + Evapotranspiration Coefficient = 1 (Eq. 1)

2.1.4.1 Evapotranspiration Estimate

To estimate the evapotranspiration (ET) coefficient for each land cover, the runoff coefficient was identified by evaluating the highest runoff potential for the most common storm conditions. Using this, the ET coefficient was calculated as the difference (i.e., ET Coefficient = 1 – Runoff Coefficient). The ET coefficient calculated for the highest runoff potential was then applied to all soil types and slopes within each land use category.

2.1.4.2 Infiltration Estimate

The infiltration coefficient for each applicable HRU (i.e., combination of soil, gradient, and land cover) was estimated by subtracting both the runoff coefficient, and the ET coefficient, from one (i.e., Infiltration Coefficient = 1 – Runoff Coefficient – ET Coefficient).

2.1.4.3 Runoff Estimate

For each applicable HRU, the runoff coefficient was divided by the infiltration coefficient to obtain a ratio representing the potential for runoff or infiltration. The higher the ratio, the greater the potential for runoff to be a more dominant hydrologic process than infiltration. Similarly, the lower the ratio, the greater the potential for infiltration to be a more dominant hydrologic process than runoff.

2.1.4.3.1 Associate Runoff and Infiltration HRUs

The following designations were assigned to each applicable HRU based on the runoff to infiltration ratio (i.e., runoff coefficient/infiltration coefficient). These designations were based on best engineering judgment with the underlying assumption that if a runoff or infiltration coefficient is more than 50% greater than its counterpart, then the prevailing process is considered dominant. Table A.5 in Attachment A summarizes these findings for Riverside County and San Diego County.

- HRUs with runoff to infiltration ratios greater than 1.5 (3:2 ratio) were assumed to have relatively high runoff and overland flow was considered its dominant hydrologic process. These HRUs are designated by the letter "O" (Overland flow is dominant process).

- HRUs with runoff to infiltration ratios less than 0.67 (2:3 ratio) were assumed to have relatively high infiltration and its dominant hydrologic process was either interflow or groundwater recharge, based on analysis described in subsequent steps. These HRUs are designated by the letter "I" (Interflow is dominant process) in Table A.5 of Attachment A.
- For HRUs with runoff to infiltration ratios ranging from 0.67 to 1.5, it was uncertain whether it was dominated by overland flow or infiltration. These HRUs are designated by the letter "U" (Dominant process is uncertain).
- For HRUs that have a Developed land cover or a gradient greater than 10%, the runoff to infiltration ratios were not calculated because these HRUs were assumed to have overland flow as the dominant hydrologic process. These HRUs are designated by the letter "O" (Overland flow is dominant process).

2.1.5 Uncertain HRUs

For HRUs considered uncertain (U), the underlying regional geology (Kennedy and Tan, 2002 and 2008; Todd, 2004 and Jennings et al., 2010) was used to evaluate whether overland flow or infiltration were dominant. If the underlying geology was considered impermeable, then these uncertain areas were considered to have overland flow as its dominant hydrologic process. If the underlying geology was considered permeable, then these uncertain areas were dominated by infiltration. The determination of whether a geologic unit is impermeable or permeable was based on desktop evaluation and the best professional judgment of a Certified Engineering Geologist (CEG). This analysis was performed in GIS and the results are displayed in Table A.6 of Attachment A.

2.1.6 Dominant Hydrologic Process Results

The resulting GIS map displaying the spatial distribution of dominant hydrologic processes within the Santa Margarita WMA is provided as Figure A.1 in Attachment A. Based on this analysis, overland flow is the predominant hydrologic process in the Santa Margarita watershed management area. This endpoint was verified by the Riverside Co-Permittees as part of their review process and was also found to be consistent with the experience of engineering professionals familiar with the hydrology of the County of San Diego. An exhibit summarizing the 2016-2017 public participation efforts for the SMR WMAA is provided as Table A.7 in Attachment A.

2.1.7 Limitations

This analysis identified the dominant hydrologic processes in the SMR WMA. The methodology was based on utilizing regional, public domain datasets. Although the analysis provided a useful, rapid framework to identify the dominant hydrologic processes, it was performed as a screening-level analysis. When more precise estimates are required, it is recommended that the SMR GIS be augmented with site specific analysis.

2.2 Existing Streams in the Watershed and Locations of Existing Flood Control Structures

Murrieta Creek, Temecula Creek and Santa Margarita River are the three major watercourses examined for the stream characterization. The Permit requires a description of existing streams in the watershed, including bed material and composition, and if they are perennial or ephemeral; and locations of existing

flood control structures and channel structures, such as stream armoring, constrictions, grade control structures, and hydromodification or flood management basins.

2.2.1 Summary of Datasets

The following datasets were used to characterize existing streams:

- Riverside County Flood Control and Water Conservation District (District) Facilities Area – "RCFC_WCD.RCFC_FACILITIES_AREA"
- RCFC&WCD As-Built Drawings
- Riverside County 2014 Hydromodification Susceptibility Report and Mapping
- National Hydrography Dataset – Flow lines in Riverside County
- Riverside County GIS Major Hydrology – "RIVCO.MAJOR_HYDROLOGY"
- Google Earth to assist in determining category selection (categories included in Section 2.2.2.1)
- USGS National Hydrography Dataset for San Diego County, downloaded from USGS November 2013
- USGS 7.5-minute quadrangles, compiled image of quadrangles covering San Diego County, various dates
- Floodplains: "National Flood Hazard Layer," for San Diego County provided by Federal Emergency Management Agency, October 2012
- Various datasets provided by San Diego County Co-Permittees depicting existing storm water conveyance infrastructure within their jurisdictions.
- Aerial photography of San Diego County by Digital Globe dated 2012

2.2.2 Methodology

2.2.2.1 Streambed Material and Composition

The Riverside County 2014 Santa Margarita Hydromodification Susceptibility Report and Mapping (2014 HMP) categorized existing streams and channel segments based on information obtained by the Co-Permittees and the National Hydrography Dataset. The Hydromodification Mapping identified streambed material and composition based on the categories described below:

Engineered, Fully Hardened and Maintained (EFHM): This category includes channel segments that are fully armored (e.g. concrete, soil cement, rock rip rap, etc.) on three sides and verified by as-built drawings, aerial photographs and/or a site visit. This category also includes channel segments with reinforced concrete pipes or boxes. The channel segments and associated armoring must be designed based on specific engineering criteria (e.g. specific storm event and duration), and maintained. Co-Permittees typically engineer the EFHM channels to completely contain the 100-year flow based on ultimate landuse conditions and remain stable under these flow conditions. Co-Permittees inspect the facilities regularly to maintain the improvements per design.

Engineered, Partially Hardened and Maintained (EPHM): This category includes channel segments that have some armoring (e.g. concrete, soil cement, rock rip rap, turf reinforcing mats, etc.) on less than three sides, and verified through the review of as-built plans, aerial photographs

and/or a site visit. The armoring placed in the channel may include bank and/or invert lining that has been design per specific engineering criteria. The channel segment and associated armoring must also be maintained.

Engineered, Earthen and Maintained (EEM): This category includes channel segments that are not armored, however, they have been constructed to resist Hydromodification as verified through the review of as-built plans. The channel segment must also be maintained to control invasive vegetation, correct any significant localized scouring identified during routine inspections, and maintain design grades in the channel. This category is intended to include channel segments constructed for flood conveyance, which generally have a design capacity in excess of a 10-year storm event.

Not Engineered and Earthen (NEE): This category includes natural channel segments that have been modified by anthropogenic activities. These may include floodplain encroachments by development, culverts, bridges, privately owned bank and/or invert stabilization (such as rip-rap or other forms of bank protection, roads, etc.), and other man-made modifications to the channel segment that are not necessarily continuous or designed to meet any specific engineering standard, but have modified the natural hydrologic characteristics of the channel segment. The improvements may or may not be maintained.

Natural (NAT): This category includes channel segments that are in a natural state, where the geometry has not been modified. The channel segment may or may not be maintained.

This information is shown on the "Existing Stream Structures – Santa Margarita Watershed" map in Attachment C.

2.2.2.2 Stream Structure Mapping

In addition to streambed material, the attached "Existing Streams and Structures – Santa Margarita River Watershed" map includes information for locations of physical structures. Determining the location of these structures was determined through a desktop analysis utilizing Google Earth and District as-built drawings. The following categories of structures were identified:

- Bridges
- Culverts
- Dams
- Streambed Stabilizer

A Streambed Stabilizer is an energy dissipater designed to reduce velocity of flow, maintain channel grade, and protect downstream areas from erosion.

2.2.2.3 Stream Hydrography

The Permit requires the WMAA to include information, "to the extent it is available" describing whether streams in the watershed are perennial or ephemeral. However, the available USGS National Hydrography Dataset (NHD) data used to describe streams provided information for "perennial" and "intermittent" streams, but not for "ephemeral" streams. For reference, the NHD defines "ephemeral" as: "contains water only during or after a local rainstorm or heavy snowmelt." None of the stream reaches

were classified as ephemeral in the NHD. Therefore, none are classified as ephemeral in this WMAA. Rather, consistent with the NHD classifications, existing streams in the watershed are described as either perennial or intermittent. This information is shown on the "Hydrographic Category – Santa Margarita River Watershed" map in Attachment D. This information was obtained from the USGS National Hydrography Dataset – Flowlines. The Flowlines dataset contains an attribute for streams called "Hydrographic Category", which is defined as the portion of the year a particular feature contains water. The definitions of these categories in the USGS NHD are:

- **Intermittent** – Contains water for only part of the year, but more than just after rainstorms and snowmelt.
- **Perennial** – Contains water throughout the year, except for infrequent periods of severe drought.

USGS NHD includes hydrographic category classification for many, but not all of the streams. To classify reaches of streams that did not already contain this data in NHD, these assumptions were made:

- The USGS NHD information for the stream hydrographic category has been used when available.
- When USGS NHD has "artificial paths" for portions of the stream, the hydrographic category of the upstream portion of the stream have been assigned to the stream unless other assumptions took precedence.
- If aerial photography shows large waterbody (lake, pond, irrigation pond, etc.) perennial has been assumed for the hydrographic category.
- For ponded areas shown on the aerial photography and if the USGS 7.5-minute quadrangles shows cross hatching for the area, intermittent has been assigned unless the upstream portion of the stream was assigned as perennial pursuant to the USGS NHD then assigned perennial for the ponded area.
- USGS has a dashed line for intermittent streams. USGS has a solid line for perennial streams. In some situations this information was used to assist in the determination of assigning perennial or intermittent to a stream.

The remaining stream reaches not classified as either perennial or intermittent are presumed to be ephemeral based on extensive field reconnaissance.

2.3 Current and Anticipated Land Uses

2.3.1 Summary of Datasets

The following datasets were referenced to meet this requirement:

- 2012 Existing Land Use - (SCAG, 2015)
- Anticipated Land Use – General Plan Land Use from Riverside County, 2015
- Anticipated Land Use – General Plan Land Use from the City of Menifee, 2010
- Anticipated Land Use – General Plan Land Use from the City of Murrieta, 2010
- Anticipated Land Use – General Plan Land Use from the City of Temecula, 2005
- Anticipated Land Use – General Plan Land Use from the City of Wildomar, 2016
- Ownership: "Parcels" dated December 2013, available from SanGIS/SANDAG
- Existing land use: "SANGIS.LANDUSE_CURRENT" dated December 2012, available from SanGIS/SANDAG (existing land use)
- Planned land use: "PLANLU" (Planned Land Use for the Series 12 Regional Growth Forecast

(2050)), dated December 2010, available from SanGIS/SANDAG

- Developable land: "DEVABLE" (Land available for potential development for the Series 12 Regional Growth Forecast), dated December 2010, available from SanGIS/SANDAG
- Redevelopment and infill areas: "REDEVINF" (Redevelopment and infill areas for the Series 12 Regional Growth Forecast), dated December 2010, available from SanGIS/SANDAG
- Floodplains: "National Flood Hazard Layer" in San Diego County provided by Federal Emergency Management Agency October 2012
- Multiple Species Conservation Program (MSCP), total of four datasets available from SanGIS/SANDAG: "MHPA_SD," dated 2012, (Multiple Habitat Planning Areas for City of San Diego); "MSCP_CN," dated 2009 (designations of the County of San Diego's Multiple Species Conservation Program South County Subregional Plan); "MSCP_EAST_DRAFT_CN," dated 2009 (draft East County MSCP Plan); and "Draft_North_County_MSCP_Version_8.0_Categories," dated 2008 (draft North County MSCP Plan)

2.3.2 Methodology

The "Current Land Use Map – Santa Margarita River Watershed" map, Attachment E, is based on the SCAG 2012 existing land use dataset, updated in February 2015. The "Anticipated Land Use Map – Santa Margarita River Watershed" map, Attachment F, is based on a compilation of General Plan Land Use data from the Co-Permittees (see 2.3.1). This analysis did not include specific land uses within Tribal lands.

2.4 Potential Coarse Sediment Yield Analysis

The Critical Coarse Sediment Yield analysis predicts the potential critical coarse sediment yield areas and is largely based on the Geomorphic Landscape Unit (GLU) methodology described by Booth et al. (2010). GLUs characterize the magnitude of sediment production from areas using three factors judged to exert the greatest influence on the variability of sediment-production rates: geology types, hillslope gradient, and land cover. The GLU layer was derived by overlaying hillslope, land cover, and geology, and then assigning a relative sediment-production rate (i.e., Low, Medium, and High) to each of the resulting categories. The relative sediment production rate was then estimated for each GLU using the Revised Universal Soil Loss Equation (RUSLE) following the method applied in the San Diego WMAA by Geosyntec Consultants and Rick Engineering Company (2015). An area that was identified as coarse bedrock (CB), coarse sedimentary impermeable (CSI) or coarse sedimentary permeable (CSP) coupled with a relative RUSLE rate of Medium was considered as a potential coarse sediment yield area. Whereas, an area that was identified as CB, CSI or CSP coupled with a relative RUSLE rate of High was considered as a potential critical coarse sediment yield area. The GLU approach plus the RUSLE equation application provided a useful, rapid framework to model sediment-delivery attributes of the SMR watershed. Potential critical coarse sediment yield analysis was performed in GIS and the analytical process is illustrated as a flowchart in Figure 2-2.

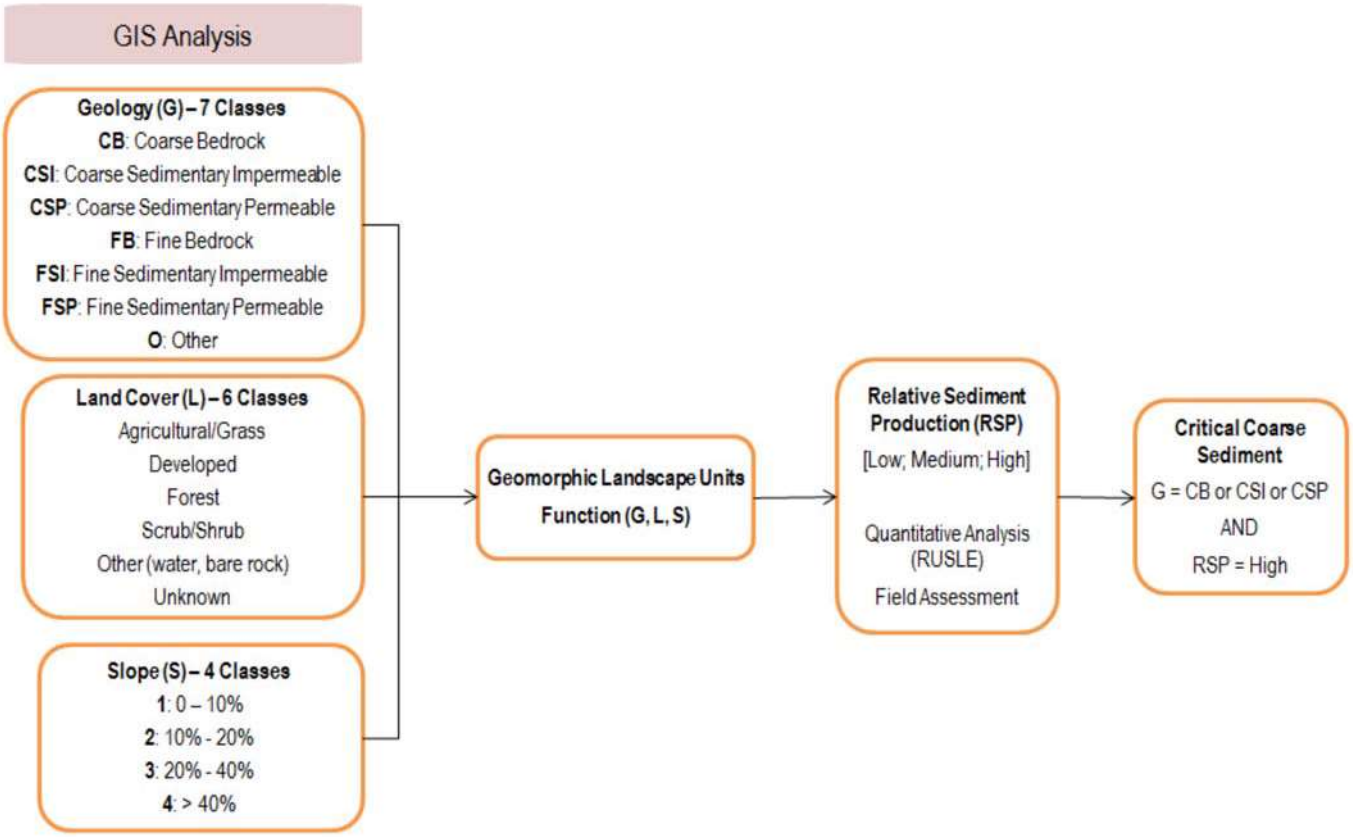


Figure 2-2. Potential Critical Coarse Sediment Field Analysis Flow Chart

2.5 Data Types and Acquisition

The geomorphic landscape unit was determined using data from the public-domain sources referenced in Table 2.3.

Table 2-3. GLU Public Domain Data Sources

GIS	Dataset	Source	Year	Description
Gradient	Elevation	USGS	2013	1/3 Arc Second (~10 meter cells) digital elevation model for San Diego County
		USGS	2016	1/3 Arc-Second digital elevation model digital elevation model for Riverside County : *https://catalog.data.gov/dataset/usgs-national-elevation-dataset-ned* *https://viewer.nationalmap.gov/basic/*
Land Cover	Vegetation Type	SanGIS	2013	Ecology-Vegetation layer for San Diego County downloaded from SanGIS
		Riverside County GIS	1994	*https://gis.countyofriverside.us/arcgis_public/rest/services /OpenData/NaturalFeaturesAndHazards/MapServer/4*
Geologic Unit	Geology	Kennedy, M.P. and Tan, S.S.	2002	Geologic Map of the Oceanside 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 2, 1:100,000 scale for San Diego County
		Kennedy, M.P. and Tan, S.S.	2008	Geologic Map of the Oceanside 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 2, 1:100,000 scale for San Diego
		Todd, V.R.	2004	Preliminary Geologic Map of the El Cajon 30'x60' Quadrangle, Southern California, United States Geological Survey, Southern California Aerial Mapping Project (SCAMP), Open File Report 2004-1361, 1:100,000 scale for San Diego County
		Jennings et al.	2010	"Geologic Map of California," California Geological Survey, Map No. 2 – Geologic Map of California, 1:750,000 scale for San Diego County
		Department of Conservation	2015	http://www.conservation.ca.gov/cgs/information/geologic_mapping

2.5.1 Geologic Categories

The geology layer was categorized based on rock types, the predominant sediment size generated upon erosion, and their associated erodibility. The attribution (and thus the naming) of the geology classes included the following categories:

- Coarse Bedrock (CB):
- Coarse Sedimentary Impermeable (CSI):
- Coarse Sedimentary Permeable (CSP);
- Fine Bedrock (FB);
- Fine Sedimentary Impermeable (FSI);
- Fine Sedimentary Permeable (FSP); and
- Other (O).

Using GIS, 35 map units were identified in the Riverside County portion Santa Margarita watershed management area and 46 map units were identified in the San Diego County portion. Table B.1 and Table B.2 in Attachment B summarize how each of the map units related to a geologic category. The geologic categories considered to have the potential to generate coarse sediment are coarse bedrock (CB); coarse sedimentary impermeable (CSI); and coarse sedimentary permeable (CSP). An exhibit displaying the geologic categories in the Santa Margarita watershed management area is presented as Figure B.1 in Attachment B.

2.5.2 Land Cover

Land cover categories were defined using the ecology vegetation GIS map layers developed for Western Riverside County for the Riverside County portion of the Santa Margarita region (Riverside County GIS, 2014). For area within San Diego County, land cover categories were defined using the Ecology Vegetation GIS map layer developed for the City of San Diego, the County of San Diego and SANDAG. The vegetation categories in the GIS layer were grouped to match the following categories: Agriculture/Grass; Developed; Forest; Scrub/Shrub, Other (Water), and Unknown.

2.5.3 Slope Classes

The hillslope DEM was analyzed to produce a grid of slope values, which were subsequently classified into discrete categories. The following category percentages were used to categorize hillslope gradients: 0 to 10%; 10 to 20%; 20 to 40%; and greater than 40%.

2.6 GLU Results

The result of evaluating geology, land cover and slope equated to 133 GLUs within the Riverside County portion of the study area and 112 GLUs within the San Diego County portion of the study area. The GIS analysis indicated that the Santa Margarita WMA is predominated by CB, CSI and CSP geologic categories and is therefore considered as an area with the potential to contribute coarse sediment. These GLUs were then evaluated to determine their relative sediment production to identify potential critical coarse sediment yield areas.

2.7 Relative Sediment Production

Relative sediment production was estimated for each GLU using the Revised Universal Soil Loss Equation (RUSLE) (see Equation 2).

A = R x K x LS x C x P (Equation 2), where

A = estimated average soil loss in tons/acre/year
R = rainfall-runoff erosivity factor
K = soil erodibility factor
LS = slope length and steepness factor
C = cover-management factor
P = support practice factor; assumed 1 for this analysis

Datasets used to estimate the average soil loss were acquired from public-domain sources as indicated below.

- RUSLE R Factor:
  ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_R_Factor/[1]

[1] R-Factor database provided by Geosyntec, January 2017.

- RUSLE K Factor: State Water Resources Control Board: *ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_K_Factor/*
- RUSLE LS Factor: State Water Resources Control Board: *ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_LS_Factor/*
- RUSLE C Factor: US EPA, EMAP West Metric Browser: *https://archive.epa.gov/esd/archive-nerl-esd1/web/html/wemap_download.html* for the Riverside County portion of the study area and *http://www.epa.gov/esd/land-sci/emap_west_browser/pages/wemap_mm_sl_rusle_c_qt.htm#mapnav* for the San Diego portion.

GIS analysis was used to calculate the area weighted estimate of R, K, LS and C factors using the datasets listed above. For the developed land[2] cover the C factor was adjusted to 0 for the regional estimate to account for management actions implemented on developed sites (e.g., impervious surfaces). The estimated average annual soil loss ranged from 0 to 15.2 tons/acre/year in the San Diego County portion of the Santa Margarita WMA, whereas, the estimated average annual soil loss in the Riverside County area ranged from 0 to 23 tons/acre/year.

To assess the amount of relative risk to stream channels resulting from watershed-scale changes in sediment yield and/or water delivery, the following opinions included in Technical Report 605 (Booth et al. 2010) were considered:

"The challenge in implementing this step is that presently we have insufficient basis to defensibly identify either low-risk or high-risk conditions using these metrics. For example, channels that are close to a threshold for geomorphic change may display significant morphological changes under nothing more than natural year-to-year variability in flow or sediment load.

Acknowledging this caveat, we nonetheless anticipate that changes of less than 10% in either driver are unlikely to instigate, on their own, significant channel changes. This value is a conservative estimate of the year-to-year variability in either discharge or sediment flux that can be accommodated by a channel system in a state of dynamic equilibrium. It does not "guarantee," however, that channel change may not occur—either in response to yet modest alterations in water or sediment delivery, or because of other urbanization impacts (e.g., point discharge of runoff or the trapping of the upstream sediment flux; see Booth 1990) that are not represented with this analysis.

In contrast, recognizing a condition of undisputed "high risk" must await broader collection of regionally relevant data. We note that >60% reductions in predicted sediment production have resulted in both minimal (McGonigle) and dramatic (Agua Hedionda) channel changes, indicating that "more data" may never provide absolute guidance. At present, we suggest using predicted watershed changes of 50% or more in either runoff (as indexed by change in impervious area) or sediment production as provisional criteria for requiring a more detailed evaluation of both the drivers and the resisting factors for channel change, regardless of other screening-level assessments. Clearly, however, only more experience with the application of such

[2] Developed (i.e., impervious) area data layer provided by WRCOG, January 2017.

"thresholds," and the actual channel conditions that accompany them, will provide a defensible basis for setting numeric standards."

Considering the thresholds indicated above, the relative sediment production rating for each GLU followed the criterion indicated as follows:

Riverside County

Low: Soil Loss < 3.4 tons/acre/year (GLUs that have a soil loss of 0 to 3.39 tons/acre/year produce approximately 10% of the total potential coarse sediment soil loss from the Riverside County portion of the Santa Margarita WMA)

Medium: 3.4 tons/acre/year < Soil Loss < 9.55 tons/acre/year (GLUs that have a soil loss ranging from 3.40 to 9.55 tons/acre/year produce approximately 50% of the total potential coarse sediment soil loss from the Riverside County portion of the Santa Margarita WMA)

High: >9.6 tons/acre/year (GLUs that have a soil loss greater than 9.57 tons/acre/year produce approximately 40% of the total potential coarse sediment soil loss from the Riverside County portion of the Santa Margarita WMA)

San Diego County

Low: Soil Loss < 5.6 tons/acre/year (GLUs that have a soil loss of 0 to 5.6 tons/acre/year produce approximately 10% of the total potential coarse sediment soil loss from the study area)

Medium: 5.6 tons/acre/year < Soil Loss < 8.4 tons/acre/year (GLUs that have a soil loss ranging from 5.6 to 8.4 tons/acre/year)

High: >8.4 tons/acre/year (GLUs that have a soil loss greater than 8.4 tons/acre/year produce approximately 42% of the total potential coarse sediment soil loss from the study area)

2.8 Potential Critical Coarse Sediment Yield Results

Attachment B provides tables displaying GLUs that were rated as critical coarse sediment yield areas in Riverside County and San Diego County. This analysis is summarized in tabular format as Table B.3 and Table B.4, for Riverside County and San Diego County, respectively.

The resulting GIS map showing the spatial distribution of the potential critical coarse sediment yield areas within the Santa Margarita WMA is provided as Figure B.2 in Attachment B. Based on this analysis it was estimated that 28% of the of the Riverside County portion of the Santa Margarita WMA is a potential coarse sediment yield area and 9% of the study area is a potential critical coarse sediment yield area. Most of the potential critical coarse sediment yield areas were identified to be in the Scrub/ Shrub land cover areas with hillslope gradients ranging from 20 to 40%.

For the San Diego County portion of the Santa Margarita WMA, approximately 39% of the study area is a potential coarse sediment yield area and 30% of the study area is a potential critical coarse sediment yield area. Most of the potential critical coarse sediment yield areas were identified to be on slopes greater than 30%.

2.9 Limitations for Potential Critical Coarse Sediment Yield Areas

The potential critical coarse sediment yield analysis utilized regional, public domain datasets and provided a useful, rapid framework to perform a screening level analysis for the Santa Margarita WMA. This mapping effort essentially provided a high-level analysis to provide informed decision making at a regional scale. Because of the regional-scale datasets, and commensurate data resolution used to map the potential critical coarse sediment yield areas, some areas may have been mapped that do not produce critical coarse sediment as they are existing developed areas. Furthermore, the analysis did not consider instream sediment supply or fire-induced sediment production (Lave and Burbank 2004) as this was beyond the scope of a regional study. In addition, the resolution differences among the R-factor data resulted in differences in potential critical coarse sediment yield areas near the county border (see Technical Memo in Attachment B). As such, for future projects within the Santa Margarita WMA, especially along the county border, more precise data should be required by performing a site-specific analysis along with a careful interpretation of the results. The Santa Margarita WMA area GIS should then be supplemented with this site-specific data. Ultimately, the Santa Margarita WMA data for the potential critical coarse sediment yield areas should be verified in the field according to the procedures outlined in the Model BMP Design Manual and/or jurisdiction specific BMP Design Manual.

3 Potential Candidate Projects

The Permit requires Co-Permittees to use the results of the WMAA to identify and compile a list of candidate projects that Priority Development Projects could potentially use as alternative compliance options. Criteria for selecting candidate projects includes (San Diego RWQCB, 2015):

Structural Projects

1. Stream or riparian area rehabilitation; projects will restore streams to a natural, stabilized condition that can accommodate both historic and future hydromodification impacts.
2. Retrofittingexistinginfrastructuretoincorporatestormwaterretentionortreatment; projects will add or modify structural BMPs where practices do not currently exist, are ineffective, or can be significantly enhanced.
3. Regional; projects will treat stormwater, improve water quality, protect downstream channels, or reduce flooding, from a drainage area consisting of more than one development.
4. Water supply; projects will capture stormwater and infiltrate, pump or otherwise recharge groundwater, surface reservoirs, or other water supply systems.

Natural System Management Practices

5. Land Restoration; projects will restore currently developed land back to a stabilized, predevelopment condition.
6. Land Preservation; projects will prevent increases in stormwater runoff volumes and preserve floodplain function through preservation of undeveloped land.
7. Stream Rehabilitation; projects that restore a stream to a natural, stabilized condition that can accommodate both historical and future hydromodification impacts.

Potential candidate projects within the SMR are described below.

3.1 Candidate Projects for the Middle SMR Subwatershed

MEADOWVIEW STREAM RESTORATION PILOT PROJECT: The project will reduce public and water quality hazards due to existing erosion by removing vertical cut banks and restoring the natural functions of the stream using primarily soft-armoring and vegetative techniques. The project is located in the City of Temecula. This project will be a stream restoration project and be eligible for hydromodification flow control credit by providing permanent stabilization of the stream.

SANTA GERTRUDIS VALLEY- BROWNING STREET WATER QUALITY BASIN: The project will alleviate water quality concerns associated with dry weather flows at the system outfall at the northwest corner of Encanto Road, in the French Valley area in unincorporated Riverside County. This will be a regional project that improves water quality. Given the primary purpose of the project is to treat dry weather flows, it is unclear what benefit will be provided to stormwater. Coordination will continue to determine if dry weather flow treatment is eligible for stormwater pollutant control credits.

WILDOMAR MDP LATERAL C BASIN: The project will reduce flooding along Bundy Canyon Wash in the City of Wildomar. The project consists of a 19-acre footprint detention basin and outlet proposed at the

southeast corner of Monte Vista Drive and Bundy Canyon Road to collect and attenuate runoff. The detention basin will incorporate water quality features to alleviate dry weather concerns in the City of Wildomar. This project will be a regional project. The project has the potential to generate both hydromodification and/or stormwater pollutant control credit depending on the final design of the facility.

COUNTY OF RIVERSIDE INTEGRATED MITIGATION PROJECT: The project is located in the French Valley area in unincorporated Riverside County and proposes to restore and enhance habitats that have been lost or degraded as a result of past agricultural and other human activities. The proposed project includes channel grading, diversion channels, check dams, habitat preservation, and habitat enhancement and creation. The project will be a stream rehabilitation project with the potential to generate hydromodification and/or stormwater pollutant control credit.

TEMECULA CREEK STREAMBED STABILIZATION: The project proposes to restore and stabilize the reach of Temecula Creek between Pechanga Parkway and Avenida Missiones, just downstream of the existing engineered channel. The project will reduce erosion susceptibility along this reach of the creek to reinstate the Temecula Creek hydromodification exemption. This will be a stream rehabilitation project with the potential to generate hydromodification credit.

MURRIETA CREEK CHANNEL FLOOD CONTROL PROJECT: The project includes construction of a 250 acre detention basin that will attenuate flows from the over 150 square mile watershed. It includes: creation of over 160 acres of wildlife habitat, development of a 50 acre regional sports park, reduction in downstream flood flow peaks, creation of regional sports park within the detention basin. This will be a regional project that will have the potential to provide hydromodification credit and stormwater pollutant control credit.

Exhibit showing approximate project location for Middle SMR Subwatershed candidate projects can be found in the Candidate Projects for the Upper SMR Subwatershed map located in Attachment J.

The projects above represent those projects planned by the District as Principal Permittee. The Co-Permittees have convened a Technical Advisory Group of regional stakeholders to develop a framework for facilitating the use of Alternative Compliance in those jurisdictions that choose to adopt an alternative compliance program. As part of these discussions, the Co-Permittees have noted that a variety of individual and programmatic actions may be taken that potentially can be credited using the adopted Water Quality Equivalency (WQE) framework (San Diego RWQCB, 2017). Such actions may include, but are not limited to, implementing stormwater runoff treatment and control measures for dirt and gravel roadways; modifying drainage and surfacing at municipal facilities to provide treatment and control of previously untreated surfaces; "over-sizing" stormwater treatment measures in conjunction with public roadway projects; and providing enhanced stormwater treatment within linear projects such as recreation pathways.

While many of these approaches would fall under the broad category of (2) above, "retrofitting existing infrastructure to incorporate storm water retention or treatment," it is not possible to identify all potential project options that may emerge over the period that this WMAA is in effect. These types of retrofits or regional projects, which have the potential to support enhanced water quality and robust implementation of Alternative Compliance, typically are identified in the course of regular planning and design processes for

private development or public works projects. Therefore, the Co-Permittees emphasize that projects that are identified in the design process, and that can be credited properly in a manner consistent with the adopted WQE, are considered to be Candidate Projects for Alternative Compliance. These projects will be added to the WMAA on an annual update basis as they are identified by the Co-Permittees.

3.2 Candidate Projects for the Lower SMR Subwatershed

Analysis for the Lower SMR Subwatershed was previously conducted for the 2015 San Diego County Regional WMAA. Summaries of candidate projects within the Lower SMR Subwatershed are provided in the following sections.

3.2.1 Santa Margarita River Habitat Assessment and Enhancement Plan

The purpose of the Santa Margarita River Steelhead Habitat Assessment and Enhancement Plan is to develop a Watershed Management Area (WMA) restoration plan for the anadromous waters of the Santa Margarita River and major tributaries that emphasizes the needs of southern steelhead. The primary objective is to document existing WMA conditions, identify limiting factors to steelhead recovery, and provide prioritized solutions to address limiting factors to steelhead recovery. This objective will be accomplished through the following tasks: 1) Compile information on existing and historical conditions, including available data from studies on Camp Pendleton, and solicit input from stakeholders; 2) Conduct a WMA habitat assessment using California Department of Fish and Wildlife (CDFW) protocols that documents passage barriers and limiting habitat factors; 3) Develop prioritized recommendations for restoration opportunities and prepare a Steelhead Habitat Assessment and Enhancement Plan.

3.2.2 Santa Margarita River Fish Passage Design - Sandia Creek

A completed steelhead habitat assessment study by Cardno ENTRIX and Trout Unlimited – South Coast Chapter mapped habitat quality and fish passage barriers in detail upstream of Camp Pendleton (2013) and cited two barriers (SMR01 and SMR02) that need to be remediated in the main stem for fish passage upstream. This project has requisite engineering tasks by the WEST Consultants engineering team to arrive at design alternatives for the barriers. These include fish passage and flood flow determination, topographic survey, hydraulic analysis and fish passage evaluation, sediment transport and scour analysis, basis of design report (30-40% plans) and 65% design plans for review by relevant Co-Permittees. This project will capitalize on the opportunity for public outreach and education in this area. The project site has public access to the Santa Margarita River and to local hiking and riding trails from the nearby communities of Fallbrook and Temecula that have close regional ties to the River. The development of backcountry communities in the priority WMAs presents challenges to habitat and connectivity, and increases demand on limited water resources. This indicates a need for raising public awareness to mitigate human impact, restore ecosystems and improve water and resource management practices.

3.2.3 Fallbrook Public Utilities District Recycled Water Storage

The project would construct a recycled water storage tank that would allow for the Fallbrook Public Utility District (FPUD) to store and utilize recycled water during periods of the day when recycled demands exceed wastewater supplies. Currently, the FPUD utilizes make-up potable water to supplement the recycled water supply. Because there is currently no storage and the high demand periods occur during the day when wastewater flows are low, a large volume of make-up water is required to maintain service. It is projected

that 132 acre-feet of make-up water will be used in 2010, which would be 25% of the total recycled water supply. This project would construct a below grade uncovered storage structure located adjacent to the existing equalization basin at the Water Recycling Facility. The project would be connected hydraulically to the recycled water wet well in the contact tank, which would allow utilization of stored recycled water in place of potable make-up water.

3.2.4 Implementing Nutrient Management in the Santa Margarita River Watershed - Phase I/II

The project aims to establish the science and stakeholder consensus to support the adoption of alternative nutrient Water Quality Objectives (WQOs) in the SMR WMA through the San Diego RWQCB Basin Plan triennial update. It will optimize irrigation practices by coordinating with local Resource Conservation Districts. Major tasks include: 1) facilitate SMR WMA stakeholder group to guide activities; 2) conduct monitoring and special studies to address data; 3) develop proposed nutrient WQOs for the SMR and estuary based, and 4) optimize irrigation on agricultural lands. This effort would model for the region, reduce nutrient loads and conserve water. The project leverages an investment of over $2 million contributed by WMA stakeholders since 2007.

3.2.5 Implementing Nutrient Management in the Santa Margarita River Watershed Phase III

This project aims to establish the science and seek stakeholder consensus to support the adoption of alternative nutrient Water Quality Goals (WQGs) in SMR watershed and to implement nutrient management activities. The project is the third phase of the overall project that will develop proposed nutrient WQGs for the SMR Estuary (Phase I), provide additional site-specific studies and modeling of nutrient sources and responses in the main stem of the Lower SMR River (Phase II), and in Upper SMR River and selected tributaries (Phase III) that may lead to development of nutrient site-specific objectives (SSOs) or other regulatory alternative by the SDRWQCB that are protective of beneficial uses. Nutrient management activities will include agricultural irrigation system evaluations, residential and equestrian property conservation plans and educational workshops, and will include a rebate program to encourage irrigation retrofits.

The project goals are to:

1. Maximize community involvement in SMR watershed by continued stakeholder group facilitation (established in Phase I).
2. Continue work with the group to obtain feedback and critical review of technical work products to achieve consensus on proposed WQGs.
3. Continue core monitoring and special studies to address data gaps required to develop WQGs for the SMR and tributaries.
4. Develop proposed nutrient WQGs for the SMR and tributaries, as needed, based on sound science and local data.
5. Develop proposed nutrient WQGs for selected streams in SMR watershed that are protective of beneficial uses.
6. Encourage the implementation of BMPs to reduce nutrient loading into the SMR and its tributaries.

3.2.6 Monitoring, Special Studies and Modeling will be conducted in selected SMR tributaries to further refine WQGs that are protective of beneficial uses for the SMR Watershed. Collected data and model-generated information will be used to track nutrient loads and sources, and where warranted, this data and information will be used to identify areas of the watershed where implementation of nutrient management activities would be the most beneficial. Collected data and model-generated information efforts during Phase III can be used alone or in combination with any existing data collected during Phases I and II, and any other available studies.

4 Hydromodification Exempt Areas

Hydromodification, which is caused by both altered stormwater flow and altered sediment flow regimes, can cause degradation of creeks, streams, and associated habitats. The purpose of the hydromodification management requirements in the Regional MS4 Permit is to maintain or restore more natural hydrologic flow regimes to prevent accelerated erosion and other impacts in downstream receiving waters.

In some cases, priority development projects may be exempt from hydromodification management requirements if the project site discharges runoff to receiving waters that are not susceptible to erosion (e.g., a lake, bay, or the Pacific Ocean) either directly or via an engineered facility. According to Section F.1.h.4 of the Permit. Each Co-Permittee has the discretion to exempt a priority development project from hydromodification management where the project:

(a) Discharges stormwater runoff into underground storm drains discharging directly to water storage reservoirs and lakes;

(b) Discharges stormwater runoff into conveyance channels whose bed and bank are concrete lined all the way from the point of discharge to water storage reservoirs and lakes; or

(c) Discharges stormwater runoff into other areas identified in the HMP as acceptable to not need to meet the requirements of Section F.1.h by the San Diego Water Board Executive Officer.

The June 2013 Santa Margarita Region Hydromodification Management Plan (HMP) identified certain exemptions from hydromodification management requirements by presenting "HMP Exemptions." The Regional MS4 Permit maintains some of these HMP exemptions. However, some of the exemptions are not included under the Regional MS4 Permit unless the area or receiving water is mapped in the WMAA. The intent of this section is to provide supporting technical analyses for exemptions that are recommended by the WMAA.

4.1 Additional Analysis for Hydromodification Management Exemptions

This section documents additional analysis performed to further evaluate the following exemptions (See Figure 4-1) that were approved by the San Diego Regional Board with the June 2013 Santa Margarita Region Hydromodification Management Plan. This study provides additional analysis, data, and rationale for supporting or eliminating the following existing exemptions but does not propose or study any new exemptions.

- Santa Margarita River

- Upstream Limit: At Origin, i.e. Confluence with Temecula Creek and Murrieta Creek
- Downstream Limit: Outfall to Pacific Ocean

- Temecula Creek
  - Upstream Limit: Outflow of Vail Lake
  - Downstream Limit: Confluence with Santa Margarita River
- Murrieta Creek
  - Upstream Limit: 850 feet upstream of Hawthorn Street
  - Downstream Limit: Confluence with Santa Margarita River

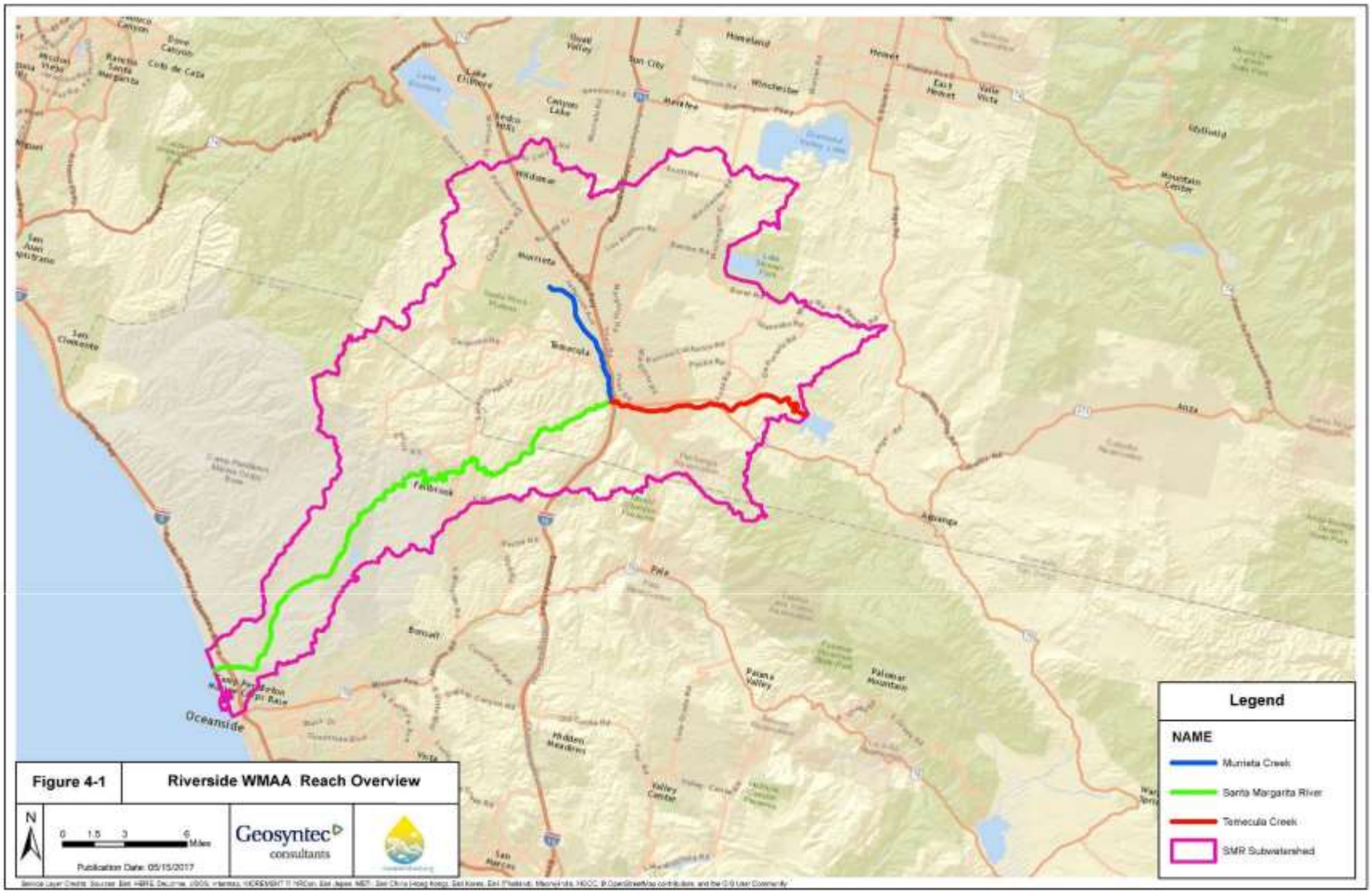
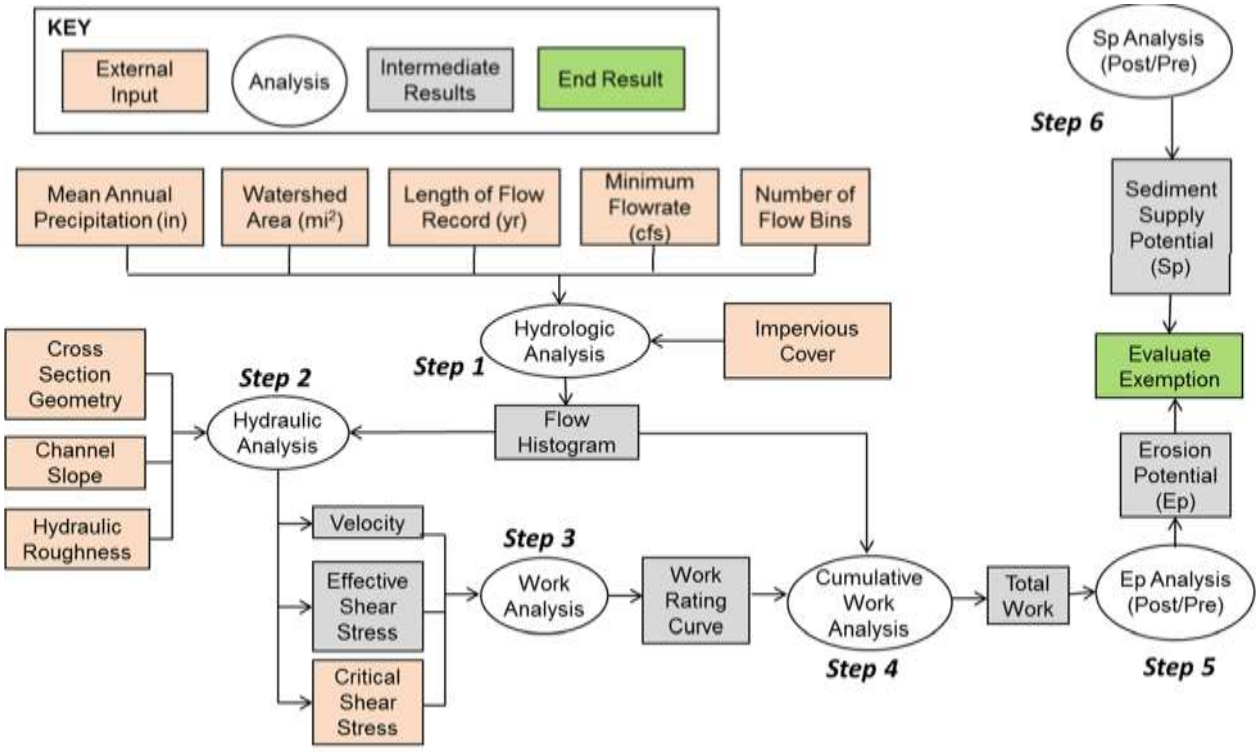


Figure 4-1. WMAA Reach Overview

4.2 Approach for Evaluating Hydromodification Management Exemptions

The approach (see diagram below) in this cumulative hydromodification impacts study accounts for: (1) hydrology, (2) channel geometry, (3) bed and bank material, and (4) sediment supply. This approach compares long-term changes in sediment transport capacity, or in-stream work, and sediment supply at specific sections of the creek for existing and future land use conditions. The ratio of future to existing condition transport capacity, or work, is termed Erosion Potential (Ep). The ratio of future/existing condition bed sediment supply is termed Sediment Supply Potential (Sp). To calculate Ep, the hydrology, channel geometry, and bed/bank materials are characterized for the existing and future conditions. To calculate Sp, the sediment supply factor is characterized for the existing and future conditions.



The findings in this study propose exemption for a given river reach if the analysis satisfies the following criteria:

- Ep < 1.05 when d50 < 16 mm or Ep < 1.20 when d50 > 16 mm, and;
- Sp > 0.5

The following bullet points provide basis for the criteria listed above:

- For Ep

  According to the Journal of Hydrology article titled Channel Enlargement in Semiarid Suburbanizing Watersheds: A Southern California Case Study (Hawley and Bledsoe, 2013): "The threshold corresponding to the presence/absence of headcutting varied based on substrate type, and was roughly quantified as a sediment-transport ratio greater than ~1.20 in systems with a median grain size > 16mm, and [Ep] ~ 1.05 when d50 < 16 mm"

- For Sp
- Technical Advisory Committee (TAC) recommendation
- County of San Diego BMP Manual Appendix H requires Sp > 0.5

According to SCCCWRP Technical Report 605, 2010, When the criteria for Ep and Sp are met, then changes in sediment supply and erosion potential are not anticipated to instigate, on their own, significant channel changes that would destabilize the stream. At present, the report suggests using predicted watershed changes of 50% or more in either runoff (as indexed by change in impervious area) or sediment production as provisional criteria for requiring a more detailed evaluation of both the drivers and the resisting factors for channel change, regardless of other screening-level assessments (SCCWRP Technical Report 605, 2010).

4.2.1 Erosion Potential Analysis

The following steps were implemented to estimate Erosion Potential (Ep):

- **Step 1** – Hydrologic Analysis
  - Due to limited flow data, a flow duration equation developed for Southern California (Hawley and Bledsoe, 2011) was used to estimate existing and future flow histograms for each watershed.
  - The change in impervious cover between existing and future development conditions was estimated using the existing and anticipated land use layer summarized in section 2.3.
    - Planning land use layers from Section 2.3 were used to estimate the existing impervious area and identify the developable parcels in each watershed. A GIS exercise was performed to identify the developable parcels in each watershed that will be exempt from hydromodification management requirements if the exemption is granted.
    - GLU analysis and its associated quantitative analysis described in Section 2.4 were used to determine Sp metric for each watershed. In this study, coarse sediment supply changes were limited to changes in hill slope erosion between existing condition and future condition (for parcels that are proposed to be exempt from hydromodification management) of the watershed. It was assumed that the changes in instream sediment supply between existing and future condition for these large depositional river systems are very minimal.
  - The process for quantifying existing vs future land use is as follows
    - Obtain and process land use data and impervious raster
      - Clip impervious raster (https://www.mrlc.gov/) to watershed boundary; Values of raster vary from 0 to 100 and represent percent impervious
      - Process land use data based on SCAG codes from 1100 to 9999
    - Perform zonal statistical analysis using ArcGIS
      - Imperviousness for each type of land use is calculated
    - Analyze results for imperviousness in each SCAG code
      - Determine total area corresponding to each SCAG code

        - Using simple average for each impervious surface coefficient associated with each SCAG code global imperviousness is calculated for each jurisdiction
    - Assumptions for percent imperviousness for each land use type were based on:
        - Office of Environmental Health Hazard Assessment (OEHHA) tool for the impervious fraction determination for areas within Riverside County.
        - The information provided in the San Diego County Imperviousness Study (County of San Diego, 2010) for areas within San Diego County.

- **Step 2** -Hydraulic Analysis
    - Critical cross section was selected for performing hydraulic analysis for each reach.
- **Step 3**: Work Analysis: The simplified effective work equation shown below is used to calculate the work done for each flow bin.
- $W = (r - r_c)^{l.S}V$

  Where
  W = Work (dimensionless)
  τ = effective Shear Stress [lb/ft^2]
  τ_c = Critical Shear Stress [lb/ft^2]
  V = Flow Velocity [ft/s]

- **Step 4**: Cumulative Work Analysis: Cumulative work is a measure of the long-term total work or sediment transport capacity performed at a given stream location. Cumulative work incorporates both discharge magnitude and flow duration distributions for the full range of simulated flow rates. Cumulative work is calculated by multiplying work and duration for each bin. Total work is calculated through summation of work from all flow bins.
- **Step 5**: Ep Analysis: Ep is calculated by dividing the total work of the future condition by that of the existing condition. The existing river reaches analyzed appear relatively stable and have not experienced excessive geomorphic instability due to the alteration of the drainage areas. Given the stable condition of the existing channels, the existing condition was used as the baseline condition instead of natural.

Steps 1 to 5 were performed in Excel. Ep estimates are included in the attachments and are summarized in a table in the corresponding section.

4.2.2 Sediment Supply Potential Analysis

- **Step 6** – Sp Analysis; Sp was estimated using the following equation; it was developed with input from Technical Advisory Committee members formed by the San Diego County Co-Permittees to develop streamlined guidance that provides applicants with simplified methods to determine impacts to coarse sediment delivery based on robust scientific principles. Sp is a metric to evaluate the changes in bed sediment supply for susceptible receiving channels of concern. Sp is directly proportional to Ep (Erosion potential). Sp has to be greater than 0.5, to substantiate a hydromodification exemption, based on current understanding of risks to receiving waters arising from changes in sediment production. Sp is estimated based on the following equation

  $Sp = 0.7*SY_{RUSLE}+0.3*SY_{NHD}$.

The hillslope coarse sediment supply (SY_{RUSLE}) was estimated using the quantitative results from Section 2.4. First, the watershed coarse sediment soil loss was estimated for all GLUs producing coarse sediment below the reservoirs in the existing condition. Then, the future-condition coarse sediment soil loss was estimated by subtracting the developed parcel below the reservoirs soil loss from the existing soil loss.

4.2.3 Criteria for Exemption

The following assessments were performed to evaluate if the projects directly discharging to the reaches discussed in Section 4.1 (see Figure 4.1) should be exempt from hydromodification management requirements. The criteria used in this analysis are consistent with the criteria approved in the San Diego Regional WMAA for determining if exemptions are appropriate, and are summarized below:

- For Flow Control:
  - Erosion potential (Ep) for the fully built-out condition compared to the existing condition shall be less than 1.20 when the median grain size (d_{50}) > 16 mm (Hawley and Bledsoe, 2013).
- For Coarse Sediment Supply:
  - Sediment supply potential (Sp) shall be greater than 0.5, based on current understanding of risks to receiving waters arising from changes in sediment production (SCCWRP Technical Report 605, 2010). Refer to the San Diego Regional WMAA report (Prepared by Geosyntec and RICK, 2015) and the San Diego Model BMP Design Manual for additional details about this criterion.

The watershed characterization maps summarized in Chapter 2 were used to evaluate the applicability of hydromodification management requirements.

4.3 Santa Margarita River

The extents of the Santa Margarita River (Upstream Limit: At Origin, i.e. Confluence with Temecula Creek and Murrieta Creek; Downstream Limit: Outfall to Pacific Ocean) for which hydromodification assessment is performed is shown in Figure 4-1. The river flows southwest through Temecula Canyon at the south end of the Santa Ana Mountains and then enters the coastal region where the river forms a large flood plain as it crosses Camp Pendleton Marine Corps Base before it enters the Pacific Ocean. The upper 15 miles of the river is characterized by a relatively narrow channel, slopes of approximately 1%, significant meanders and rocky terrain. The lower 15 miles within the coastal plain is characterized by a broader channel, shallower slopes of approximately 0.3%, and sandy substrate. Due to the two discrete channel types with varying substrate and associated particle size, two field assessments were conducted to characterize d50 and evaluate stability. Given that erosion potential (Ep) is greatest in the steepest channel, a critical section will be considered at the steepest point in the river profile. Sediment Supply (Sp) will be applied to the tributary watershed for existing and future conditions to quantify reductions in future critical course sediment supply. An additional assessment was conducted in the coastal plain to quantify the (Ep) and evaluate stability.

4.3.1 Erosion Potential Analysis

See section 4.2.1 for a description of the entire erosion potential analysis. This section includes specific information on erosion potential in the extents of the Santa Margarita River:

- The table below presents the input parameters used to construct flow histograms, as well as the estimated channel slope at the two cross sections.

Exempt River Reach	Area below the reservoirs (sq. miles)	Mean Annual Precipitation (in)	Length of Daily Flow Record (Years)	Channel Slope (ft/ft)
Upstream Santa Margarita River	352	16.3	30	0.025
Down Stream Santa Margarita River	352	16.4	30	0.003

- The upstream critical cross section along the reach for Ep analysis was selected by plotting the longitudinal profile of the reach (Figure 4-2) and selecting a cross section along the steeper portion of the channel where flow velocities would tend to be higher. A critical flow rate of 0.5Q2 was assigned to estimate the critical shear stress for the analyzed cross section.
- The downstream cross section along the reach for Ep analysis was selected based on its locations within the coastal region. The specific section investigated was selected on what could be accessed safely within Camp Pendleton. Critical shear stress for the reach was estimated based on Fischenich 2001, Stability Thresholds for Stream Restoration Materials. A value of 0.02 was assigned to estimate the critical shear stress for the analyzed cross section.

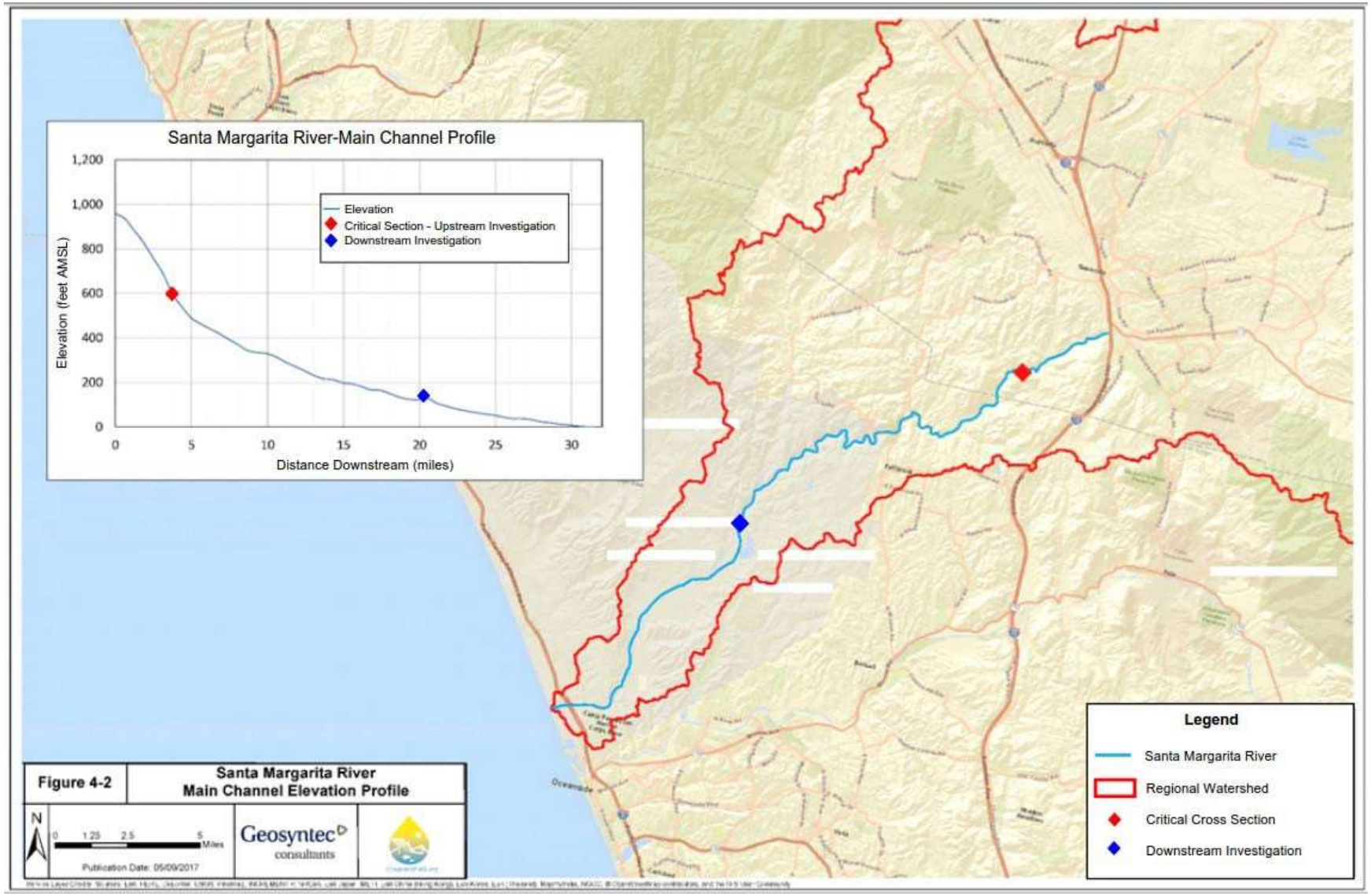


Figure 4-2. Santa Margarita River: Main Channel Elevation Profile

Upstream Investigation

- Field assessment was conducted on June 16, 2017 by Geosyntec Consultants (Geosyntec) within the vicinity of the critical cross section on the Santa Margarita River to assess channel stability and estimate the median grain size of the channel bed material. Based on the results of the field screening performed, the equivalent grain size for the reach with the critical cross section was determined to be greater than 16 mm. Representative channel and flood plain photos based on the field visit are shown in Figure 4-3 and Figure 4-4 below. As can be seen in both photos, the bed material is comprised mostly of large cobble and boulders well in excess of 128 mm. No evidence of downcutting or lateral adjustment was observed. Per SCCWRP Technical Report No. 606, the channel was determined to be consistent with a CEM Type 1 channel.
- Bed Material – Coarse/Armored Bed with boulders/cobbles, d50>128 mm
- Channel Evolution Model - CEM Type 1



Figure 4-3. Upstream Representative Channel



Figure 4-4. Upstream Representative Floodplain

Downstream Investigation

- Field assessment was conducted on March 20, 2018 by Riverside County Flood Control and Water Conservation District staff, within the downstream reach in the vicinity of Camp Pendleton on the Santa Margarita River to assess channel stability and estimate the median grain size of the channel bed material. Based on the results of the field screening performed, the equivalent grain size for the reach was determined to be greater than 16 mm. Representative channel and flood plain photos based on the field visit are shown in Figure 4-5 and Figure 4-6 below. As can be seen in both photos, the bed material is comprised mostly of sands, silts and gravel in excess of 16 mm. No evidence of downcutting or lateral adjustment was observed. Sedimentation was apparent throughout the stream bed. Per SCCWRP Technical Report No. 606, the channel was determined to be consistent with a CEM Type 1 channel.
- Bed Material – Sand and Gravel, d50>16 mm
- Channel Evolution Model - CEM Type 1



Figure 4-5. Downstream Representative Channel



Figure 4-6. Downstream Bed Material

EP estimates are included in Attachment H and are summarized in table below.

Exempt River Reach	Area below the reservoirs (Vail Lake and Skinner Reservoir) (acres)	Impervious Area (acres) [%]			Upstream Ep (Post/Pre)	Downstream Ep (Post/Pre)
		Pre	Post	Increase	[Criteria <1.20]	[Criteria <1.20]
Santa Margarita River	225,505	29,772 [13.2]	40,106 [17.8]	10,334 [4.6]	1.13	1.13

The estimated Ep is smaller than the threshold value of 1.20, hence the flow control criteria for Ep is considered to be met. Ep values less than 1.2 indicate the transport capacity of instream work for pre and post conditions will not be significantly altered or lead to unstable conditions. The factor of safety = 1.13/1.20 = 0.94, or a 6-7% factor of safety.

4.3.2 Sediment Supply Potential (Sp) Analysis

Results from this calculation (see Section 4.2.2 for approach) are presented in the below table.

Exempt River Reach	Coarse Sediment Soil Loss (tons/yr.)			SY_{RUSLE}
	Pre	Developed Parcels (downstream of Reservoirs)	Post [Pre – Developed Parcels]	
Santa Margarita River	1,352,421	432,298	920,123	0.68

Disturbance to NHDPlus channels are protected through 401 water quality certifications or waste discharge requirements issued by the RWQCB, so it is assumed that SY_{NHD} =1.

$$\text{Estimated Sp} = 0.7*SY_{RUSLE}+0.3*SY_{NHD} = 0.7*0.68 + 0.3*1 = 0.78.$$

The estimated Sp is greater than 0.5 so the reach meets the sediment supply potential criteria. The value being greater than 0.5 indicate that sediment supply for pre and post conditions will not be significantly

different and adequate sediment supplies to the stream will continue. The factor of safety = 0.78/0.5 = 1.56 or 56% factor of safety.

4.3.3 Recommendation

Based on the results from this study, it is recommended that hydromodification management exemption be reinstated for projects discharging runoff directly to the Santa Margarita River (Upstream Limit: At Origin, i.e. Confluence with Temecula Creek and Murrieta Creek; Downstream Limit: Outfall to Pacific Ocean).

Each municipality must define/approve "direct discharge" based on the project site conditions. To qualify for the potential exemption, the outlet elevation must be between the river bottom elevation and the 100-year flood plain elevation and properly designed energy dissipation must be provided.

The Santa Margarita River Estuary (Estuary) is on the 303(d) impairment list for eutrophic conditions. While no analysis has been performed within this assessment, the proposed exemption is not anticipated to conflict with water quality objectives in the Estuary for the following reasons.

1. Nitrogen and Phosphorus loading from the watershed will not be measurably different with or without the proposed hydromodification management exemption. The primary driver of the eutrophic conditions in the Estuary is during dry weather. The exemption has no effect on dry weather discharges or rising groundwater inputs to the Estuary in which the eutrophication symptoms are most prevalent.
2. According to the exemption analysis, this stream system is anticipated to be stable, (i.e., excessive or accelerated erosion is not expected), such that, sediments carrying nutrients would not increase downstream. Furthermore, Ep and Sp analysis indicate that channel erosion and transport will not be significantly changed and therefore instream channel derived sediment and associated nutrients are not expected to increase.
3. Water Quality Analysis Simulation Program model results, included in the Model Application Report, notes that the hydromodification controls are unlikely to have a significant impact on the Estuary. Implications of the findings is that wet weather structural BMPs, which generally cost an order of magnitude or higher to implement, may not provide any additional environmental benefits to the Estuary than implementation of dry weather BMPs alone.
4. The watershed of the Santa Margarita River downstream from the reservoirs totals 352 square miles. The area being evaluated for the proposed hydromodification exemption totals approximately 10 square miles or 2.8 % of the total watershed. Given the relatively small area in which the proposed hydromodification exemption will be applied within the greater Santa Margarita Watershed, the exemption is not expected to exacerbate eutrophic conditions.
5. Within the hydromodification exemption area, priority development projects in the absence of hydromodification requirements will still be required to provide treatment of the 85th percentile rainfall with an effective combination of BMPs that target the constituents of concern such as nitrogen and phosphorus. Additionally, all priority development projects will implement peak flow control BMPs as required by Riverside County Flood Control and Water Conservation District to preserve the 2 to 10-year peak flow rates generated by the project site. Treatment of stormwater runoff through effective BMPs combined with preservation of 2-10 year peak flow rates will ensure target pollutants such as nitrogen and phosphorus are effectively treated and the drainage response is preserved. This strategy will effectively provide a similar level of mitigation required by hydromodification.
6. Hydromodification BMPs are designed to release stored volume over an extended period which effectively increases the duration of low flows. Increasing durations will expand the wet weather

response and could contribute to dry weather flow volume, thereby contributing to dry weather flows. This could conflict with the effort to reduce dry weather input of nitrogen and phosphorus to the estuary. The proposed hydromodification exemption could serve to minimize these potential adverse impacts.

7. Other contributors such as lateral inputs and tidal exchange will not be impacted by the hydromodification exemption. The agricultural fields near the Santa Margarita River Estuary have been identified as a significant source of sediment and nutrients from erosion and subsequent sedimentation in the estuary. Additionally, lack of tidal exchange has been identified as contributing to lower levels of dissolved oxygen. These contributing factors will not be exacerbated from a hydromodification exemption.

These findings strongly support the determination that a hydromodification exemption will not contribute to further degradation of the Santa Margarita River Estuary. The condition of the estuary and the stability of the Santa Margarita River will continue to be monitored and ongoing evaluations will continue as permits are reissued to verify the river is stable.

4.4 Temecula Creek

The extents of the Temecula Creek (Upstream Limit: Outflow of Vail Lake; Downstream Limit: Confluence with Santa Margarita River) for which hydromodification assessment is performed is shown in Figure 4-5.

On September 14, 2017, a field team from Geosyntec investigated segments along Temecula Creek to assess channel stability and susceptibility to erosion, and hydromodification impacts. An initial desktop assessment of aerial maps was used to determine areas of interest showing signs of erosion or geomorphic change. Information was collected based on Hydromodification Screening Tools: Field Manual for Assessing Channel Susceptibility (Booth et al., 2010).

Although multiple locations along the creek were visited, this report is focused on the downstream reach of Temecula Creek, particularly between Pechanga Parkway, at the downstream end, and Avenida de Missiones, at the upstream end. Aerial and field photographs are presented below to highlight observed susceptibility to erosion in the Creek.

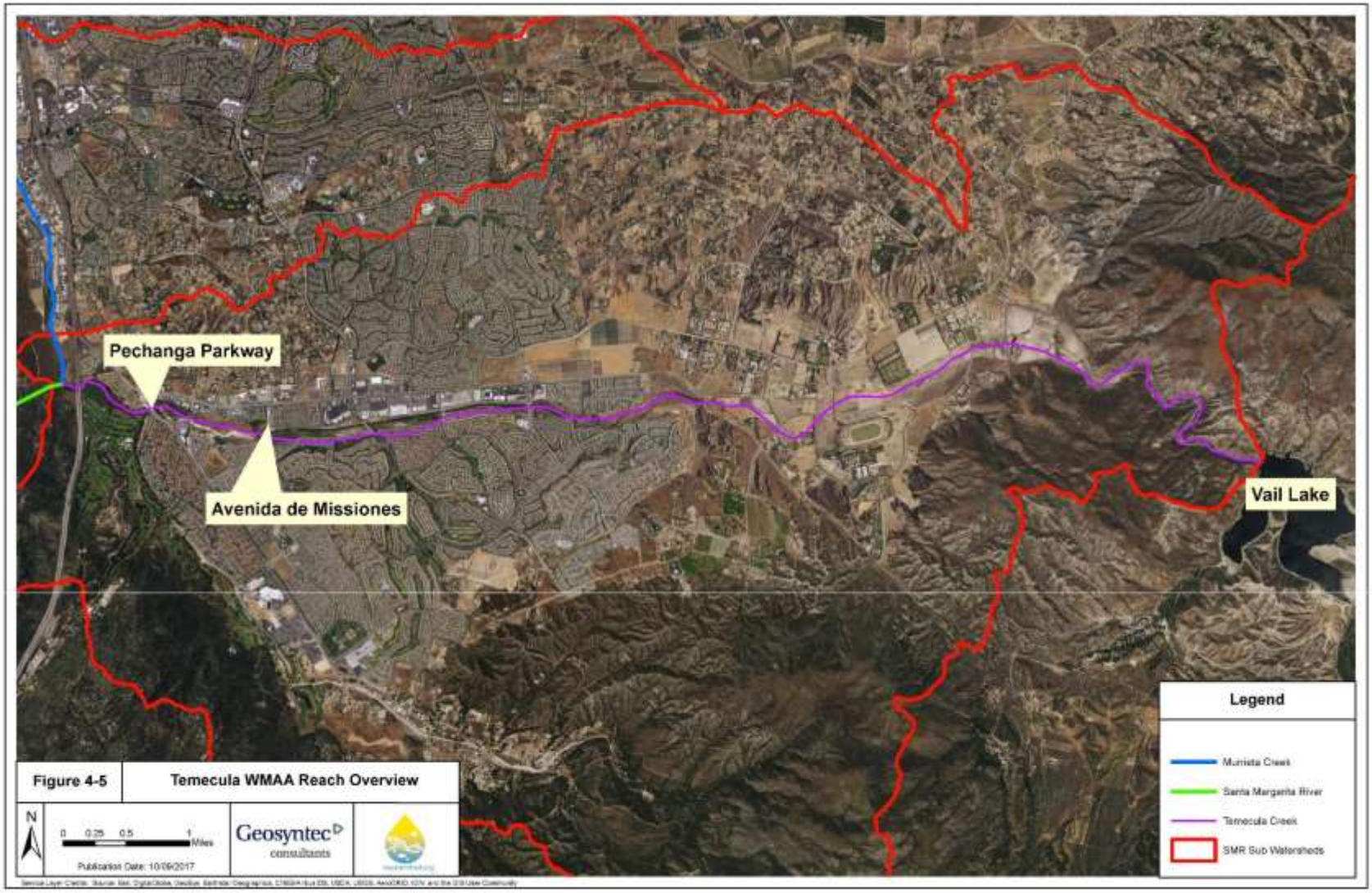


Figure 4-7.: Temecula WMAA Reach Overview

4.4.1 Temecula Creek between Pechanga Parkway and Avenida de Missiones

This segment of Temecula Creek was observed to be wide and heavily vegetated in parts; however, the main portion of the Creek that handles flows was deeply incised at points, with eight-to-nine-foot vertical cuts, soft banks, and a sandy bed. The historical aerials below (Figures 4-6 to 4-11) demonstrate how the channel planform has changed since 1995, and particularly show how concentrated flow has affected the channel form. Field photographs from September 14, 2017 (Figures 4-12 to 4-15) provide documentation of current conditions within the channel.

Figure 4-6 shows Temecula Creek upstream of Pechanga Parkway in late 1995. Per historical aerials, development of the Redhawk community was partially complete by this point, and development of a small residential neighborhood on Temecula Parkway between Country Glen Way and Avenida De Missiones was complete (partially shown in the top-right corner of Figure 4-6). The majority of the remainder of the upstream watershed was not yet developed, though some grading along the north bank of the Creek had begun.

The yellow arrow on the left side of Figure 4-6 shows a drainage lateral to the Creek. Subsequent aerial photos show the lateral enlarging and the effect on Temecula Creek is noticeable. For example, Figure 4-9 shows the Creek in January 2006, after this storm drain channel appears to have been completed. The Creek bed has widened substantially at this confluence and threatens the integrity of the adjacent parking lot. This area is circled in yellow on the left of Figures 4-6 to 4-11.

The yellow circle in the middle of Figure 4-6 shows Creek adjustment near a park on the south bank. This geomorphic adjustment appears to threaten to the structural integrity of the adjacent park.

The yellow arrow on the right side of Figure 4-6 shows the concentrated flow path for upstream flows in the Creek, including flows coming from the Country Glen Way development. Over time, as demonstrated in subsequent aerial photos, the flow path in this portion of Temecula Creek has adjusted. The Creek at this point becomes incised, with eroded vertical banks along the southern bank of the Creek. In addition, the southern bank of the Creek grows wider over time, and gets nearer and nearer to Strawberry Tree Lane.



Figure 4-8. Temecula Creek at Pechanga Parkway, October 1995



Figure 4-9. Temecula Creek at Pechanga Parkway, October 2003



Figure 4-10. Temecula Creek at Pechanga Parkway, July 2004



Figure 4-11. Temecula Creek at Pechanga Parkway, January 2006



Figure 4-12. Temecula Creek at Pechanga Parkway, June 2012



Figure 4-13. Temecula Creek at Pechanga Parkway, October 2016



Figure 4-14. Temecula Creek at Pechanga Parkway, September 2017. Vertical cut along the north bank of the Creek



Figure 4-15. Temecula Creek at Pechanga Parkway, September 2017. Vertical cut along the south bank of the Creek



Figure 4-16. Temecula Creek at Pechanga Parkway, September 2017. Vertical cuts along the south bank of the Creek, adjacent to Pala Community Park



Figure 4-17. Temecula Creek at Pechanga Parkway, September 2017. Vertical cuts along the north bank of the Creek. Exposed tree roots shown

4.4.2 Recommendation

Based on the historical aerial photo review and field investigation conducted by Geosyntec staff, the downstream end of Temecula Creek is susceptible to erosion. Aerial photographs demonstrate a widening of flow path over the past 20 years. The field investigation observed soft, unconsolidated sand bed material and eroded channel banks, some of which threaten the physical integrity of infrastructure along the southern bank between Pechanga Parkway, at the downstream end, and Via Del Coronado, at the upstream end (e.g., parking lot, park with soccer field, and Strawberry Tree Lane). (Note: The calculations described in Section 4.2 only apply to channels that are stable in present condition; therefore, no calculations are provided for this reach of Temecula Creek being analyzed.)

In light of the creek's susceptibility to erosion and existing infrastructure concerns associated with geomorphic adjustment, it is recommended that the hydromodification exemption not be reinstated at this time. Temecula Creek can be considered a potential candidate for an in-stream restoration/stabilization project to remedy current stability issues and manage for future hydromodification effects associated with new development in its tributary watershed.

4.4.3 Murrieta Creek

The extents of the Murrieta Creek (Upstream Limit: 850 feet upstream of Hawthorn Street; Downstream Limit: Confluence with Santa Margarita River) for which hydromodification assessment is performed is shown in Figure 4-16. Section 4.5.1 presents an overview of the Murrieta Creek Flood Control, Environmental Restoration and Recreation Project.



Figure 4-18: Murrieta WMAA Reach Overview

4.4.4 Murrieta Creek Flood Control, Environmental Restoration and Recreation Project

Murrieta Creek traverses the cities of Temecula and Murrieta in the densely populated southwest region of Riverside County. At the confluence with Temecula Creek, it forms the Santa Margarita River which flows through Camp Pendleton Marine Base and on to the Pacific Ocean. As a result of repeated flood events, culminating with the catastrophic flood in 1993, the U.S. Army Corps of Engineers initiated a study on a 7.5-mile section of the creek, which led to the 2000 Congressional recognition of the 4-phase Murrieta Creek Flood Control, Environmental Restoration and Recreation Project.

The project is anticipated to:

- Improve flood control and storm water retention
- Enhance water conservation and supply
- Provide recreation-related opportunities along the Santa Margarita River and its tributaries in Riverside and San Diego counties

Flood Control Features include:

- Widening and deepening of Murrieta Creek from the USGS stream gauge in Temecula to Tenaja Road in Murrieta
- A flood control detention basin occupying approximately 250 acres on the eastern side of Murrieta Creek between Santa Gertrudis Channel to approximately 500 feet upstream of the confluence with Warm Springs Creek and bordering Adams Avenue, Cherry Street and Jefferson Avenue
- Stream bank protection features between Rancho California Road and First Street

Locally Funded Recreation Features include:

- Construction of a public park of about 50 acres in size within the easternmost portion of the detention basin. This will include parking lot, children's play area, shade structures, comfort station, barbecues, open space, walks, baseball and soccer fields, security lighting, pedestrian/bicycle/equestrian bridges spanning Santa Gertrudis Creek and Murrieta Creek
- Bicycle and equestrian/hiking trails along the eastern and western park in the detention basin, with undercrossing structures beneath the bridges on First Street, Rancho California Road, Winchester Road, Guava Street and Ivy Street

Environmental Restoration Features include:

- Constructing a low flow channel with natural backwaters
- Creating a transitional wetland habitat from freshwater marsh habitat to willow riparian woodland with an upland buffer of mulefat scrub and coastal sage scrub within a 163 acre site
- A 13.7 acre sediment catchment area at the confluence of Murrieta and Warm Springs Creeks

The four phases of the project are shown in Figure 4-17. Phase 1 construction is complete. Phase 2 construction is anticipated to be complete by January 2018. Typical existing and proposed cross section for phase 2 is shown in Figure 4-18.



Figure 4-19. Murrieta Creek Flood Control, Environmental Restoration and Recreation Project

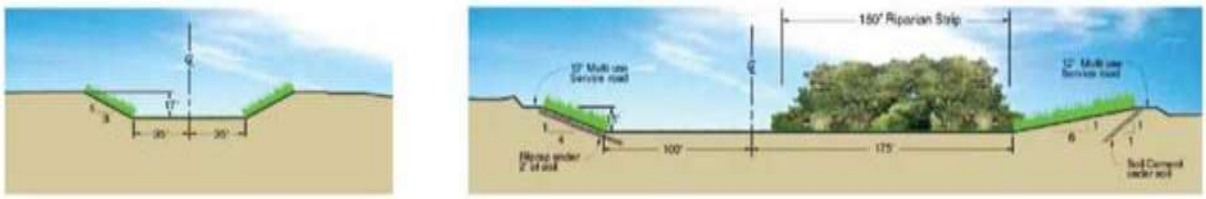


Figure 4-20. Typical existing and proposed cross section for Phase 2

Based on the field visit and assessment conducted by Geosyntec staff on September 14, 2017 the existing phase 3 reach is stable (see Figure 4-19). In the Phase 4 area, walking from downstream to upstream the first sign of erosion was observed at around 80 feet upstream of Washington Avenue (see Figure 4-20).



Figure 4-21. Looking downstream near the Murrieta Creek and Santa Gertrude Creek confluence. Heavily vegetated channel bed and concrete side slope.



Figure 4-22. Looking towards east riverbank 80 feet upstream of Washington Avenue overpass. Sandy gravel riverbanks showing a 25 foot high erosion cut.

Based on the findings from the field visit and consideration of the ongoing Phase 2 of the Murrieta Creek Flood Control, Environmental Restoration and Recreation Project that is anticipated to be complete by

January 2018, the exemption analysis extents were revised for Murrieta Creek (Upstream Limit: Washington Avenue; Downstream Limit: Confluence with Santa Margarita River). The same approach that was used for Forester Creek (engineered channels that are stabilized with materials other than concrete, such as riprap, turf reinforcement mat, or vegetation) as part of the San Diego River WQIP was implemented for Murrieta Creek and summarized below.

4.4.5 Erosion Potential Analysis

See section 4.2.1 for a description of the entire erosion potential analysis. This section includes specific information on erosion potential in the extents of the Murrieta Creek:

The following steps were implemented to estimate the Erosion Potential:

- The table below presents the input parameters used to construct flow histograms. The critical slope and cross-section was obtained from Phase 2 design plans.

Stabilized Conveyance System	Area below the reservoirs/lakes (sq. miles)	Mean Annual Precipitation (in)	Length of Daily Flow Record (Years)	Channel Slope (ft/ft)
Murrieta Creek	149	14.7	30	0.002

- The critical cross section was based on the narrowest cross section (140 feet wide trapezoidal channel) and the steepest slope (0.2% longitudinal slope) in the phase 2 plans.
- Critical shear stress was estimated to be greater than or equal to 1.2 pounds per square foot (lb/ft2), based on review of permissible shear stress values presented in "Stability Thresholds for Stream Restoration Materials" (Fischenich 2001) and "Streambank Soil Bioengineering Considerations for Semi-Arid Climates" (Hoag and Fripp 2005). Based on Fischenich 2001, permissible shear stress for "long native grasses" is approximately 1.2 to 1.7 lb/ft2. The side slopes are generally either turn reinforcement mat, soil cement protection, rip-rap or dense vegetation all of which have critical shear stress greater than or equal to 8 pounds per square foot (lb/ft2)

Steps 1 to 5 were performed in Excel. Ep estimates for the exempt river reaches are included as an Attachment H. Results from the Ep analysis are summarized in table below.

Stabilized Conveyance System	Area below the reservoirs (Skinner Reservoir) (acres)	Impervious Area (acres) [%]			Ep (Post/Pre)
		Pre (existing)	Post (built out)	Increase	
Murrieta Creek	95,251	13,762 [14.4]	20,634 [21.7]	6872 [7.3]	1

The analysis results, presented in Attachment H, show that for both the existing and future condition, the shear stress for all geomorphically-effective flows is less than the estimated critical shear stress of 1.2 lb/ft^2. This means that no excess shear stress or "work" occurs in the channel in either the existing or future condition. Therefore, there is no increase in the duration of "work" (cumulative work), in the future condition, and erosion potential is 1.0.

Note that while the flow rates are the same in both the existing and future condition analyses, the duration of each flow rate is increased in the future condition. The flow rates in the flow bins are based on the watershed area, mean annual precipitation, and length of the synthetic record. The synthetic record means the modeled or analytically- derived series of hydrology parameters such as flow rate and duration of flow at points or nodes in the system. Available measures parameters such as precipitation, catchment area, catchment slopes, channel conditions, and are used as inputs to the model or algorithm. Watershed area, mean annual precipitation, and length of the synthetic record do not change from existing to future condition. The duration for each flow bin is related to the watershed area, mean annual precipitation, length of the synthetic record, and the impervious area. The duration increases in the future condition based on the increased impervious area. The increase in duration would result in increased cumulative work in the future condition if any of the flow rates resulted in shear stress greater than the estimated critical shear stress (excess shear stress, or "work"), because cumulative work is the product of work times duration.

The scenario that occurred in the Murrieta Creek analysis, in which no work occurred in the expected range of geomorphically-effective flow rates, is a potential scenario for engineered channels because engineered conveyance systems are typically engineered for flood flows much greater and less frequent than the geomorphically-effective flows. For example, Murrieta Creek is being engineered to convey a 100-year flow rate of approximately 30,900 cubic feet per second (cfs) (100-year flow estimate is from FEMA Flood Insurance Study). The maximum geomorphically-effective flow rate for Murrieta Creek is 11,000 cfs.

In addition, the USACE report states that for the Phase 2 design it is anticipated that flows of about seven feet/second and above could cause erosion and scouring of the unmaintained riparian/low-flow corridor. These occurrences of erosion and scour are expected to be within the range of current conditions. It is anticipated that the larger trees would remain in place once established; however, the smaller trees and shrubs may be washed out during significant storm events. Natural recruitment is expected within areas of scour as has occurred within the Phase I area, where riparian and wetland vegetation within the channel invert has re-established after completion of construction. The estimated velocity for the maximum geomorphically-effective flow rate of 11,000 cfs for Murrieta Creek is 5.8 feet/second. This also supports the hydromodification management exemption.

4.4.6 Recommendation

Based on the results from this study, it is recommended that hydromodification management exemption be reinstated for projects discharging runoff directly to the Murrieta Creek (Upstream Limit: Washington Avenue; Downstream Limit: Confluence with Santa Margarita River).

Hydromodification management exemption from Washington Avenue to 850 feet upstream of Hawthorn Street is not reinstated at this time. Based on the field visit and assessment by Geosyntec staff, this segment of channel appeared to be unstable and susceptible to erosion.

4.5 Conclusion

Based on the results from this study, it is recommended that hydromodification management exemption be reinstated for projects discharging runoff directly to the following exempt river reaches:

- Santa Margarita River

- Upstream Limit: At Origin, i.e. Confluence with Temecula Creek and Murrieta Creek
- Downstream Limit: Outfall to Pacific Ocean

- Murrieta Creek
  - Upstream Limit: Washington Avenue
  - Downstream Limit: Confluence with Santa Margarita River

Each municipality must define/approve "direct discharge" based on the project site conditions. To qualify for the potential exemption, the outlet elevation must be between the river bottom elevation and the 100-year floodplain elevation and properly designed energy dissipation must be provided.

4.5.1 Factors of Safety

The analysis conducted to evaluate the applicability of hydromodification management requirements to priority development projects directly discharging to the exempt river reaches have the following implicit factors of safety:

- The analysis assumes all projects within the watershed will be exempt from hydromodification management requirements for erosion potential and coarse sediment supply calculations (note: during actual implementation only projects directly discharging to the exempt reach will be exempt). This conservative assumption provides an implicit (non-quantified) factor of safety.
- The analysis assumes all impervious area in the watershed is directly connected impervious area. In actuality, some portion of these impervious areas will sheet flow through pervious areas prior to discharging to the streams. This dispersion will result in attenuation of flow rates and durations that are not accounted for when estimating the sediment transport capacity of the built-out condition. This conservative assumption provides an implicit (non-quantified) factor of safety.
- New priority development projects, including projects that are proposed to be exempt from hydromodification management requirements through this study, must implement retention BMPs to the extent feasible if participation in alternative compliance is not selected or allowed. This requirement will result in attenuation of flow rates and durations that are not accounted for when estimating the sediment transport capacity of the built-out condition. This conservative assumption provides an implicit (non-quantified) factor of safety.
- Redevelopment priority development projects in the watershed that do not directly discharge to the river reach that is exempt by this study must mitigate flows to the pre-developed condition. This will result in over mitigation of flow rates and durations for redevelopment projects which are not accounted for when estimating the sediment transport capacity of the built-out condition. This conservative assumption provides an implicit (non-quantified) factor of safety.

4.5.2 Limitations

The analysis and associated recommendations as presented above were based on instream erosion as the primary consideration to support reinstatement of exemptions from hydromodification management controls for discharges directly to these river reaches. While it is recognized that other factors contribute to adverse impacts (e.g., salinity imbalance, pollutants) to instream habitat and resulting biotic integrity, hydromodification management control has traditionally been considered an "umbrella process" that encompasses most of the highest risk stressors (percent sands and fines present, channel alteration, and riparian disturbance) to physical habitat.

The current assessment methods may yield inconclusive results when attempting to identify causal relationships between degraded instream habitat solely due to increased flows and erosive force from hydromodification. A causal assessment recently conducted in the lower reaches of the San Diego River, conducted as a partnership between the Southern California Coastal Water Research Project (SCCWRP), the City of San Diego, the County of San Diego, and the San Diego RWQCB, focused on stressors potentially responsible for known biological impairment of the river. Once the data of the causal assessment become available, it may be useful in classifying the potential stressors such as altered physical habitat as likely, unlikely, or an uncertain cause to biological impairment.

With respect to adverse impacts to habitat as a result of pollutants entrained in storm water discharges, these areas will still be subject to the pollutant control requirements of the Regional MS4 Permit as areas develop or redevelop. The current requirements require development to maximize retention of the design storm volume which will mitigate a portion of the volume that would otherwise be controlled with hydromodification management BMPs. In some cases, this offsetting of volume reduction through pollutant control BMPs may exceed the HMP volumes. In addition, the development that occurs within the exempted watershed areas is still required to provide any applicable flood control measures. Risk of flooding as a result of exemption from hydromodification controls is unlikely as the control thresholds are significantly lower (order of magnitude) than flood control requirements implemented to protect life and property.

5 Conclusions

This WMAA used available regional data to understand watershed-scale characteristics and processes in the SMR. The results of this analysis are shown on the maps in Attachment A. This analysis combined with the San Diego Water Quality Equivalency guidance can be used to provide flexibility with meeting the Permit's land development requirements. The WMAA mapping includes readily available regional datasets and specific projects will be augmented with site-specific analysis. As such, projects will also consult the future BMP Design manual for options to meet the Permit requirements. The Co-Permittees continue to develop the BMP Manual and are looking for additional compliance options for small projects, single-family residences or sites that substantially mimic predevelopment conditions.

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7 Glossary

Term	Definition
Alternative Compliance Program	An optional program that may be implemented by individual Co-Permittees to allow for offsite ACPs to offset stormwater pollutant control and hydromodification impacts that are not fully addressed at PDP sites.
Best Management Practice (BMP)	Any procedure or device designed to minimize the quantity of Pollutants that enter the MS4 or to control stormwater flow.
Bioretention	A type of BMP that is designed to capture a certain volume of stormwater within a biologically active soil media. Retained water is evapotranspired by plants in the BMP or allowed to slowly infiltrate into the underlying soils.
Hydromodification	The change in the natural watershed hydrologic processes and runoff characteristics (i.e., interception, infiltration, overland flow, and groundwater flow) caused by urbanization or other land use changes that result in increased stream flows and sediment transport. In addition, alteration of stream and river channels, such as stream channelization, concrete lining, installation of dams and water impoundments, and excessive streambank and shoreline erosion are also considered hydromodification, due to their disruption of natural watershed hydrologic processes.
Municipal Separate Storm Sewer System (MS4)	A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels or storm drains) as defined in 40 CFR 122.26(b)(8).
Priority Development Project	New development and redevelopment projects defined under Provision E.3.b of the Permit.
Structural BMP	A subset of BMPs which detains, retains, filters, removes, or prevents the release of pollutants to surface waters from development projects in perpetuity, after construction of a project is completed.
Water Quality Improvement Plan (WQIP)	A planning document which describes programs which will be implemented to meet water quality requirements as described in Provision B of the Permit.
Water Quality Equivalency	Methodologies and calculations used to determine water quality benefits and water quality impacts, and to apply them toward the design, review, and approval of PDPs and ACPs in meeting the Section E.3.c.(3) requirements of the Permit.
SMR Co-Permittees	The SMR Co-Permittees include County of Riverside, Riverside County Flood Control and Water Conservation District, City of Wildomar, City of Murrieta, City of Temecula, City of Menifee and County of San Diego.

Attachments

Attachment A. Dominant Hydrologic Processes

Table A.1
Land Cover Categories
Riverside County

ID	Vegetation Category	Land Cover Grouping
1	Annual Grassland	Agricultural/Grass
2	Cropland, Orchard - Vineyard	Agricultural/Grass
3	Urban	Developed
4	Barren	Forest
5	Coastal Oak Woodland	Forest
6	Eucalyptus	Forest
7	Jeffrey Pine	Forest
8	Mixed Chaparral	Forest
9	Montane Hardwood	Forest
10	Montane Hardwood - Conifer	Forest
11	Montane Hardwood, Montane Hardwood - Conifer	Forest
12	Montane Riparian, Valley Foothill Riparian	Forest
13	Pinyon - Juniper	Forest
14	Sierran Mixed Conifer	Forest
15	Valley Foothill Riparian	Forest
16	White Fir, Sierran Mixed Conifer	Forest
17	Desert Riparian, Desert Wash	Other
18	Fresh Emergent Wetland	Other
19	Lacustrine	Other
20	Riverine, Lacustrine	Other
21	Wet Meadow	Other
22	Lacustrine	Other
23	Alkali Desert Scrub	Scrub/Shrub
24	Chamise-Red Shank Chaparral	Scrub/Shrub
25	Coastal Scrub	Scrub/Shrub
26	Mixed Chaparral	Scrub/Shrub
27	Sagebrush	Scrub/Shrub

Three scenerios led to an overide or modification of the Land Cover value

1. Impervious layer union resulted in a Developed value
2. Aerial shows urban development for a given area
3. Road ROW union resulted in a Developed value

Table A.2 Land Cover Grouping
San Diego County

ID	Vegetation Category	Land Cover Grouping
1	42000 Valley and Foothill Grassland	Agricultural/Grass
3	42110 Valley Needlegrass Grassland	Agricultural/Grass
5	42200 Non-Native Grassland	Agricultural/Grass
11	45110 Wet Montane Meadow	Agricultural/Grass
12	45120 Dry Montane Meadows	Agricultural/Grass
19	18000 General Agriculture	Agricultural/Grass
20	18100 Orchards and Vineyards	Agricultural/Grass
22	18200 Intensive Agriculture - Dairies, Nurseries, Chicken Ranches	Agricultural/Grass
23	18300 Extensive Agriculture - Field/Pasture, Row Crops	Agricultural/Grass
24	18310 Field/Pasture	Agricultural/Grass
26	18320 Row Crops	Agricultural/Grass
27	12000 Urban/Developed	Developed
29	81100 Mixed Evergreen Forest	Forest
32	81320 Canyon Live Oak Forest	Forest
33	81340 Black Oak Forest	Forest
36	84000 Lower Montane Coniferous Forest	Forest
39	84150 Bigcone Spruce (Bigcone Douglas Fir)-Canyon Oak Forest	Forest
41	84500 Mixed Oak/Coniferous/Bigcone/Coulter*	Forest
42	85100 Jeffrey Pine Forest	Forest
43	11100 Eucalyptus Woodland	Forest
45	61000 Riparian Forests	Forest
46	61300 Southern Riparian Forest	Forest
47	61310 Southern Coast Live Oak Riparian Forest	Forest
48	61320 Southern Arroyo Willow Riparian Forest	Forest
49	61330 Southern Cottonwood-willow Riparian Forest	Forest
50	61510 White Alder Riparian Forest	Forest
56	62400 Southern Sycamore-alder Riparian Woodland	Forest
58	71000 Cismontane Woodland	Forest
59	71100 Oak Woodland	Forest
60	71120 Black Oak Woodland	Forest
61	71160 Coast Live Oak Woodland	Forest
62	71161 Open Coast Live Oak Woodland	Forest
63	71162 Dense Coast Live Oak Woodland	Forest
66	71181 Open Engelmann Oak Woodland	Forest
67	71182 Dense Engelmann Oak Woodland	Forest
74	79000 Undifferentiated Dense Woodland*	Forest
76	52120 Southern Coastal Salt Marsh	Other
78	52310 Cismontane Alkali Marsh	Other
80	52410 Coastal and Valley Freshwater Marsh	Other
87	13110 Marine	Other
96	13140 Freshwater	Other
97	13200 Non-Vegetated Channel, Floodway, Lakeshore Fringe	Other
99	13400 Beach	Other
100	21230 Southern Foredunes	Scrub/Shrub
106	63300 Southern Riparian Scrub	Scrub/Shrub
107	63310 Mule Fat Scrub	Scrub/Shrub
109	63320 Southern Willow Scrub	Scrub/Shrub
112	63400 Great Valley Scrub	Scrub/Shrub
120	32500 Diegan Coastal Sage Scrub	Scrub/Shrub
123	32700 Riversidian Sage Scrub	Scrub/Shrub
125	32720 Alluvial Fan Scrub	Scrub/Shrub
137	35200 Sagebrush Scrub	Scrub/Shrub
142	37000 Chaparral	Scrub/Shrub
143	37120 Southern Mixed Chaparral	Scrub/Shrub
145	37121 Granitic Southern Mixed Chaparral	Scrub/Shrub
148	37130 Northern Mixed Chaparral*	Scrub/Shrub
149	37131 Granitic Northern Mixed Chaparral*	Scrub/Shrub
150	37132 Mafic Northern Mixed Chaparral*	Scrub/Shrub
151	37200 Chamise Chaparral	Scrub/Shrub
154	37300 Red Shank Chaparral	Scrub/Shrub
156	37500 Montane Chaparral	Scrub/Shrub
158	37520 Montane Manzanita Chaparral	Scrub/Shrub
160	37540 Montane Scrub Oak Chaparral	Scrub/Shrub
162	37830 Ceanothus crassifolius Chaparral	Scrub/Shrub
163	37900 Scrub Oak Chaparral	Scrub/Shrub
166	37G00 Coastal Sage-Chaparral Scrub	Scrub/Shrub
167	37K00 Flat-topped Buckwheat*	Scrub/Shrub
168	39000 Upper Sonoran Subshrub Scrub	Scrub/Shrub
175	11300 Disturbed Habitat	Unknown

Table A.3 Runoff Coefficients versus Land Use, Hydrologic Soil Group and Slope Range

	A			B			C			D		
Land Use	0–2%	2–6%	6%+	0–2%	2–6%	6%+	0–2%	2–6%	6%+	0–2%	2–6%	6%+
Cultivated land	0.08[a]	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
	0.14[b]	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Pasture	0.12	0.20	0.30	0.18	0.28	0.37	0.24	0.34	0.44	0.30	0.40	0.50
	0.15	0.25	0.37	0.23	0.34	0.45	0.30	0.42	0.52	0.37	0.50	0.62
Meadow	0.10	0.16	0.25	0.14	0.22	0.30	0.20	0.28	0.36	0.24	0.30	0.40
	0.14	0.22	0.30	0.20	0.28	0.37	0.26	0.35	0.44	0.30	0.40	0.50
Forest	0.05	0.08	0.11	0.08	0.11	0.14	0.10	0.13	0.16	0.12	0.16	0.20
	0.08	0.11	0.14	0.10	0.14	0.18	0.12	0.16	0.20	0.15	0.20	0.25
Residential lot	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
size 1/8 acre	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Residential lot	0.22	0.26	0.29	0.24	0.29	0.33	0.27	0.31	0.36	0.30	0.34	0.40
size 1/4 acre	0.30	0.34	0.37	0.33	0.37	0.42	0.36	0.40	0.47	0.38	0.42	0.52
Residential lot	0.19	0.23	0.26	0.22	0.26	0.30	0.25	0.29	0.34	0.28	0.32	0.39
size 1/3 acre	0.28	0.32	0.35	0.30	0.35	0.39	0.33	0.38	0.45	0.36	0.40	0.50
Residential lot	0.16	0.20	0.24	0.19	0.23	0.28	0.22	0.27	0.32	0.26	0.30	0.37
size 1/2 acre	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.48
Residential lot	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.29	0.35
size 1 acre	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Industrial	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.89	0.90
Streets	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78
	0.76	0.77	0.79	0.80	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Open space	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.15	0.21	0.28
	0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Parking	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97

[a] Runoff coefficients for storm recurrence intervals less than 25 years.

[b] Runoff coefficients for storm recurrence intervals of 25 years or longer.

Source: Table 7-9 in *Hydrologic Analysis and Design* (McCuen, 2005)

Table A.4
Land Cover and Land Use

Land Cover Categories	Land Use per Table A.3
Agriculture/Grass	Meadow
Forest	Forest
Scrub/Shrub	Average (Meadow,Forest)
Unknown/Other	Meadow

Table A.5 Hydrologic Response Unit Calculations

Land Cover	HSG	Gradient	Runoff Coefficient	ET Coefficient	Infiltration Coefficient	Runoff/ Infiltration Ratio	Hydrologic Process Designation
Agriculture/Grass	A	0-2%	0.1	0.6	0.3	0.33	I
Agriculture/Grass	A	2-6%	0.16	0.6	0.24	0.67	U
Agriculture/Grass	A	6-10%	0.25	0.6	0.15	1.67	O
Agriculture/Grass	B	0-2%	0.14	0.6	0.26	0.54	I
Agriculture/Grass	B	2-6%	0.22	0.6	0.18	1.22	U
Agriculture/Grass	B	6-10%	0.3	0.6	0.1	3	O
Agriculture/Grass	C	0-2%	0.2	0.6	0.2	1	U
Agriculture/Grass	C	2-6%	0.28	0.6	0.12	2.33	O
Agriculture/Grass	C	6-10%	0.36	0.6	0.04	9	O
Agriculture/Grass	D	0-2%	0.24	0.6	0.16	1.5	U
Agriculture/Grass	D	2-6%	0.3	0.6	0.1	3	O
Agriculture/Grass	D	6-10%	0.4	0.6	0	infinite	O
Forest	A	0-2%	0.05	0.8	0.15	0.33	I
Forest	A	2-6%	0.08	0.8	0.12	0.67	U
Forest	A	6-10%	0.11	0.8	0.09	1.22	U
Forest	B	0-2%	0.08	0.8	0.12	0.67	U
Forest	B	2-6%	0.11	0.8	0.09	1.22	U
Forest	B	6-10%	0.14	0.8	0.06	2.33	O
Forest	C	0-2%	0.1	0.8	0.1	1	U
Forest	C	2-6%	0.13	0.8	0.07	1.86	O
Forest	C	6-10%	0.16	0.8	0.04	4	O
Forest	D	0-2%	0.12	0.8	0.08	1.5	U
Forest	D	2-6%	0.16	0.8	0.04	4	O
Forest	D	6-10%	0.2	0.8	0	infinite	O
Scrub/Shrub	A	0-2%	0.08	0.7	0.23	0.33	I
Scrub/Shrub	A	2-6%	0.12	0.7	0.18	0.67	U
Scrub/Shrub	A	6-10%	0.18	0.7	0.12	1.5	U
Scrub/Shrub	B	0-2%	0.11	0.7	0.19	0.58	I
Scrub/Shrub	B	2-6%	0.17	0.7	0.14	1.22	U
Scrub/Shrub	B	6-10%	0.22	0.7	0.08	2.75	O
Scrub/Shrub	C	0-2%	0.15	0.7	0.15	1	U
Scrub/Shrub	C	2-6%	0.21	0.7	0.1	2.16	O
Scrub/Shrub	C	6-10%	0.26	0.7	0.04	6.5	O
Scrub/Shrub	D	0-2%	0.19	0.7	0.12	1.5	U
Scrub/Shrub	D	2-6%	0.23	0.7	0.07	3.29	O
Scrub/Shrub	D	6-10%	0.3	0.7	0	infinite	O

Hydrologic process designation: I = Interflow; O = Overland Flow; U = Uncertain

Table A.6
Hydrologic Response Unit Designations

Land Cover	Slope	Soil Type				
		A	B	C	D	Other
Agricultural/Grass/ Unknown/Other	0-2%	I	I	U	U	U
	2-6%	U	U	O	O	U
	6-10%	O	O	O	O	O
	>10%	O	O	O	O	O
Developed	0-2%	O	O	O	O	O
	2-6%	O	O	O	O	O
	6-10%	O	O	O	O	O
	>10%	O	O	O	O	O
Forest	0-2%	I	U	U	U	U
	2-6%	U	U	O	O	U
	6-10%	U	O	O	O	U
	>10%	O	O	O	O	O
Scrub/Shrub	0-2%	I	I	U	U	U
	2-6%	U	U	O	O	U
	6-10%	U	O	O	O	U
	>10%	O	O	O	O	O

Hydrologic Process Designation: I = Interflow; O = Overland Flow; U = Uncertain

Dominant Hydrologic Processes - Santa Magarita River Watershed

Figure A.1

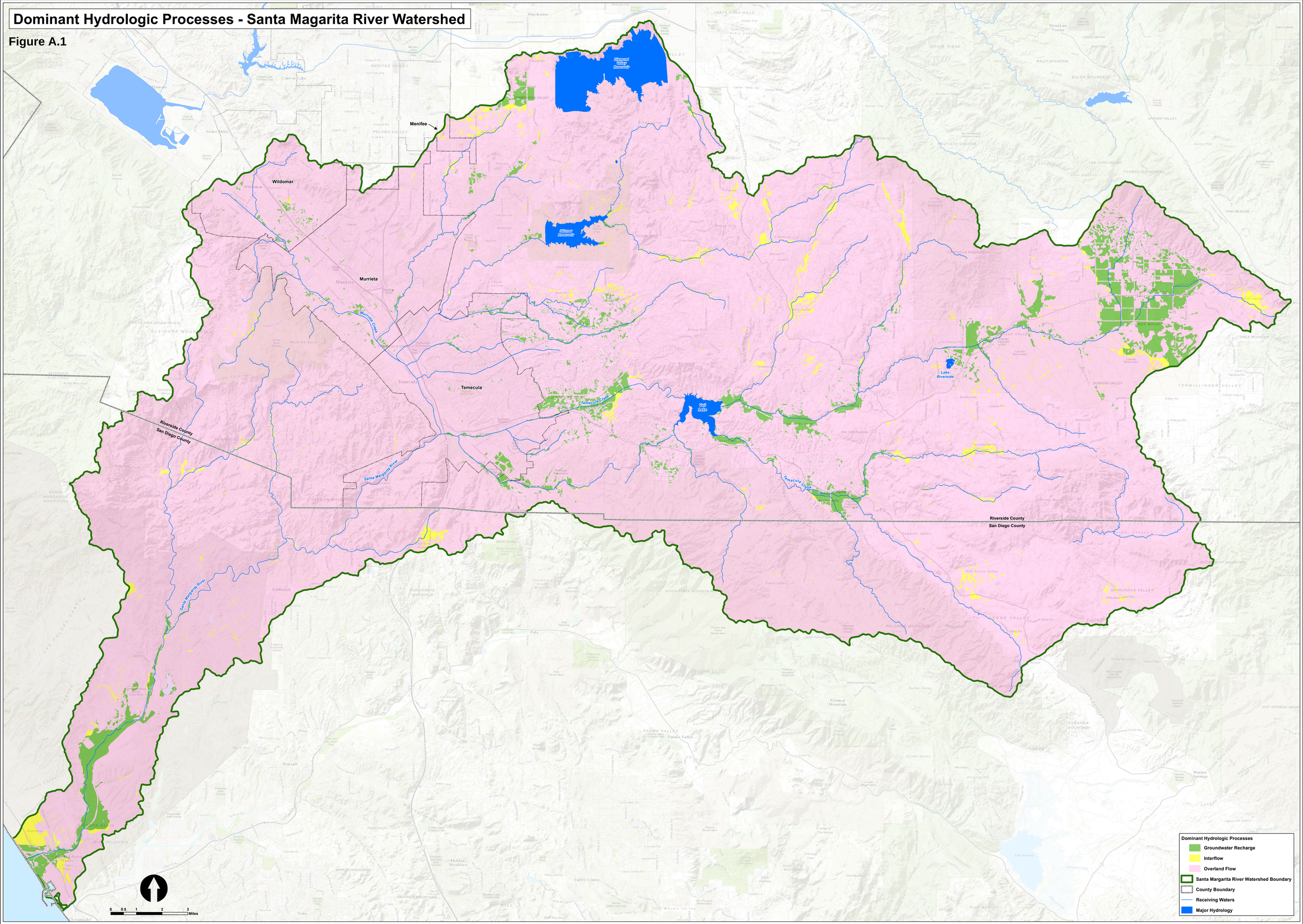


Table A.7. Summary of Consultation Committee Meetings

Consultation Committee Meeting Date/Location	Key Meeting Content
February 24, 2017 Western Riverside Council of Governments Technical Advisory Committee	• Upper SMR Hydrologic Response Unit and Critical Coarse Sediment Yield Report
May 17, 2017 City of Wildomar	• Revisions to Prioritization Process • Priority Water Quality Conditions • Proposed goals and scheduled • Overview of strategies and schedules • Watershed Management Area Analysis
May 25, 2017 Riverside County Flood Control & Water Conservation District	• Comments on the Draft Hydrologic Response Unit and Critical Coarse Sediment Yield Report (WSP 2017)
October 17, 2017 City of Temecula	• Watershed Management Area Analysis • Monitoring and Assessment Program • Adaptive Management

Attachment B. Potential Critical Coarse Sediment Yield Areas

Table B.1 Riverside County
Geologic Map Units

Map Unit	Map Name	Anticipated Grain Size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
gr	santa_ana_30x60_reference.pdf	Coarse	Bedrock	Impermeable	CB
gr-m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
grMz	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Kgd	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kt	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ktc	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ktc-w	San Diego & Oceanside 30' x 60	Coarse	Bedrock	Impermeable	CB
af	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Impermeable	CSI
Qvoa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvof	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tt	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qa+Qya	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qds	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qf	palm_springs_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Qoa	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qof	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Qp	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qss	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Qsu	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Qw	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Qya	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qya+Qoa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qyf	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Tss	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Ttl	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Ttu	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
JTrm	San Diego & Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kat	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgb	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
pKm	palm_springs_30x60_reference.pdf	Fine	Bedrock	Impermeable	FB
Qls	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
sp	santa_ana_30x60_reference.pdf	Fine	Bedrock	Impermeable	FB
Tv	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
water	San Diego & Oceanside 30' x 60'	Water	Water	Impermeable	Other

Table B.2 San Diego County Geologic Map Units

Map Unit	Map Name	Anticipated Grain Size of Weathered Material	Bedrock or Sedimentary	Impermeable/Permeable	Geology Grouping
gr-m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
grMz	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Kat	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgb	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgd	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgdf	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Khg	San Diego 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kt	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ktr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Mzu	San Diego & Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Q	Jennings; CA	Coarse	Sedimentary	Permeable	CSP
Qa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qd	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qls	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Qmb	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop1	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop2-4	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop3	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop4	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop6	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop6-7	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qvoa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop10	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop10-13	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop11	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop12	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop3	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop4	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop7	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop8	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop9	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qw	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qya	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Tmo	Oceanside 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
Tsa	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsi	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsm	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tso	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tta	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
water	San Diego & Oceanside 30' x 60'	Water	Water	Impermeable	Other

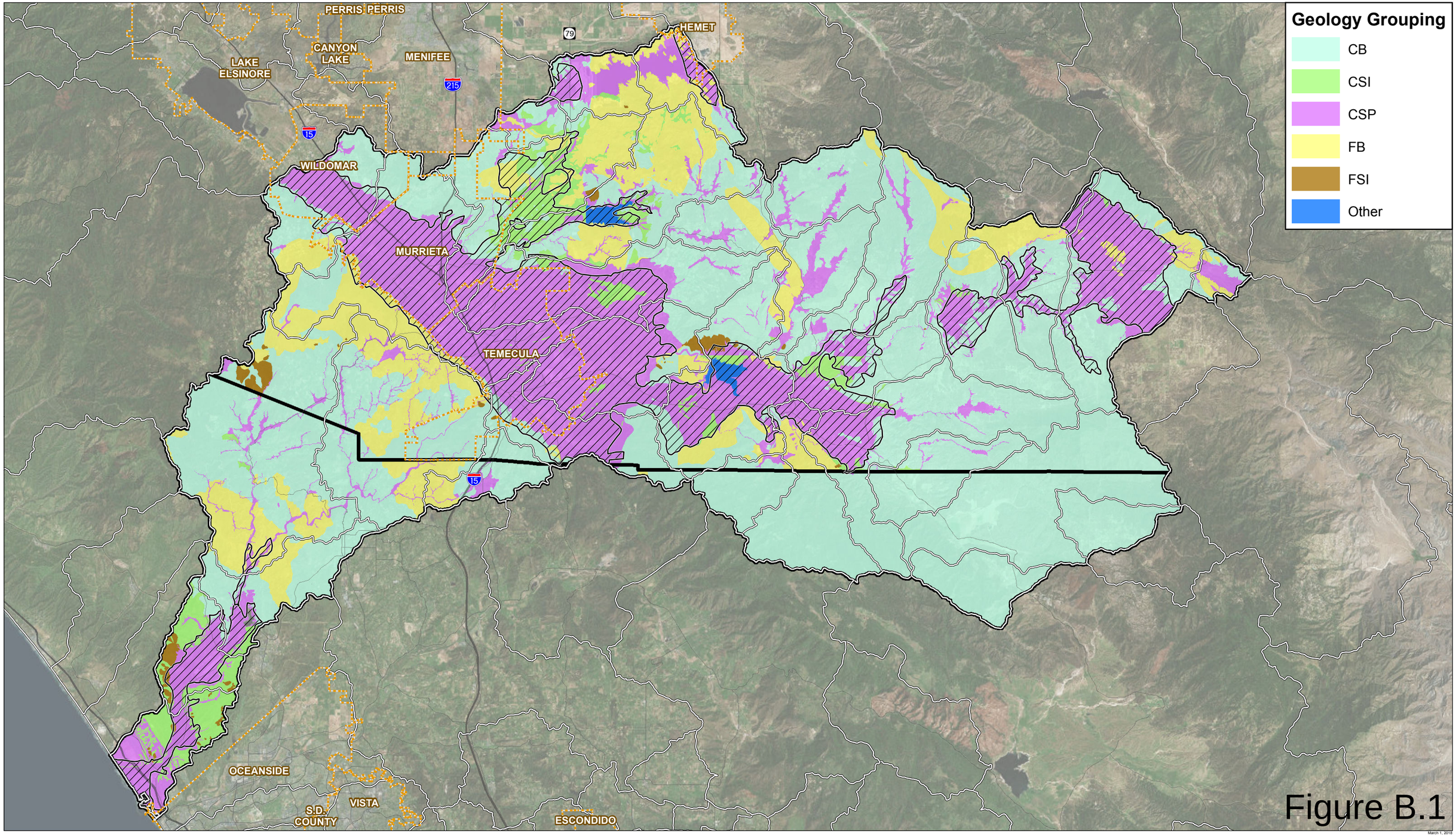


Figure B.1

March 1, 2018

0 1 2 Miles

Legend

Cities | Hydrologic Basin Units | Groundwater Basins

Table B.3
Riverside County - Critical Coarse Sediment and Geomorphic Landscape Units

GLU	Acreage	K	LS	C	R	A	Relative Sediment Production	Critical
CB-Agricultural/Grass-1	7686.98	0.27	3.33	0.15	33.50	4.62	Medium	No
CB-Agricultural/Grass-2	3485.75	0.27	3.67	0.15	34.57	5.22	Medium	No
CB-Agricultural/Grass-3	2935.80	0.27	4.10	0.15	36.97	6.23	Medium	No
CB-Agricultural/Grass-4	739.22	0.26	5.95	0.15	44.70	10.08	High	Yes
CB-Developed-1	14499.35	0.25	3.67	0.00	33.15	0.00	Low	No
CB-Developed-2	7885.00	0.25	4.02	0.00	34.34	0.00	Low	No
CB-Developed-3	3648.28	0.26	4.38	0.00	36.45	0.00	Low	No
CB-Developed-4	460.94	0.27	5.64	0.00	41.16	0.00	Low	No
CB-Forest-1	2142.78	0.26	4.74	0.15	36.70	6.78	Medium	No
CB-Forest-2	1510.57	0.26	5.11	0.15	37.38	7.41	Medium	No
CB-Forest-3	1752.29	0.26	5.56	0.15	38.95	8.45	High	Yes
CB-Forest-4	1244.47	0.26	6.57	0.15	41.37	10.40	High	Yes
CB-Other-1	165.35	0.21	3.07	0.15	28.24	3.18	Low	No
CB-Other-2	39.22	0.23	3.70	0.15	29.37	4.49	Medium	No
CB-Other-3	12.13	0.25	4.18	0.15	32.31	5.83	Medium	No
CB-Other-4	0.95	0.29	5.60	0.15	36.56	9.77	High	Yes
CB-Other-Water-1	23.37	0.28	4.12	0.00	35.42	0.00	Low	No
CB-Other-Water-2	11.73	0.27	4.53	0.00	37.00	0.00	Low	No
CB-Other-Water-3	6.23	0.26	4.66	0.00	36.60	0.00	Low	No
CB-Other-Water-4	0.83	0.24	6.66	0.00	46.89	0.00	Low	No
CB-Scrub/Shrub-1	33188.03	0.24	4.38	0.14	30.60	4.89	Medium	No
CB-Scrub/Shrub-2	34452.62	0.24	4.67	0.14	31.57	5.41	Medium	No
CB-Scrub/Shrub-3	36432.18	0.25	5.06	0.14	33.11	6.21	Medium	No
CB-Scrub/Shrub-4	15560.57	0.25	5.94	0.14	35.14	7.72	Medium	No
CSI-Agricultural/Grass-1	3933.40	0.30	2.13	0.15	33.96	3.27	Low	No
CSI-Agricultural/Grass-2	245.71	0.31	2.76	0.15	33.62	4.30	Medium	No
CSI-Agricultural/Grass-3	24.22	0.32	3.00	0.15	34.45	4.87	Medium	No
CSI-Agricultural/Grass-4	0.17	0.31	3.46	0.15	36.14	5.59	Medium	No
CSI-Developed-1	4949.47	0.31	2.39	0.00	34.67	0.00	Low	No
CSI-Developed-2	289.72	0.32	2.81	0.00	35.67	0.00	Low	No
CSI-Developed-3	75.91	0.33	2.84	0.00	38.36	0.00	Low	No
CSI-Developed-4	1.91	0.33	2.93	0.00	39.88	0.00	Low	No
CSI-Forest-1	126.74	0.33	3.69	0.15	34.41	6.18	Medium	No
CSI-Forest-2	35.16	0.34	4.07	0.15	35.01	7.02	Medium	No
CSI-Forest-3	20.59	0.34	4.50	0.15	36.44	7.64	Medium	No
CSI-Forest-4	4.16	0.33	5.17	0.15	38.21	8.63	High	Yes
CSI-Other-1	33.59	0.30	2.53	0.15	34.16	4.03	Medium	No
CSI-Other-2	4.04	0.32	3.48	0.15	33.28	5.33	Medium	No
CSI-Other-3	1.07	0.33	3.77	0.15	32.83	5.42	Medium	No
CSI-Other-4	0.07	0.37	3.35	0.15	34.00	6.11	Medium	No
CSI-Other-Water-1	170.42	0.32	2.79	0.00	32.63	0.00	Low	No
CSI-Other-Water-2	7.18	0.35	3.44	0.00	33.42	0.00	Low	No
CSI-Other-Water-3	1.74	0.34	3.52	0.00	32.63	0.00	Low	No
CSI-Other-Water-4	0.47	0.24	1.19	0.00	25.00	0.00	Low	No
CSI-Scrub/Shrub-1	1256.01	0.32	3.77	0.14	34.26	6.01	Medium	No
CSI-Scrub/Shrub-2	986.87	0.33	3.91	0.14	34.40	6.26	Medium	No
CSI-Scrub/Shrub-3	665.98	0.34	4.02	0.15	35.40	6.81	Medium	No
CSI-Scrub/Shrub-4	121.03	0.35	4.45	0.15	37.65	8.20	Medium	No
CSP-Agricultural/Grass-1	16856.07	0.30	2.63	0.14	35.30	4.18	Medium	No
CSP-Agricultural/Grass-2	2418.68	0.32	2.97	0.15	38.00	5.12	Medium	No
CSP-Agricultural/Grass-3	814.48	0.34	2.98	0.15	40.64	5.74	Medium	No
CSP-Agricultural/Grass-4	13.06	0.34	3.81	0.15	41.82	7.60	Medium	No
CSP-Developed-1	37033.30	0.30	2.68	0.00	36.94	0.00	Low	No
CSP-Developed-2	9045.81	0.32	2.98	0.00	39.41	0.00	Low	No
CSP-Developed-3	3979.17	0.33	2.87	0.00	41.28	0.00	Low	No
CSP-Developed-4	86.40	0.34	3.13	0.00	42.37	0.00	Low	No
CSP-Forest-1	3380.20	0.29	3.98	0.14	37.90	6.41	Medium	No
CSP-Forest-2	985.24	0.29	4.41	0.15	38.58	7.13	Medium	No
CSP-Forest-3	634.95	0.29	4.66	0.15	39.92	7.77	Medium	No
CSP-Forest-4	111.73	0.28	5.46	0.15	41.14	8.78	High	Yes
CSP-Other-1	1406.81	0.26	3.17	0.15	31.96	4.47	Medium	No
CSP-Other-2	75.01	0.28	4.30	0.15	33.31	6.21	Medium	No
CSP-Other-3	17.08	0.29	4.88	0.15	35.96	7.70	Medium	No
CSP-Other-4	1.38	0.30	6.92	0.15	40.57	11.22	High	Yes
CSP-Other-Water-1	3386.44	0.27	3.21	0.00	32.49	0.00	Low	No
CSP-Other-Water-2	67.29	0.28	3.82	0.00	34.34	0.00	Low	No
CSP-Other-Water-3	41.31	0.28	3.78	0.00	32.42	0.00	Low	No
CSP-Other-Water-4	42.07	0.26	3.25	0.00	30.71	0.00	Low	No
CSP-Scrub/Shrub-1	11329.78	0.29	3.54	0.14	32.61	5.05	Medium	No
CSP-Scrub/Shrub-2	6414.46	0.30	3.81	0.14	34.60	5.74	Medium	No
CSP-Scrub/Shrub-3	6519.26	0.32	3.94	0.14	36.53	6.39	Medium	No
CSP-Scrub/Shrub-4	1843.69	0.33	4.17	0.15	39.09	7.53	Medium	No
FB-Agricultural/Grass-1	4547.24	0.31	3.99	0.14	35.62	6.98	Medium	No
FB-Agricultural/Grass-2	2155.70	0.32	4.34	0.14	36.65	7.71	Medium	No
FB-Agricultural/Grass-3	2086.05	0.32	4.58	0.15	37.80	8.32	High	No
FB-Agricultural/Grass-4	627.53	0.31	5.58	0.15	42.30	10.91	High	No
FB-Developed-1	3018.49	0.30	4.32	0.00	35.91	0.00	Low	No
FB-Developed-2	1985.30	0.31	4.71	0.00	38.10	0.00	Low	No

Table B.3
Riverside County - Critical Coarse Sediment and Geomorphic Landscape Units

FB-Developed-3	2097.08	0.31	5.00	0.00	39.75	0.00	Low	No
FB-Developed-4	509.12	0.31	5.50	0.00	42.18	0.00	Low	No
FB-Forest-1	652.90	0.30	5.64	0.14	38.88	9.38	High	No
FB-Forest-2	712.38	0.29	5.84	0.15	39.15	9.66	High	No
FB-Forest-3	1179.81	0.29	6.13	0.15	39.56	10.04	High	No
FB-Forest-4	645.91	0.28	6.71	0.15	39.70	10.61	High	No
FB-Other-1	151.43	0.31	5.43	0.15	40.66	9.70	High	No
FB-Other-2	15.22	0.31	5.65	0.15	39.00	9.56	High	No
FB-Other-3	7.31	0.31	6.05	0.15	39.51	10.46	High	No
FB-Other-4	3.80	0.30	7.10	0.15	38.08	11.66	High	No
FB-Other-Water-1	859.14	0.28	3.72	0.00	26.66	0.00	Low	No
FB-Other-Water-2	175.43	0.29	4.35	0.00	27.68	0.00	Low	No
FB-Other-Water-3	67.09	0.29	4.52	0.00	28.05	0.00	Low	No
FB-Other-Water-4	24.94	0.29	3.92	0.00	25.29	0.00	Low	No
FB-Scrub/Shrub-1	4818.92	0.29	5.30	0.14	31.65	7.09	Medium	No
FB-Scrub/Shrub-2	6638.89	0.29	5.48	0.14	32.25	7.39	Medium	No
FB-Scrub/Shrub-3	15147.82	0.29	5.69	0.14	32.72	7.68	Medium	No
FB-Scrub/Shrub-4	9728.58	0.29	6.21	0.14	33.62	8.39	High	No
FSI-Agricultural/Grass-1	33.74	0.30	6.94	0.15	40.81	12.03	High	No
FSI-Agricultural/Grass-2	43.33	0.29	7.05	0.15	41.36	11.83	High	No
FSI-Agricultural/Grass-3	77.58	0.30	7.02	0.15	41.29	12.18	High	No
FSI-Agricultural/Grass-4	3.74	0.32	6.27	0.15	39.92	11.47	High	No
FSI-Developed-1	12.99	0.22	7.02	0.00	44.93	0.00	Low	No
FSI-Developed-2	46.62	0.23	7.16	0.00	44.62	0.00	Low	No
FSI-Developed-3	43.93	0.23	7.47	0.00	44.88	0.00	Low	No
FSI-Developed-4	15.22	0.28	7.22	0.00	44.81	0.00	Low	No
FSI-Forest-1	10.50	0.24	7.74	0.15	44.50	11.91	High	No
FSI-Forest-2	68.88	0.24	7.57	0.15	44.36	11.55	High	No
FSI-Forest-3	127.41	0.25	7.44	0.15	43.79	11.84	High	No
FSI-Forest-4	49.55	0.27	7.46	0.15	43.33	12.60	High	No
FSI-Other-1	0.34	0.29	5.63	0.15	37.25	9.01	High	No
FSI-Other-2	1.35	0.27	6.06	0.15	38.80	9.24	High	No
FSI-Other-3	1.80	0.31	4.90	0.15	35.00	8.69	High	No
FSI-Other-4	1.04	0.31	4.90	0.15	35.00	8.69	High	No
FSI-Scrub/Shrub-1	39.79	0.30	7.01	0.15	41.11	12.48	High	No
FSI-Scrub/Shrub-2	198.57	0.30	6.85	0.15	40.91	11.77	High	No
FSI-Scrub/Shrub-3	667.72	0.30	7.01	0.15	41.02	12.15	High	No
FSI-Scrub/Shrub-4	519.27	0.30	7.17	0.15	41.29	12.80	High	No
Other-Agricultural/Grass-1	7.15	0.37	4.07	0.00	39.17	0.00	Low	No
Other-Agricultural/Grass-2	0.04	0.37	3.86	0.00	38.50	0.00	Low	No
Other-Agricultural/Grass-3	0.00	0.37	3.86	0.00	38.00	0.00	Low	No
Other-Developed-1	15.09	0.33	3.10	0.00	37.00	0.00	Low	No
Other-Forest-1	154.61	0.37	3.79	0.00	39.15	0.00	Low	No
Other-Forest-2	10.34	0.37	3.85	0.00	39.82	0.00	Low	No
Other-Forest-3	3.98	0.37	3.86	0.00	39.89	0.00	Low	No
Other-Forest-4	0.03	0.37	3.82	0.00	40.00	0.00	Low	No
Other-Other-1	23.14	0.37	4.08	0.00	39.50	0.00	Low	No
Other-Other-2	0.00	0.37	4.48	0.00	41.00	0.00	Low	No
Other-Other-Water-1	1396.46	0.35	2.96	0.00	36.65	0.00	Low	No
Other-Other-Water-2	13.62	0.36	3.44	0.00	38.00	0.00	Low	No
Other-Other-Water-3	1.58	0.37	3.82	0.00	40.00	0.00	Low	No
Other-Scrub/Shrub-1	7.07	0.37	3.80	0.00	39.46	0.00	Low	No
Other-Scrub/Shrub-2	4.92	0.37	3.87	0.00	39.65	0.00	Low	No
Other-Scrub/Shrub-3	2.17	0.37	3.79	0.00	39.84	0.00	Low	No
Other-Scrub/Shrub-4	0.22	0.37	3.82	0.00	40.00	0.00	Low	No

Table B.4
San Diego County - Critical Coarse Sediment and Geomorphic Landscape Units

GLU	Acreage	K	LS	C	R	A	RSP	Critical
CB-Agricultural/Grass-1	4207.12025	0.4	9.34	0.28	100	12.98	Medium	No
CB-Agricultural/Grass-2	2602.294916	0.42	10.38	0.28	112	16.68	Medium	No
CB-Agricultural/Grass-3	3201.956796	0.22	6.04	0.14	57	10.57	High	Yes
CB-Agricultural/Grass-4	1452.123019	0.23	7.38	0.14	57	13.46	High	Yes
CB-Developed-1	2192.483367	0.66	11.31	0	147	0	Low	No
CB-Developed-2	911.1252571	0.44	8.56	0	100	0	Low	No
CB-Developed-3	388.2247298	0.22	4.86	0	49	0	Low	No
CB-Developed-4	79.85684775	0.22	5.63	0	48	0	Low	No
CB-Forest-1	2042.769347	0.4	12.76	0.28	78	13.64	Medium	No
CB-Forest-2	1388.228004	0.2	7.2	0.13	45	8.76	High	Yes
CB-Forest-3	2586.360015	0.2	8.14	0.13	48	10.57	High	Yes
CB-Forest-4	4161.260102	0.2	9.95	0.14	50	13.63	High	Yes
CB-Other-1	44.27957187	0.2	5.52	0.13	45	6.48	Medium	No
CB-Other-2	15.91897875	0.2	6.46	0.13	45	7.92	Medium	No
CB-Other-3	9.964938052	0.2	6.96	0.14	43	8.32	Medium	No
CB-Other-4	1.616170372	0.21	6.84	0.14	41	8.18	Medium	No
CB-Scrub/Shrub-1	11016.60072	0.2	5.66	0.14	33	5.27	Low	No
CB-Scrub/Shrub-2	13033.61337	0.2	6.51	0.14	37	6.77	Medium	No
CB-Scrub/Shrub-3	21329.28411	0.21	7.33	0.14	41	8.37	Medium	No
CB-Scrub/Shrub-4	21470.71697	0.21	8.28	0.14	42	9.84	High	Yes
CB-Unknown-1	11.48018908	0.21	5.32	0.13	44	6.3	Medium	No
CB-Unknown-2	12.6556765	0.21	5.95	0.13	44	7.09	Medium	No
CB-Unknown-3	15.21557361	0.22	6.21	0.13	44	7.67	Medium	No
CB-Unknown-4	1.645373006	0.22	6.61	0.13	44	8.44	High	Yes
CSI-Agricultural/Grass-1	925.5538264	0.34	2.72	0.14	39	4.82	Low	No
CSI-Agricultural/Grass-2	1278.657552	0.37	3.61	0.14	47	8.7	High	Yes
CSI-Agricultural/Grass-3	1922.868841	0.38	3.99	0.14	47	9.8	High	Yes
CSI-Agricultural/Grass-4	554.6779845	0.37	4.33	0.14	47	10.47	High	Yes
CSI-Developed-1	86.87776816	0.28	2.51	0	39	0	Low	No
CSI-Developed-2	60.59757587	0.3	2.66	0	41	0	Low	No
CSI-Developed-3	46.82102408	0.3	2.89	0	40	0	Low	No
CSI-Developed-4	15.24581302	0.27	3.2	0	39	0	Low	No
CSI-Forest-1	15.58893957	0.27	4.26	0.13	43	6.6	Medium	No
CSI-Forest-2	17.34311817	0.25	5.11	0.13	44	7.49	Medium	No
CSI-Forest-3	10.03886387	0.29	4.43	0.13	44	7.4	Medium	No
CSI-Forest-4	1.660919051	0.3	4.49	0.13	43	7.61	Medium	No
CSI-Other-1	18.02047788	0.31	2.5	0.13	32	3.19	Low	No
CSI-Other-2	9.615652947	0.27	3.01	0.13	39	4.3	Low	No
CSI-Other-3	5.485885584	0.28	3.03	0.13	39	4.49	Low	No
CSI-Other-4	0.7418804	0.24	4.01	0.14	39	5.17	Low	No
CSI-Scrub/Shrub-1	282.584646	0.26	3.53	0.13	39	4.67	Low	No
CSI-Scrub/Shrub-2	473.1055229	0.27	4.36	0.13	41	6.35	Medium	No
CSI-Scrub/Shrub-3	1117.895224	0.26	4.82	0.13	41	6.69	Medium	No
CSI-Scrub/Shrub-4	927.690404	0.26	5.52	0.13	41	7.8	Medium	No
CSP-Agricultural/Grass-1	2737.802423	0.22	3.01	0.14	44	3.97	Low	No
CSP-Agricultural/Grass-2	387.1522554	0.23	3.81	0.14	42	5.17	Low	No
CSP-Agricultural/Grass-3	155.4903262	0.24	4.05	0.14	41	5.56	Low	No
CSP-Agricultural/Grass-4	6.713337103	0.22	6.28	0.14	52	10.09	High	Yes
CSP-Developed-1	2980.902158	0.27	2.1	0	42	0	Low	No
CSP-Developed-2	140.0082488	0.26	2.77	0	42	0	Low	No
CSP-Developed-3	34.81810133	0.27	2.7	0	40	0	Low	No

Table B.4
San Diego County - Critical Coarse Sediment and Geomorphic Landscape Units

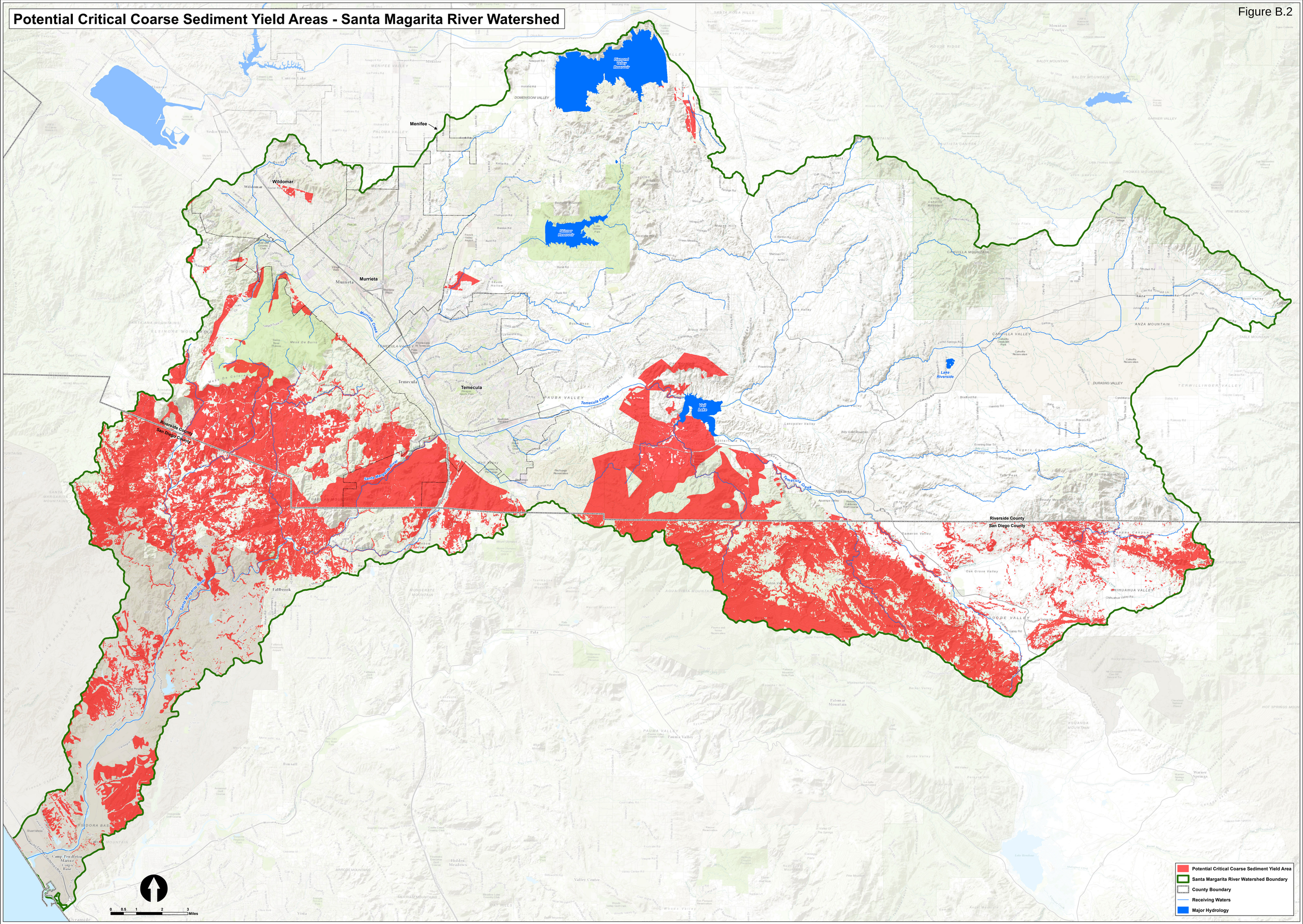
CSP-Developed-4	0.887532855	0.27	2.76	0	38	0	Low	No
CSP-Forest-1	1859.036483	0.22	4.52	0.14	44	5.97	Medium	No
CSP-Forest-2	356.6859183	0.22	5.99	0.14	45	8.15	Medium	No
CSP-Forest-3	190.1243432	0.21	6.42	0.14	45	8.49	High	Yes
CSP-Forest-4	43.14434988	0.21	7.62	0.14	48	10.25	High	Yes
CSP-Other-1	1038.483925	0.23	2.61	0.14	39	3.18	Low	No
CSP-Other-2	46.16538313	0.24	3.68	0.13	40	4.76	Low	No
CSP-Other-3	9.527040963	0.24	3.76	0.13	40	4.86	Low	No
CSP-Other-4	0.406388289	0.24	4.19	0.13	39	5.27	Low	No
CSP-Scrub/Shrub-1	1727.23043	0.23	3.75	0.14	41	4.85	Low	No
CSP-Scrub/Shrub-2	400.7401323	0.24	5.63	0.14	40	7.14	Medium	No
CSP-Scrub/Shrub-3	285.098895	0.23	6.15	0.13	39	7.51	Medium	No
CSP-Scrub/Shrub-4	65.82252137	0.22	7.16	0.14	43	9.32	High	Yes
CSP-Unknown-1	2.168837488	0.25	2.63	0.13	40	3.45	Low	No
CSP-Unknown-2	0.400864075	0.27	3.49	0.13	39	4.76	Low	No
FB-Agricultural/Grass-1	588.4165067	0.25	5.49	0.14	49	9.15	High	No
FB-Agricultural/Grass-2	482.1666445	0.25	5.87	0.14	51	10.12	High	No
FB-Agricultural/Grass-3	499.3422436	0.24	6.43	0.14	53	11.26	High	No
FB-Agricultural/Grass-4	239.6396713	0.22	8.62	0.14	57	15.19	High	No
FB-Developed-1	79.8775956	0.28	3.94	0	46	0	Low	No
FB-Developed-2	78.73206254	0.28	4.41	0	45	0	Low	No
FB-Developed-3	67.68640109	0.27	4.72	0	44	0	Low	No
FB-Developed-4	17.15389025	0.27	5.08	0	43	0	Low	No
FB-Forest-1	125.3517506	0.21	7.24	0.13	39	8.04	Medium	No
FB-Forest-2	180.3094439	0.21	7.53	0.13	43	8.84	High	No
FB-Forest-3	311.2361877	0.22	8.02	0.13	43	9.67	High	No
FB-Forest-4	232.2978921	0.26	9.63	0.13	35	11.54	High	No
FB-Other-1	17.24708788	0.26	5.72	0.13	44	8.63	High	No
FB-Other-2	0.69688975	0.26	5.97	0.13	38	7.73	Medium	No
FB-Other-3	0.202063574	0.28	6.27	0.13	34	7.61	Medium	No
FB-Other-4	0.035280176	0.31	6.7	0.13	33	8.64	High	No
FB-Scrub/Shrub-1	624.4951848	0.24	6.94	0.14	36	8.26	Medium	No
FB-Scrub/Shrub-2	1569.395997	0.25	7.24	0.14	38	9.04	High	No
FB-Scrub/Shrub-3	3844.606579	0.25	7.89	0.13	38	10	High	No
FB-Scrub/Shrub-4	4008.360006	0.26	9.05	0.14	39	12.12	High	No
FB-Unknown-1	0.622954589	0.3	5.33	0.13	37	7.56	Medium	No
FB-Unknown-2	4.191995085	0.29	5.26	0.13	40	7.92	Medium	No
FB-Unknown-3	12.71576486	0.29	5.54	0.13	39	8.21	Medium	No
FB-Unknown-4	4.603722008	0.28	6.02	0.13	38	8.43	High	No
FSI-Agricultural/Grass-1	84.66480013	0.32	3.91	0.13	24	3.92	Low	No
FSI-Agricultural/Grass-2	267.2869696	0.33	4.29	0.13	31	5.67	Medium	No
FSI-Agricultural/Grass-3	295.4970826	0.34	4.26	0.13	34	6.31	Medium	No
FSI-Agricultural/Grass-4	72.45552697	0.35	4.11	0.13	36	6.69	Medium	No
FSI-Developed-1	0.72730955	0.29	3.09	0	34	0	Low	No
FSI-Developed-2	3.807619001	0.31	3.22	0	37	0	Low	No
FSI-Developed-3	1.048132455	0.29	3.3	0	36	0	Low	No
FSI-Forest-1	4.7383172	0.33	4.62	0.13	37	7.21	Medium	No
FSI-Forest-2	0.867669898	0.35	4.47	0.13	39	7.95	Medium	No
FSI-Forest-3	0.044445413	0.37	4.71	0.13	40	9.21	High	No
FSI-Other-1	2.327768318	0.31	3.11	0.13	24	2.87	Low	No
FSI-Other-2	1.252340665	0.3	3.29	0.13	25	3.1	Low	No
FSI-Other-3	0.065239224	0.31	3.04	0.13	27	3.23	Low	No

Table B.4
San Diego County - Critical Coarse Sediment and Geomorphic Landscape Units

FSI-Scrub/Shrub-1	21.39582291	0.27	4.46	0.13	29	4.49	Low	No
FSI-Scrub/Shrub-2	65.84035365	0.28	4.96	0.13	31	5.65	Medium	No
FSI-Scrub/Shrub-3	97.16588596	0.29	5.05	0.13	34	6.35	Medium	No
FSI-Scrub/Shrub-4	80.40557523	0.3	5.14	0.13	37	7.54	Medium	No
O-Agricultural/Grass-1	3.402172805	0.2	2.93	0.14	34	2.8	Low	No
O-Agricultural/Grass-2	0.144075102	0.21	3.44	0.14	32	3.21	Low	No
O-Developed-1	3.585648795	0.27	1.37	0	39	0	Low	No
O-Other-1	120.1921569	0.25	3.86	0.13	36	4.31	Low	No
O-Other-2	0.277422913	0.24	3.32	0.13	35	3.53	Low	No

Potential Critical Coarse Sediment Yield Areas - Santa Magarita River Watershed

Figure B.2



MEMO

TO: Matt Yeager, D.Env, CPSWQ, QSD/P

FROM: Veronica Seyde

SUBJECT: Santa Margarita Watershed Management Area – RUSLE Analysis

DATE: June 29, 2018

INTRODUCTION

A review of the potential critical coarse sediment yield areas within the Santa Margarita watershed management area was conducted as a response to San Diego Regional Water Quality Control Board (San Diego RWQCB) comments. Differences in potential critical coarse sediment yield areas along the county line were noted, focusing within the northeastern portion of the watershed management area (see Exhibit 1). This memo evaluates the critical coarse sediment yield analysis conducted in this area to identify the data sources that were attributable to the final results that indicated these differences.

CRITICAL COARSE SEDIMENT YIELD ANALYSIS

GEOMORPHIC LANDSCAPE UNIT

Critical coarse sediment yield analysis is based on the Geomorphic Landscape Unit (GLU) method described by Booth et al. (2010). GLUs characterize the magnitude of sediment production from areas using three factors judged to exert the greatest influence on the variability of sediment-production rates: geology types, hillslope gradient and land cover. The geologic categories considered to have the potential to generate coarse sediment are coarse bedrock (CB), coarse sedimentary impermeable (CSI) and coarse sedimentary permeable (CSP). Exhibit 2 displays the geologic categories in the Santa Margarita watershed management area. Based on the GIS analysis, the Santa Margarita watershed management area is predominantly characterized with geologic categories that contribute coarse sediment (i.e., CB, CSI and CSP). Once the GLUs were identified, they were then evaluated to determine their relative sediment production to identify potential critical coarse sediment yield areas.

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RELATIVE SEDIMENT PRODUCTION

Relative sediment production is estimated for each GLU using the Revised Universal Soil Loss Equation (RUSLE) (see Equation 2).

$$A = R \times K \times LS \times C \times P \quad \text{(Equation 2), where}$$

A = estimated average soil loss in tons/acre/year

R = rainfall-runoff erosivity factor

K = soil erodibility factor

LS = slope length and steepness factor

C = cover-management factor

P = support practice factor; assumed 1 for this analysis

An area that is identified as CB, CSI or CSP coupled with a relative RUSLE rate of High is considered as a potential critical coarse sediment yield area.

Evaluation of the K, LS and C factors indicated that the results along the San Diego and Riverside county border are similar. The P factor results are also similar because this factor was assumed as equal to 1 for both the San Diego County and Riverside County analyses. Although the same public domain data sources were used for these data sets, among the five data sets, it was noted that the R factor, or the rainfall-runoff erosivity factor[1], was attributable to the difference in critical coarse sediment yield areas along the county border (See Exhibit 3).

For the Santa Margarita watershed management area in San Diego County, a broad approach was used where one R value was assigned for each GLU by estimating the area weighted number. For example, a R value of 30 was assigned if a GLU was located between the 40 and 20 isoerodent contours (see Exhibit 3, Figure 3.A). Whereas, for the study area in Riverside County, the R factor varies spatially by using specific available R value isoerodent contour data, resulting in a very fine resolution R value (see Exhibit 3, Figure 3.A, Figure 3.B and Figure 3.C).

These area resolution differences among the R factor data along the county border resulted in identified differences in potential critical coarse sediment yield areas. These differences are solely due to the broad assumption method versus the use of specific contour data.

[1] The R factor is the total storm kinetic energy (E) times the maximum 30-minute intensity (I30). The numerical value of R is the average annual sum of EI30 for storm events during a rainfall record of at least 22 years.

BORDER PROJECTS

The potential critical coarse sediment yield analysis utilized regional, public domain datasets and provided a useful, rapid framework to perform a screening level analysis for the Santa Margarita watershed management area. This mapping effort essentially provided a high-level analysis to provide informed decision making at a regional-scale. Because of the regional-scale datasets, and commensurate data resolution used to map the potential critical coarse sediment yield areas, some areas may have been mapped that do not produce critical coarse sediment as they are existing developed areas. Furthermore, the analysis did not consider instream sediment supply or fire-induced sediment production (Lave and Burbank 2004). In addition, the resolution differences among the R-factor data resulted in differences in potential critical coarse sediment yield areas along the county border. Given the GLU characteristics in the watershed, however, a further evaluation of hydrologic soil groups and sand and gravel deposits along the border and in the northeastern portion of the watershed was performed.

GRAVEL AND SAND DEPOSITS

To verify the differences in potential critical coarse sediment yield areas along the county border, an evaluation of hydrologic soil groups (HSG) and gravel and sand deposits was conducted. HSG type A and type B soils are considered sands, gravelly sands and coarse textured soils which would contribute coarse sediment. The custom HSG report for the study area along the border indicated that only 22 percent of the soil material in this area was considered as deep, well drained to excessively well drained sands or gravelly sands (HSG A) or moderately well drained soils that have moderately fine texture to moderately coarse texture (HSG B) (Natural Resources Conservation Service 2018). Of special interest is the area in the northeastern part of the watershed. According to the HSG report, this area is predominated by HSG type D soils and would therefore not be expected to exhibit the characteristics associated with a coarse sediment yield area. The HSG reports generated for this evaluation are provided as a Supplemental Attachment.

Another line of evidence to support potential critical coarse sediment areas was provided by evaluating United States Geological Survey mineral resource maps online (USGS 2018). Based on the area of interest along the border, there are no sand and gravel deposits within a 2-mile radius north and south of the border. Sand and gravel deposits, however, were noted in areas generally downstream of CB, CSI, and CSP geologic units. These deposits were therefore considered as an area that may be a potential sediment source area and it was decided that further evaluation was warranted.

The identification of potential sediment source areas was determined using the following process:

- Overlay sand/gravel deposits onto Geology Grouping GIS layer
- Using USGS quad maps, identify the tributary drainage area for each deposit located in a CB, CSI or CSP area
- Exclude the following areas:
    - Agricultural Land
    - Developed Land
    - Non-Permittee Area
        - Camp Pendleton
    - Protected Lands

The resulting GIS map showing the spatial distribution of the potential critical coarse sediment yield areas along with potential sediment source areas within the SMR is provided as Exhibit 4.

REFERENCES

Booth, D. B., S. R. Dusterhoff, E. D. Stein, and B. P. Bledsoe. 2010. Technical Report 605: Hydromodification Screening Tools: GIS-based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge. March 2010.

Lavé, J. and D. Burbank 2004. Denudation processes and rates in the Transverse Ranges, southern California: Erosional response of a transitional landscape to external and anthropogenic forcing. Journal of Geophysical Research 109.

Natural Resources Conservation Service. Custom HSG Report for San Diego County Area, California and Western Riverside Area, California. http://websoilsurvey.nrcs.usda.gov/app/. March 13, 2018.

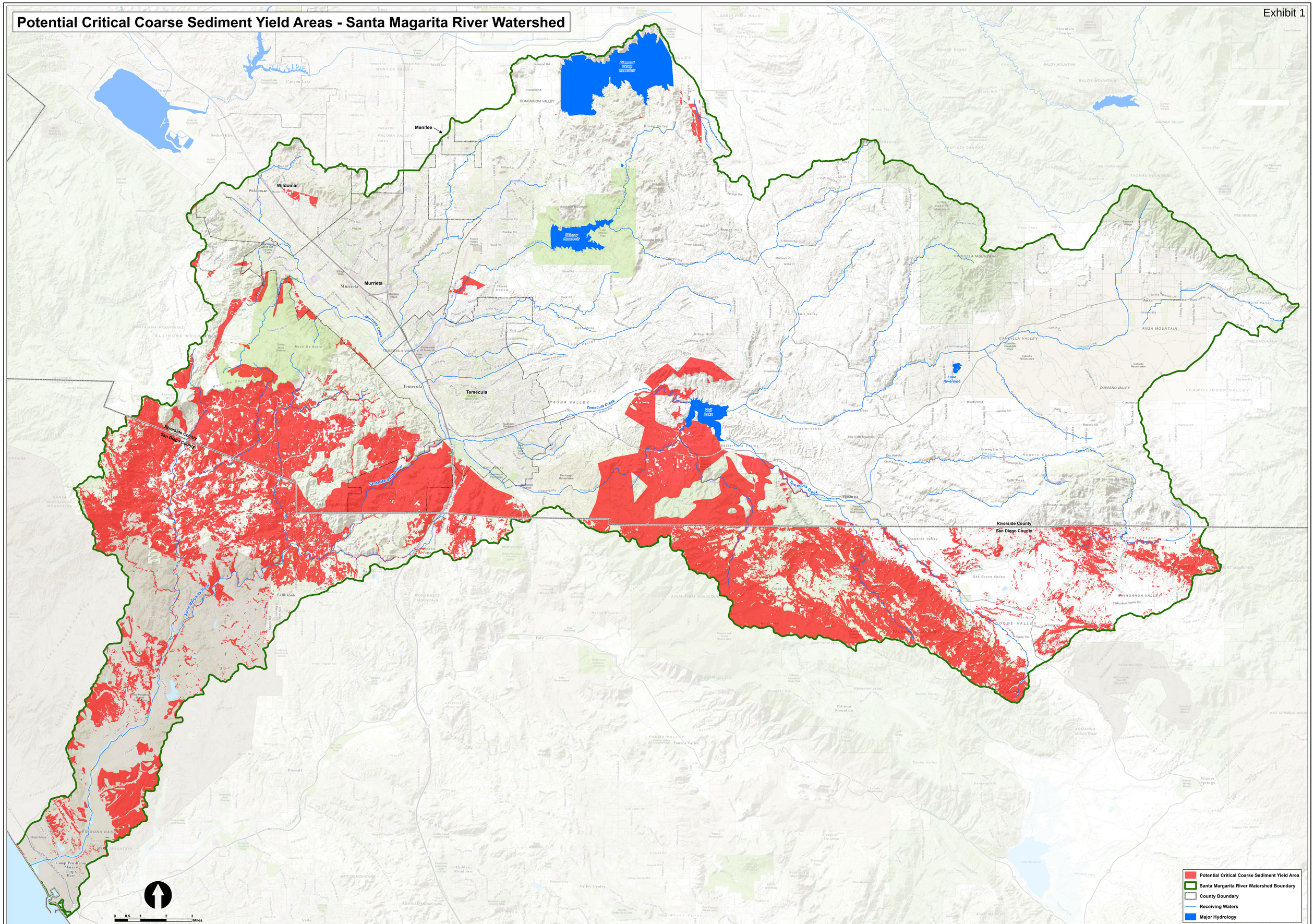
Sanford, W. E. and D. L. Selnick, 2013. Estimation of Evapotranspiration Across the Conterminous United States Using a Regression with Climate and Land-Cover Data. Journal of the American Water Resources Association. February 2013.

United States Geological Survey. Custom Sand and Gravel Map for San Diego County Area, California and Riverside County Area, California. https://mrdata.usgs.gov/general/map.html. March 13, 2018.

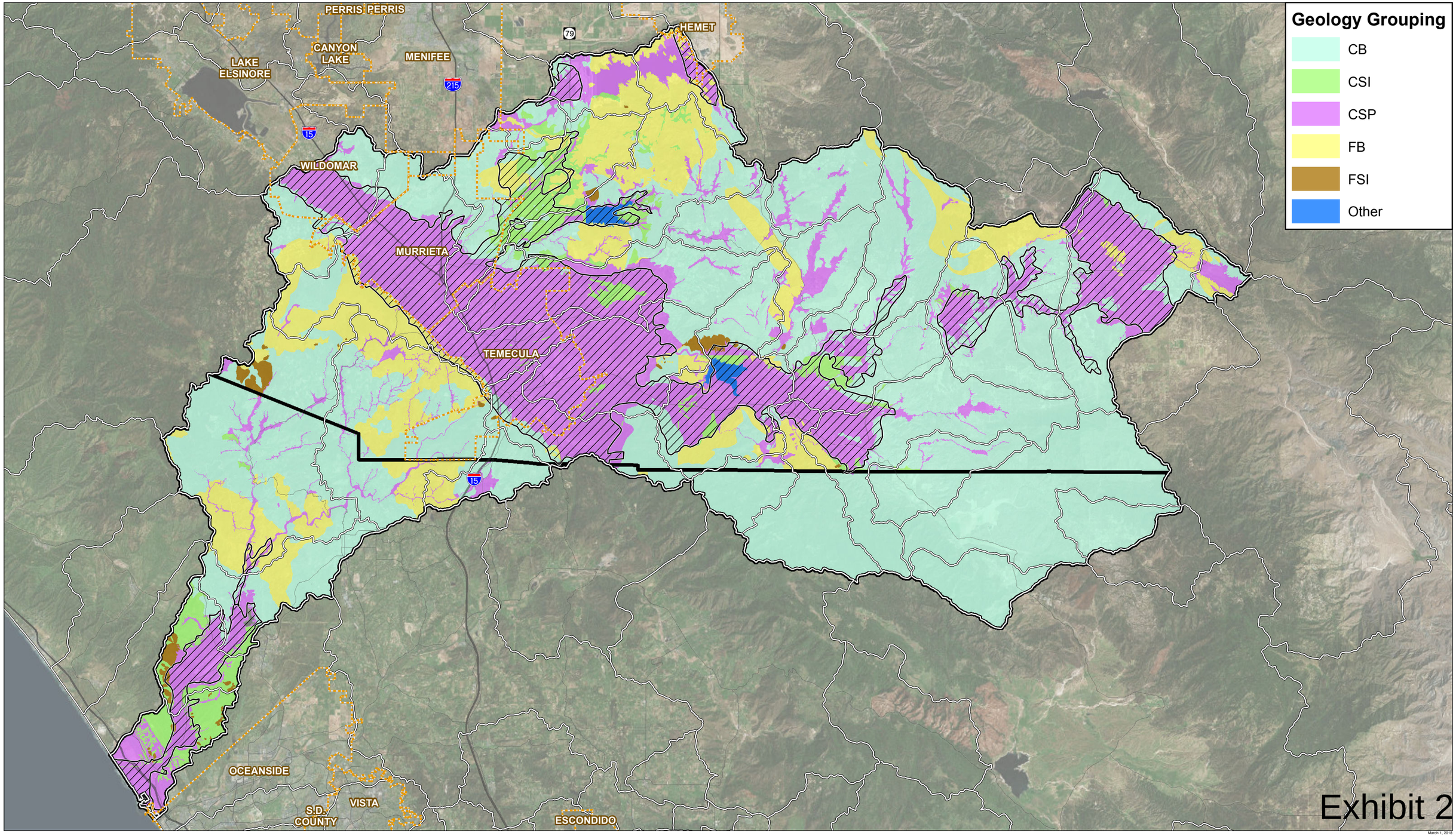
EXHIBITS

Exhibit 1

Potential Critical Coarse Sediment Yield Areas - Santa Magarita River Watershed



SANTA MARGARITA WATERSHED MANAGEMENT AREA ANALYSIS
GEOLOGY GROUPING



0 1 2 Miles

Legend

Cities | Hydrologic Basin Units | Groundwater Basins

WRCOG | RIVERSIDE COUNTY

wsp

Exhibit 3
R Factor Differences Along Riverside/San Diego County Border

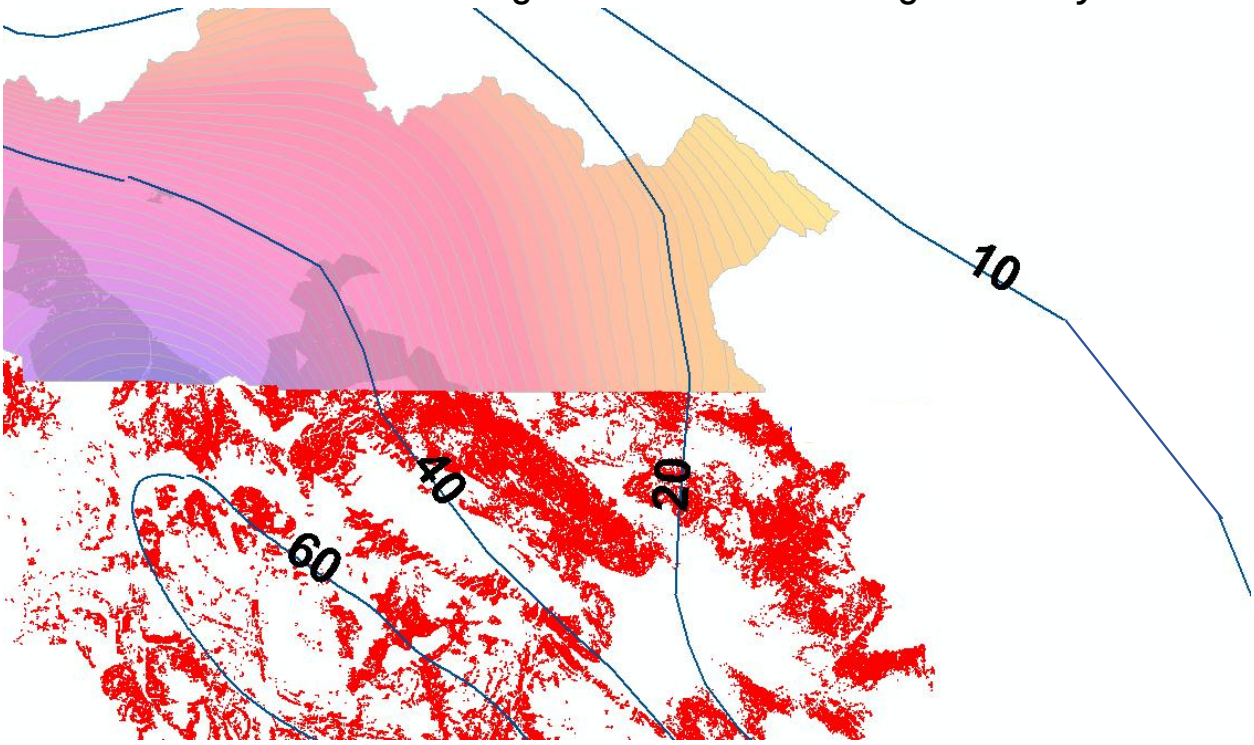
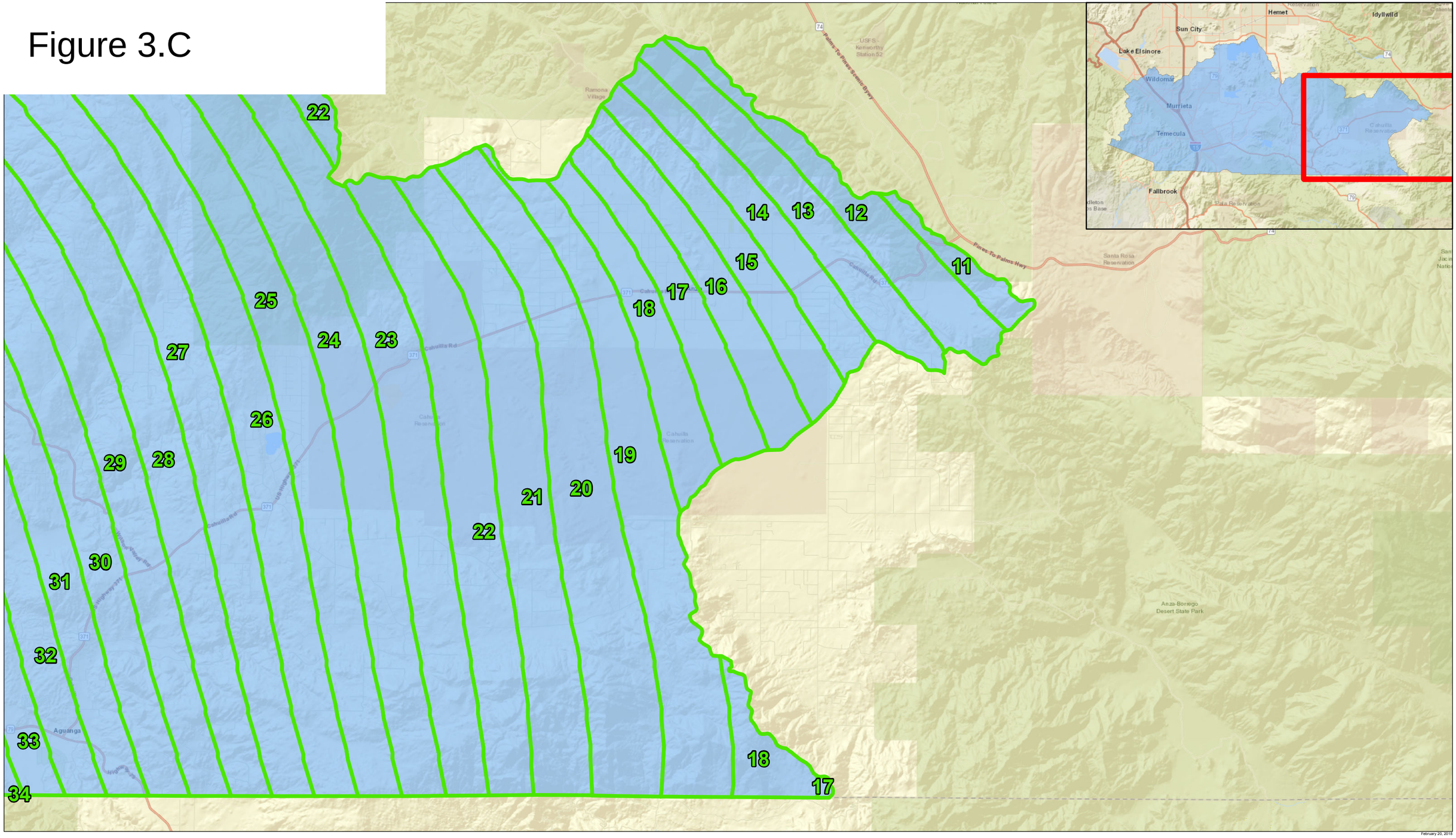


Figure 3.A Isoerodent Contour Lines – Santa Margarita Watershed Management Area – San Diego County and Riverside County



Figure 3.B Zoom in of Isoerodent contour lines (Compare area between the 40 and 10 Isoerodent contour lines with Figure 6.C)

Figure 3.C


22
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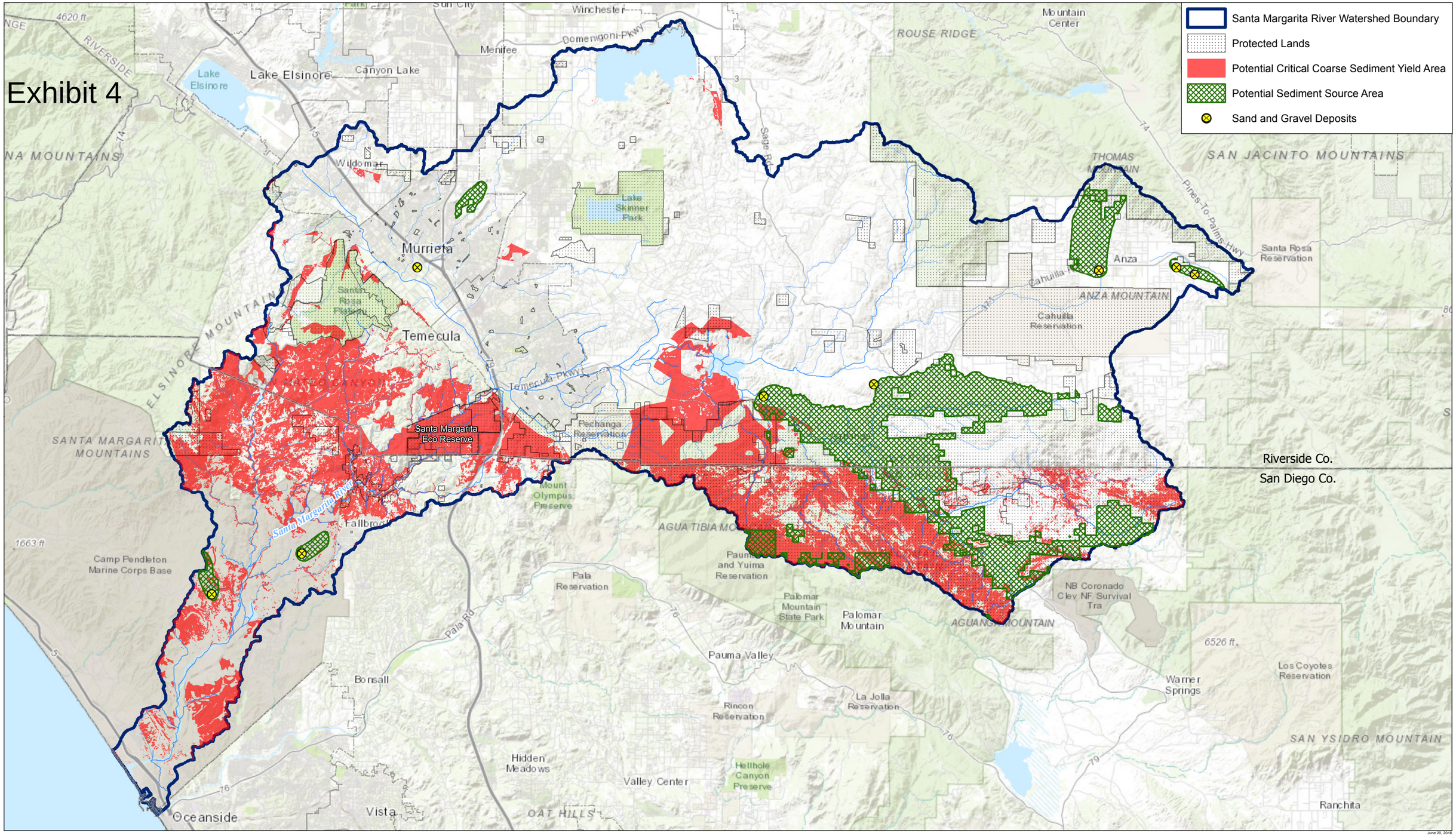
17
Ramona Village
Cahuilla Rd
Pines To Palms Hwy
Santa Rosa Reservation
Anza-Borrego Desert State Park
Aguanga
Hemet
Idyllwild
Sun City
Lake Elsinore
Wildomar
Murrieta
Temecula
Fallbrook
Pala Reservation
Cahuilla Reservation
February 20, 2018
Miles
Legend
RUSLE_R_Factor

Exhibit 4



0 1 2 Miles

SANTA MARGARITA RIVER WATERSHED

POTENTIAL CRITICAL COARSE SEDIMENT YIELD AREAS AND POTENTIAL SEDIMENT SOURCE AREAS

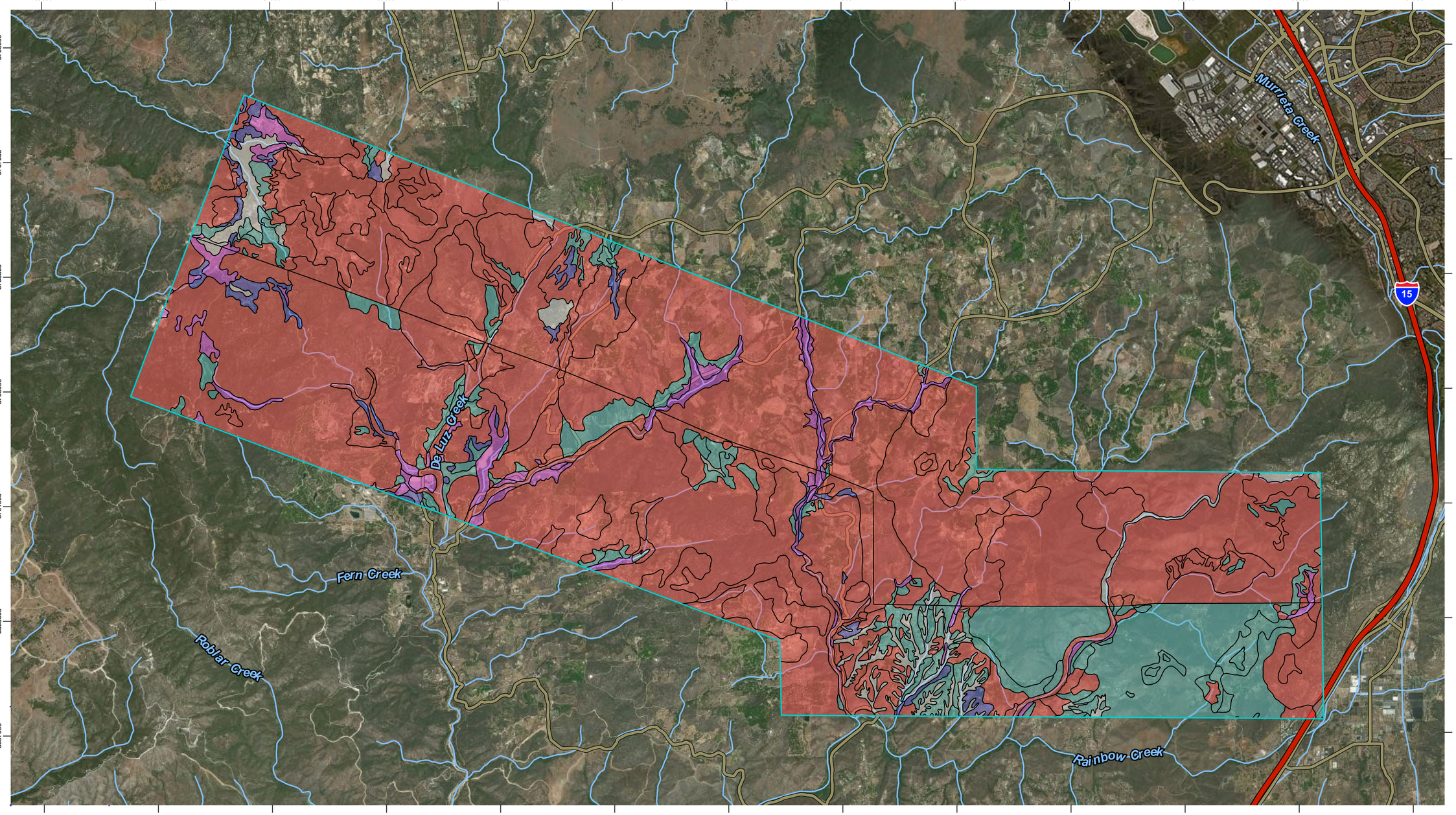
WRCOG

RIVERSIDE COUNTY

wsp

SUPPLEMENTAL ATTACHMENTS

Hydrologic Soil Group—San Diego County Area, California, and Western Riverside Area, California
(Area 1 - West of I-15)



Map Scale: 1:67,700 if printed on B landscape (17" x 11") sheet.

N

Meters
0 1000 2000 4000 6000

Feet
0 3000 6000 12000 18000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:15,800 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Diego County Area, California
Survey Area Data: Version 12, Sep 13, 2017

Soil Survey Area: Western Riverside Area, California
Survey Area Data: Version 10, Sep 12, 2017

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Feb 2, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
AcG	Acid igneous rock land	D	616.9	2.3%
AvC	Arlington coarse sandy loam, 2 to 9 percent slopes	C	12.4	0.0%
BlC	Bonsall sandy loam, 2 to 9 percent slopes	D	3.5	0.0%
BlC2	Bonsall sandy loam, 2 to 9 percent slopes, eroded	D	3.3	0.0%
BuC	Bull Trail sandy loam, 5 to 9 percent slopes	C	8.9	0.0%
CaD2	Calpine coarse sandy loam, 9 to 15 percent slopes, eroded	A	0.1	0.0%
CbF2	Cajalco rocky fine sandy loam, 15 to 50 percent slopes, eroded	D	97.8	0.4%
ClD2	Cieneba coarse sandy loam, 5 to 15 percent slopes, erod ed	D	75.9	0.3%
ClE2	Cieneba coarse sandy loam, 15 to 30 percent slopes, ero ded	D	448.2	1.7%
ClG2	Cieneba coarse sandy loam, 30 to 65 percent slopes, ero ded	D	477.4	1.8%
CmE2	Cieneba rocky coarse sandy loam, 9 to 30 percent slopes , eroded	D	401.8	1.5%
CmrG	Cieneba very rocky coarse sandy loam, 30 to 75 percent slopes	D	5,877.4	21.7%
CnE2	Cieneba-Fallbrook rocky sandy loams, 9 to 30 percent slopes, eroded	D	177.9	0.7%
CnG2	Cieneba-Fallbrook rocky sandy loams, 30 to 65 percent slopes, eroded	D	567.1	2.1%
Co	Clayey alluvial land		21.4	0.1%
EsC	Escondido very fine sandy loam, 5 to 9 percent slopes	C	11.6	0.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
EsE2	Escondido very fine sandy loam, 15 to 30 percent slopes , eroded	C	24.9	0.1%
FaC	Fallbrook sandy loam, 5 to 9 percent slopes	C	68.5	0.3%
FaC2	Fallbrook sandy loam, 5 to 9 percent slopes, eroded	C	17.9	0.1%
FaD2	Fallbrook sandy loam, 9 to 15 percent slopes, eroded	C	69.5	0.3%
FaE2	Fallbrook sandy loam, 15 to 30 percent slopes, eroded	C	34.2	0.1%
FcF2	Fallbrook rocky sandy loam, shallow, 15 to 50 percents lopes, eroded	D	585.5	2.2%
FeE	Fallbrook rocky sandy loam, 9 to 30 percent slopes	C	26.3	0.1%
FeE2	Fallbrook rocky sandy loam, 9 to 30 percent slopes, eroded	C	12.0	0.0%
FfC2	Fallbrook fine sandy loam, 2 to 8 percent slopes, eroded	C	1.0	0.0%
FvD	Fallbrook-Vista sandy loams, 9 to 15 percent slopes	C	38.4	0.1%
FvE	Fallbrook-Vista sandy loams, 15 to 30 percent slopes	C	9.8	0.0%
FxE	Friant rocky fine sandy loam, 9 to 30 percent slopes	D	21.9	0.1%
FxG	Friant rocky fine sandy loam, 30 to 70 percent slopes	D	3.1	0.0%
HcC	Hanford coarse sandy loam, 2 to 8 percent slopes	A	5.4	0.0%
LpC2	Las Posas fine sandy loam, 5 to 9 percent slopes, eroded	C	3.8	0.0%
LpD2	Las Posas fine sandy loam, 9 to 15 percent slopes, eroded	C	8.8	0.0%
LpE2	Las Posas fine sandy loam, 15 to 30 percent slopes, eroded	C	3.9	0.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
LrE	Las Posas stony fine sandy loam, 9 to 30 percent slopes	C	317.6	1.2%
LrE2	Las Posas stony fine sandy loam, 9 to 30 percent slopes, eroded	C	6.4	0.0%
LrG	Las Posas stony fine sandy loam, 30 to 65 percent slopes	C	1,820.0	6.7%
PfC	Placentia sandy loam, thick surface, 2 to 9 percent slo pes	D	20.8	0.1%
RaC	Ramona sandy loam, 5 to 9 percent slopes	C	101.4	0.4%
RaC2	Ramona sandy loam, 5 to 9 percent slopes, eroded	C	126.0	0.5%
RaD2	Ramona sandy loam, 9 to 15 percent slopes, eroded	C	221.7	0.8%
RcD	Ramona gravelly sandy loam, 9 to 15 percent slopes	C	154.8	0.6%
RcE	Ramona gravelly sandy loam, 15 to 30 percent slopes	C	24.2	0.1%
Rm	Riverwash	D	414.8	1.5%
RuG	Rough broken land	D	72.3	0.3%
StG	Steep gullied land		337.9	1.2%
SvE	Stony land	A	25.5	0.1%
TeF	Terrace escarpments		10.2	0.0%
TuB	Tujunga sand, 0 to 5 percent slopes	A	47.5	0.2%
VaA	Visalia sandy loam, 0 to 2 percent slopes	A	70.2	0.3%
VaB	Visalia sandy loam, 2 to 5 percent slopes	A	257.4	0.9%
VaC	Visalia sandy loam, 5 to 9 percent slopes	A	72.9	0.3%
VaD	Visalia sandy loam, 9 to 15 percent slopes	A	8.4	0.0%
VbB	Visalia gravelly sandy loam, 2 to 5 percent slopes	A	30.0	0.1%
VbC	Visalia gravelly sandy loam, 5 to 9 percent slopes	A	10.4	0.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
VsC	Vista coarse sandy loam, 5 to 9 percent slopes	B	55.4	0.2%
VsD	Vista coarse sandy loam, 9 to 15 percent slopes, MLRA 20	B	19.4	0.1%
VsD2	Vista coarse sandy loam, 9 to 15 percent slopes, eroded	B	11.2	0.0%
VsE	Vista coarse sandy loam, 15 to 30 percent slopes, MLRA 20	B	67.6	0.2%
VsE2	Vista coarse sandy loam, 15 to 30 percent slopes, eroded	B	43.4	0.2%
VvD	Vista rocky coarse sandy loam, 5 to 15 percent slopes	B	17.8	0.1%
VvE	Vista rocky coarse sandy loam, 15 to 30 percent slopes	B	54.6	0.2%
W	Water		7.0	0.0%
WmC	Wyman loam, 5 to 9 percent slopes	C	71.3	0.3%
Subtotals for Soil Survey Area			**14,234.1**	**52.4%**
Totals for Area of Interest			**27,142.5**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
144	Cieneba-Rock outcrop complex, 9 to 30 percent slopes	D	21.6	0.1%
192	Rock outcrop-Cieneba complex, 30 to 75 percent slopes		0.8	0.0%
213	Vista coarse sandy loam, 9 to 15 percent slopes, MLRA 20	B	15.8	0.1%
CaC2	Cajalco fine sandy loam, 2 to 8 percent slopes, eroded	C	14.8	0.1%
CaD2	Cajalco fine sandy loam, 8 to 15 percent slopes, eroded	C	24.2	0.1%
CbF2	Cajalco rocky fine sandy loam, 15 to 50 percent slopes, eroded	D	401.2	1.5%
CkD2	Cieneba rocky sandy loam, 8 to 15 percent slopes, eroded	D	218.3	0.8%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
CkF2	Cieneba rocky sandy loam, 15 to 50 percent slopes, eroded	D	1,529.8	5.6%
Co	Clayey alluvial land		6.5	0.0%
EcD2	Escondido fine sandy loam, 8 to 15 percent slopes, eroded	C	38.4	0.1%
FaD2	Fallbrook sandy loam, 8 to 15 percent slopes, eroded	C	39.3	0.1%
FaE2	Fallbrook sandy loam, 15 to 25 percent slopes, eroded	C	25.2	0.1%
FbF2	Fallbrook sandy loam, shallow, 15 to 35 percent slopes, eroded	D	12.2	0.0%
FcD2	Fallbrook rocky sandy loam, shallow, 8 to 15 percent slopes, eroded	D	27.0	0.1%
FcF2	Fallbrook rocky sandy loam, shallow, 15 to 50 percent slopes, eroded	D	4,129.3	15.2%
FfC2	Fallbrook fine sandy loam, 2 to 8 percent slopes, eroded	C	60.0	0.2%
FkD2	Fallbrook fine sandy loam, shallow, 8 to 15 percent slopes, eroded	D	23.1	0.1%
FwE2	Friant fine sandy loam, 5 to 25 percent slopes, eroded	D	22.7	0.1%
FyE2	Friant rocky fine sandy loam, 8 to 25 percent slopes, e roded	D	31.2	0.1%
GyC2	Greenfield sandy loam, 2 to 8 percent slopes, eroded	A	35.9	0.1%
HcC	Hanford coarse sandy loam, 2 to 8 percent slopes	A	153.2	0.6%
HfD	Hanford sandy loam, 2 to 15 percent slopes	A	185.5	0.7%
HnC	Honcut sandy loam, 2 to 8 percent slopes	A	0.6	0.0%
LaC	Las Posas loam, 2 to 8 percent slopes	D	8.6	0.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
LaD2	Las Posas loam, 8 to 15 percent slopes, eroded	D	97.7	0.4%
LaE3	Las Posas loam, 8 to 25 percent slopes, severely eroded	D	7.3	0.0%
LcD2	Las Posas stony loam, 8 to 15 percent slopes, eroded	D	9.2	0.0%
LkD2	Las Posas rocky loam, 8 to 15 percent slopes, eroded	D	119.4	0.4%
LkF3	Las Posas rocky loam, 15 to 50 percent slopes, severely eroded	D	3,000.2	11.1%
LpF2	Lodo rocky loam, 25 to 50 percent slopes, eroded	D	1,072.6	4.0%
MuE	Murrieta stony clay loam, 2 to 25 percent slopes	D	673.9	2.5%
PoC	Porterville clay, 0 to 8 percent slopes	C	29.6	0.1%
RaB3	Ramona sandy loam, 0 to 5 percent slopes, severely eroded	C	19.5	0.1%
RaC2	Ramona sandy loam, 5 to 8 percent slopes, eroded	C	18.9	0.1%
RaD2	Ramona sandy loam, 8 to 15 percent slopes, eroded	C	119.2	0.4%
RaD3	Ramona sandy loam, 8 to 15 percent slopes, severely eroded	C	41.6	0.2%
RcD	Ramona gravelly sandy loam, 9 to 15 percent slopes	C	4.1	0.0%
RsC	Riverwash		64.6	0.2%
RtF	Rockland		106.1	0.4%
TeG	Terrace escarpments		22.7	0.1%
VaB	Visalia sandy loam, 2 to 5 percent slopes	A	12.2	0.0%
VsC	Vista coarse sandy loam, 2 to 8 percent slopes	B	48.1	0.2%
VsD2	Vista coarse sandy loam, 8 to 15 percent slopes, eroded	B	52.6	0.2%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
VtF2	Vista rocky coarse sandy loam, 2 to 35 percent slopes, eroded	B	66.6	0.2%
WeD	Wet alluvial land		176.7	0.7%
WxD2	Wyman fine sandy loam, 8 to 15 percent slopes, eroded	C	51.0	0.2%
WyC2	Wyman loam, 2 to 8 percent slopes, eroded	C	69.5	0.3%
Subtotals for Soil Survey Area			**12,908.4**	**47.6%**
Totals for Area of Interest			**27,142.5**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie. The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

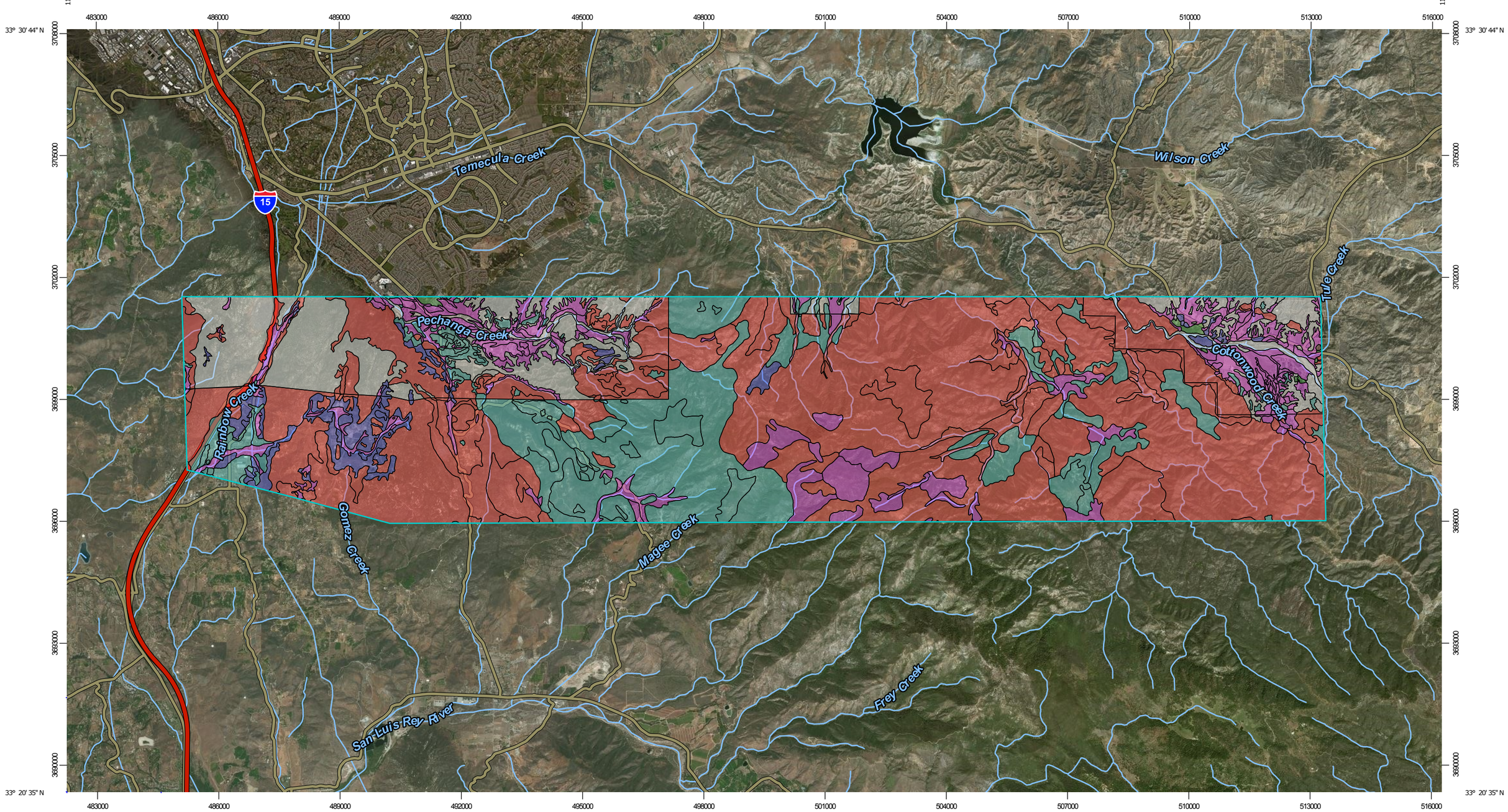
Component Percent Cutoff: None Specified

Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Hydrologic Soil Group—San Diego County Area, California, and Western Riverside Area, California
(Area 2 - I-15 to Aguanga)



Map Scale: 1:91,600 if printed on B landscape (17" x 11") sheet.

N

Meters
0 1000 2000 4000 6000

Feet
0 4000 8000 16000 24000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:15,800 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Diego County Area, California
Survey Area Data: Version 12, Sep 13, 2017

Soil Survey Area: Western Riverside Area, California
Survey Area Data: Version 10, Sep 12, 2017

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Feb 2, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
AcG	Acid igneous rock land	D	2,786.9	7.4%
AvC	Arlington coarse sandy loam, 2 to 9 percent slopes	C	204.3	0.5%
BbE	Bancas stony loam, 5 to 30 percent slopes	C	378.7	1.0%
BbE2	Bancas stony loam, 5 to 30 percent slopes, eroded	C	188.4	0.5%
CbF2	Cajalco rocky fine sandy loam, 15 to 50 percent slopes, eroded	D	16.3	0.0%
ClD2	Cieneba coarse sandy loam, 5 to 15 percent slopes, erod ed	D	3.4	0.0%
CmE2	Cieneba rocky coarse sandy loam, 9 to 30 percent slopes , eroded	D	1,442.6	3.8%
CmrG	Cieneba very rocky coarse sandy loam, 30 to 75 percent slopes	D	6,070.8	16.0%
CnE2	Cieneba-Fallbrook rocky sandy loams, 9 to 30 percent slopes, eroded	D	3.9	0.0%
CnG2	Cieneba-Fallbrook rocky sandy loams, 30 to 65 percent slopes, eroded	D	14.2	0.0%
CuE	Crouch rocky coarse sandy loam, 5 to 30 percent slopes	A	242.5	0.6%
CuG	Crouch rocky coarse sandy loam, 30 to 70 percent slopes	A	725.7	1.9%
FaC2	Fallbrook sandy loam, 5 to 9 percent slopes, eroded	C	6.0	0.0%
FaD2	Fallbrook sandy loam, 9 to 15 percent slopes, eroded	C	2.0	0.0%
FaE2	Fallbrook sandy loam, 15 to 30 percent slopes, eroded	C	5.8	0.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
FxE	Friant rocky fine sandy loam, 9 to 30 percent slopes	D	164.9	0.4%
FxG	Friant rocky fine sandy loam, 30 to 70 percent slopes	D	271.7	0.7%
GoA	Grangeville fine sandy loam, 0 to 2 percent slopes	B	37.6	0.1%
GrB	Greenfield sandy loam, 2 to 5 percent slopes	A	9.5	0.0%
GrC	Greenfield sandy loam, 5 to 9 percent slopes	A	45.8	0.1%
GrD	Greenfield sandy loam, 9 to 15 percent slopes	A	15.6	0.0%
GzG	Gullied land		6.0	0.0%
HcC	Hanford coarse sandy loam, 2 to 8 percent slopes	A	5.8	0.0%
HdD2	Hanford cobbly coarse sandy loam, 2 to 15 percent slopes, eroded	A	23.5	0.1%
LcE	La Posta rocky loamy coarse sand, 5 to 30 percent slopes	A	183.6	0.5%
LpB	Las Posas fine sandy loam, 2 to 5 percent slopes	C	7.1	0.0%
LpC	Las Posas fine sandy loam, 5 to 9 percent slopes	C	10.2	0.0%
LpD2	Las Posas fine sandy loam, 9 to 15 percent slopes, eroded	C	11.1	0.0%
LpE2	Las Posas fine sandy loam, 15 to 30 percent slopes, eroded	C	39.0	0.1%
LrE	Las Posas stony fine sandy loam, 9 to 30 percent slopes	C	897.4	2.4%
LrE2	Las Posas stony fine sandy loam, 9 to 30 percent slopes, eroded	C	496.7	1.3%
LrG	Las Posas stony fine sandy loam, 30 to 65 percent slopes	C	3,658.0	9.7%
MmD2	Monserate sandy loam, 8 to 15 percent slopes, eroded	C	1.4	0.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
MrG	Metamorphic rock land	D	96.9	0.3%
PeA	Placentia sandy loam, 0 to 2 percent slopes, warm MAAT, MLRA 19	C	169.6	0.4%
PeC	Placentia sandy loam, 2 to 9 percent slopes, warm MAAT, MLRA 19	C	17.6	0.0%
RaB	Ramona sandy loam, 2 to 5 percent slopes	C	80.5	0.2%
RaC	Ramona sandy loam, 5 to 9 percent slopes	C	2.5	0.0%
RcD	Ramona gravelly sandy loam, 9 to 15 percent slopes	C	422.0	1.1%
RcE	Ramona gravelly sandy loam, 15 to 30 percent slopes	C	119.1	0.3%
RkB	Reiff fine sandy loam, 2 to 5 percent slopes	A	44.6	0.1%
RkC	Reiff fine sandy loam, 5 to 9 percent slopes	A	135.9	0.4%
Rm	Riverwash	D	229.7	0.6%
RuG	Rough broken land	D	713.1	1.9%
SpG2	Sheephead rocky fine sandy loam, 30 to 65 percent slopes, eroded	D	3,586.7	9.5%
SsE	Soboba stony loamy sand, 9 to 30 percent slopes	A	18.8	0.0%
SvE	Stony land	A	202.4	0.5%
ToG	Tollhouse rocky coarse sandy loam, 30 to 65 percent slopes	D	2,380.5	6.3%
TuB	Tujunga sand, 0 to 5 percent slopes	A	1.9	0.0%
VaA	Visalia sandy loam, 0 to 2 percent slopes	A	105.3	0.3%
VaB	Visalia sandy loam, 2 to 5 percent slopes	A	208.1	0.5%
VaC	Visalia sandy loam, 5 to 9 percent slopes	A	75.2	0.2%
VbC	Visalia gravelly sandy loam, 5 to 9 percent slopes	A	10.7	0.0%
VsC	Vista coarse sandy loam, 5 to 9 percent slopes	B	8.9	0.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
VsD2	Vista coarse sandy loam, 9 to 15 percent slopes, eroded	B	369.1	1.0%
VsE2	Vista coarse sandy loam, 15 to 30 percent slopes, eroded	B	10.3	0.0%
VvD	Vista rocky coarse sandy loam, 5 to 15 percent slopes	B	88.4	0.2%
VvE	Vista rocky coarse sandy loam, 15 to 30 percent slopes	B	233.6	0.6%
VvG	Vista rocky coarse sandy loam, 30 to 65 percent slopes	B	169.7	0.4%
WmB	Wyman loam, 2 to 5 percent slopes	C	35.4	0.1%
WmC	Wyman loam, 5 to 9 percent slopes	C	50.7	0.1%
Subtotals for Soil Survey Area			**27,563.7**	**72.7%**
Totals for Area of Interest			**37,907.0**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
AnD	Arlington fine sandy loam, 8 to 15 percent slopes	C	2.5	0.0%
AtC2	Arlington and Greenfield fine sandy loams, 2 to 8 percent slopes , eroded	C	108.3	0.3%
AtD2	Arlington and Greenfield fine sandy loams, 8 to 15 percent slopes, eroded	C	68.6	0.2%
AtF3	Arlington and Greenfield fine sandy loams, 15 to 35 percent slopes, severely eroded	C	23.3	0.1%
BaG	Badland		76.7	0.2%
CaD2	Cajalco fine sandy loam, 8 to 15 percent slopes, eroded	C	12.1	0.0%
CbF2	Cajalco rocky fine sandy loam, 15 to 50 percent slopes, eroded	D	326.6	0.9%
ChF2	Cieneba sandy loam, 15 to 50 percent slopes, eroded	D	8.4	0.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
CkD2	Cieneba rocky sandy loam, 8 to 15 percent slopes, eroded	D	71.3	0.2%
CkF2	Cieneba rocky sandy loam, 15 to 50 percent slopes, eroded	D	1,073.1	2.8%
EcD2	Escondido fine sandy loam, 8 to 15 percent slopes, eroded	C	4.6	0.0%
FaD2	Fallbrook sandy loam, 8 to 15 percent slopes, eroded	C	5.6	0.0%
FcD2	Fallbrook rocky sandy loam, shallow, 8 to 15 percent slopes, eroded	D	0.9	0.0%
FkD2	Fallbrook fine sandy loam, shallow, 8 to 15 percent slopes, eroded	D	17.8	0.0%
FwE2	Friant fine sandy loam, 5 to 25 percent slopes, eroded	D	19.6	0.1%
FyE2	Friant rocky fine sandy loam, 8 to 25 percent slopes, e roded	D	573.9	1.5%
FyF2	Friant rocky fine sandy loam, 25 to 50 percent slopes, eroded	D	157.0	0.4%
GhC	Gorgonio loamy sand, 0 to 8 percent slopes	A	165.8	0.4%
GhD	Gorgonio loamy sand, 8 to 15 percent slopes	A	8.9	0.0%
GkD	Gorgonio loamy sand, channeled, 2 to 15 percent slopes	A	7.2	0.0%
GlC	Gorgonio loamy sand, deep, 2 to 8 percent slopes	A	76.9	0.2%
GmD	Gorgonio gravelly loamy fine sand, 2 to 15 percent slop es	A	9.0	0.0%
GrB	Grangeville sandy loam, sandy substratum, drained, 0 to 5 percent slopes	A/D	1.6	0.0%
GtA	Grangeville fine sandy loam, drained, 0 to 2 percent sl opes	A/D	70.8	0.2%
GtD	Grangeville fine sandy loam, drained, 5 to 15 percent s lopes	A/D	10.7	0.0%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
GuB	Grangeville fine sandy loam, poorly drained, saline-alk ali, 0 to 5 percent slopes	B/D	0.2	0.0%
GvB	Grangeville fine sandy loam, saline-alkali, 0 to 5 percent slopes	B/D	3.7	0.0%
GyA	Greenfield sandy loam, 0 to 2 percent slopes	A	9.6	0.0%
GyC2	Greenfield sandy loam, 2 to 8 percent slopes, eroded	A	236.3	0.6%
GyD2	Greenfield sandy loam, 8 to 15 percent slopes, eroded	A	66.8	0.2%
GzG	Gullied land		636.6	1.7%
HaC	Hanford loamy fine sand, 0 to 8 percent slopes	A	8.7	0.0%
HcA	Hanford coarse sandy loam, 0 to 2 percent slopes	A	7.3	0.0%
HcC	Hanford coarse sandy loam, 2 to 8 percent slopes	A	778.4	2.1%
HcD2	Hanford coarse sandy loam, 8 to 15 percent slopes, eroded	A	226.1	0.6%
HdD2	Hanford cobbly coarse sandy loam, 2 to 15 percent slopes, eroded	A	48.9	0.1%
HeC2	Hanford coarse sandy loam, deep, 2 to 8 percent slopes, eroded	A	146.5	0.4%
HfD	Hanford sandy loam, 2 to 15 percent slopes	A	1.6	0.0%
HgA	Hanford fine sandy loam, 0 to 2 percent slopes	A	39.1	0.1%
HnC	Honcut sandy loam, 2 to 8 percent slopes	A	16.0	0.0%
HnD2	Honcut sandy loam, 8 to 15 percent slopes, eroded	A	14.9	0.0%
HuC2	Honcut loam, 2 to 8 percent slopes, eroded	A	8.2	0.0%
LaD2	Las Posas loam, 8 to 15 percent slopes, eroded	D	24.1	0.1%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
LaE3	Las Posas loam, 8 to 25 percent slopes, severely eroded	D	4.0	0.0%
LcD2	Las Posas stony loam, 8 to 15 percent slopes, eroded	D	25.8	0.1%
LkF3	Las Posas rocky loam, 15 to 50 percent slopes, severely eroded	D	441.3	1.2%
LoF2	Lodo gravelly loam, 15 to 50 percent slopes, eroded	D	2.9	0.0%
MmB	Monserate sandy loam, 0 to 5 percent slopes	C	1.1	0.0%
MmD2	Monserate sandy loam, 8 to 15 percent slopes, eroded	C	25.8	0.1%
MmE3	Monserate sandy loam, 15 to 25 percent slopes, severely eroded	C	3.8	0.0%
MnE3	Monserate sandy loam, shallow, 15 to 25 percent slopes, severely eroded	D	0.6	0.0%
PaC2	Pachappa fine sandy loam, 2 to 8 percent slopes, eroded	B	68.8	0.2%
RaB2	Ramona sandy loam, 2 to 5 percent slopes, eroded	C	15.9	0.0%
RaC2	Ramona sandy loam, 5 to 8 percent slopes, eroded	C	1.7	0.0%
RaD3	Ramona sandy loam, 8 to 15 percent slopes, severely eroded	C	8.8	0.0%
RaE3	Ramona sandy loam, 15 to 25 percent slopes, severely eroded	C	6.5	0.0%
RmE3	Ramona and Buren sandy loams, 15 to 25 percent slopes, severely eroded	C	132.4	0.3%
RnE3	Ramona and Buren loams, 5 to 25 percent slopes, severely eroded	C	8.6	0.0%
RsC	Riverwash		478.3	1.3%
RtF	Rockland		2,330.6	6.1%
RuF	Rough broken land		798.2	2.1%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
SgC	San Emigdio loam, 2 to 8 percent slopes	A	53.4	0.1%
SmE2	San Timoteo loam, 8 to 25 percent slopes, eroded	B	7.1	0.0%
SsD	Soboba stony loamy sand, 2 to 15 percent slopes	A	4.8	0.0%
TeG	Terrace escarpments		201.8	0.5%
TuB	Tujunga loamy sand, 0 to 5 percent slopes	A	120.1	0.3%
TvC	Tujunga loamy sand, channeled, 0 to 8 percent slopes	A	67.0	0.2%
VaB	Visalia sandy loam, 2 to 5 percent slopes	A	4.9	0.0%
VaC	Visalia sandy loam, 5 to 9 percent slopes	A	10.0	0.0%
VlC2	Visalia sandy loam, 0 to 8 percent slopes, eroded	A	24.4	0.1%
VmA	Visalia fine sandy loam, 0 to 2 percent slopes	A	2.5	0.0%
VmC	Visalia fine sandy loam, 2 to 8 percent slopes	A	2.4	0.0%
VsC	Vista coarse sandy loam, 2 to 8 percent slopes	B	3.1	0.0%
VsD2	Vista coarse sandy loam, 8 to 15 percent slopes, eroded	B	28.2	0.1%
VsF2	Vista coarse sandy loam, 15 to 35 percent slopes, eroded	B	37.8	0.1%
VtF2	Vista rocky coarse sandy loam, 2 to 35 percent slopes, eroded	B	105.0	0.3%
WmC	Wyman loam, 5 to 9 percent slopes	C	7.6	0.0%
WyC2	Wyman loam, 2 to 8 percent slopes, eroded	C	4.6	0.0%
YbC	Yokohl loam, 2 to 8 percent slopes	D	19.5	0.1%
YbD2	Yokohl loam, 8 to 15 percent slopes, eroded	D	36.5	0.1%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
YbE3	Yokohl loam, 8 to 25 percent slopes, severely eroded	D	73.5	0.2%
Subtotals for Soil Survey Area			**10,343.2**	**27.3%**
Totals for Area of Interest			**37,907.0**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie. The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

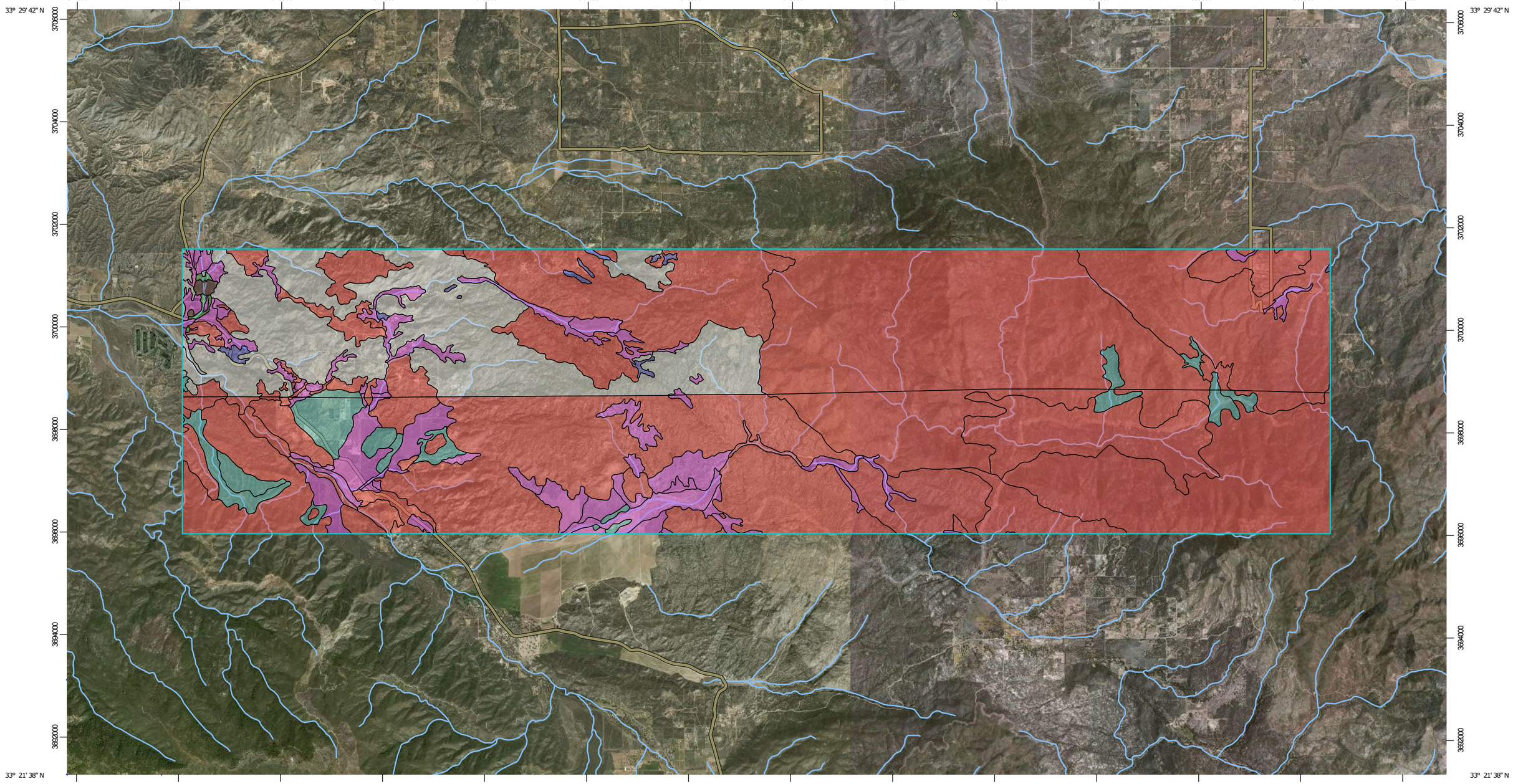
Component Percent Cutoff: None Specified

Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Hydrologic Soil Group—San Diego County Area, California, and Western Riverside Area, California
(Area 3 - East of Aguanga)



Map Scale: 1:72,800 if printed on B landscape (17" x 11") sheet.

N

Meters
0 1000 2000 4000 6000

Feet
0 3500 7000 14000 21000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 11N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
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Background
- Aerial Photography

MAP INFORMATION

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Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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Soil Survey Area: San Diego County Area, California
Survey Area Data: Version 12, Sep 13, 2017

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Survey Area Data: Version 10, Sep 12, 2017

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Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
AcG	Acid igneous rock land	D	4,341.6	14.0%
BuC	Bull Trail sandy loam, 5 to 9 percent slopes	C	90.8	0.3%
BuD2	Bull Trail sandy loam, 9 to 15 percent slopes	C	188.5	0.6%
BuE2	Bull Trail sandy loam, 15 to 30 percent slopes, eroded	C	62.8	0.2%
CaC	Calpine coarse sandy loam, 5 to 9 percent slopes	A	105.3	0.3%
CmE2	Cieneba rocky coarse sandy loam, 9 to 30 percent slopes , eroded	D	44.7	0.1%
CmrG	Cieneba very rocky coarse sandy loam, 30 to 75 percent slopes	D	143.2	0.5%
LaE2	La Posta loamy coarse sand, 5 to 30 percent slopes, eroded	A	26.4	0.1%
LcE2	La Posta rocky loamy coarse sand, 5 to 30 percent slopes, eroded	A	120.6	0.4%
LcF2	La Posta rocky loamy coarse sand, 30 to 50 percent slopes, eroded	A	181.1	0.6%
MnE3	Monserate sandy loam, shallow, 15 to 25 percent slopes, severely eroded	D	4.8	0.0%
MvC	Mottsville loamy coarse sand, 2 to 9 percent slopes	A	725.7	2.3%
MvD	Mottsville loamy coarse sand, 9 to 15 percent slopes	A	62.4	0.2%
RcD	Ramona gravelly sandy loam, 9 to 15 percent slopes	C	393.8	1.3%
RcE	Ramona gravelly sandy loam, 15 to 30 percent slopes	C	168.4	0.5%
Rm	Riverwash	D	73.2	0.2%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
RuG	Rough broken land	D	144.7	0.5%
SpE2	Sheephead rocky fine sandy loam, 9 to 30 percent slopes, eroded	D	1,245.4	4.0%
SpG2	Sheephead rocky fine sandy loam, 30 to 65 percent slopes, eroded	D	4,980.6	16.1%
SsE	Soboba stony loamy sand, 9 to 30 percent slopes	A	123.0	0.4%
SvE	Stony land	A	37.0	0.1%
ToE2	Tollhouse rocky coarse sandy loam, 5 to 30 percent slopes, eroded	D	796.1	2.6%
ToG	Tollhouse rocky coarse sandy loam, 30 to 65 percent slopes	D	870.7	2.8%
TuB	Tujunga sand, 0 to 5 percent slopes	A	263.0	0.8%
VaC	Visalia sandy loam, 5 to 9 percent slopes	A	11.6	0.0%
VaD	Visalia sandy loam, 9 to 15 percent slopes	A	7.1	0.0%
Subtotals for Soil Survey Area			**15,212.6**	**49.2%**
Totals for Area of Interest			**30,947.3**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
AtF3	Arlington and Greenfield fine sandy loams, 15 to 35 percent slopes, severely eroded	C	6.1	0.0%
BsC2	Bull Trail sandy loam, 5 to 8 percent slopes, eroded	C	39.6	0.1%
BsE3	Bull Trail sandy loam, 8 to 25 percent slopes, severely eroded	D	54.4	0.2%
BtD2	Bull Trail stony sandy loam, 8 to 15 percent slopes, eroded	C	54.5	0.2%
ChD2	Cieneba sandy loam, 8 to 15 percent slopes, eroded	D	1.6	0.0%
CkD2	Cieneba rocky sandy loam, 8 to 15 percent slopes, eroded	D	158.0	0.5%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
CkF2	Cieneba rocky sandy loam, 15 to 50 percent slopes, eroded	D	570.9	1.8%
CvD2	Crouch loamy sand, 8 to 15 percent slopes, eroded	B	64.9	0.2%
CwD2	Crouch sandy loam, 8 to 15 percent slopes, eroded	B	4.8	0.0%
GhC	Gorgonio loamy sand, 0 to 8 percent slopes	A	7.0	0.0%
GhD	Gorgonio loamy sand, 8 to 15 percent slopes	A	21.9	0.1%
GlC	Gorgonio loamy sand, deep, 2 to 8 percent slopes	A	3.4	0.0%
GrB	Grangeville sandy loam, sandy substratum, drained, 0 to 5 percent slopes	A/D	16.8	0.1%
GtA	Grangeville fine sandy loam, drained, 0 to 2 percent sl opes	A/D	10.8	0.0%
GuB	Grangeville fine sandy loam, poorly drained, saline-alk ali, 0 to 5 percent slopes	B/D	27.3	0.1%
GvB	Grangeville fine sandy loam, saline-alkali, 0 to 5 percent slopes	B/D	3.7	0.0%
GzG	Gullied land		33.5	0.1%
HcC	Hanford coarse sandy loam, 2 to 8 percent slopes	A	133.8	0.4%
HcD2	Hanford coarse sandy loam, 8 to 15 percent slopes, eroded	A	124.4	0.4%
MnD2	Monserate sandy loam, shallow, 5 to 15 percent slopes, eroded	D	37.2	0.1%
MnE3	Monserate sandy loam, shallow, 15 to 25 percent slopes, severely eroded	D	37.6	0.1%
MoC	Mottsville loamy sand, 2 to 8 percent slopes	A	67.0	0.2%
MoD	Mottsville loamy sand, 8 to 15 percent slopes	A	363.0	1.2%
RcD	Ramona gravelly sandy loam, 9 to 15 percent slopes	C	30.1	0.1%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
RsC	Riverwash		18.1	0.1%
RtF	Rockland		4,132.2	13.4%
RuF	Rough broken land		15.7	0.1%
SpG2	Sheephead rocky fine sandy loam, 15 to 75 percent slopes, eroded	D	5,234.9	16.9%
TfF2	Tollhouse rocky coarse sandy loam, 8 to 50 percent slopes, eroded	D	4,384.8	14.2%
TuB	Tujunga loamy sand, 0 to 5 percent slopes	A	0.1	0.0%
TvC	Tujunga loamy sand, channeled, 0 to 8 percent slopes	A	31.6	0.1%
VaC	Visalia sandy loam, 5 to 9 percent slopes	A	8.9	0.0%
VaD	Visalia sandy loam, 9 to 15 percent slopes	A	7.8	0.0%
VsF2	Vista coarse sandy loam, 15 to 35 percent slopes, eroded	B	28.1	0.1%
Subtotals for Soil Survey Area			**15,734.7**	**50.8%**
Totals for Area of Interest			**30,947.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie. The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Component Percent Cutoff: None Specified

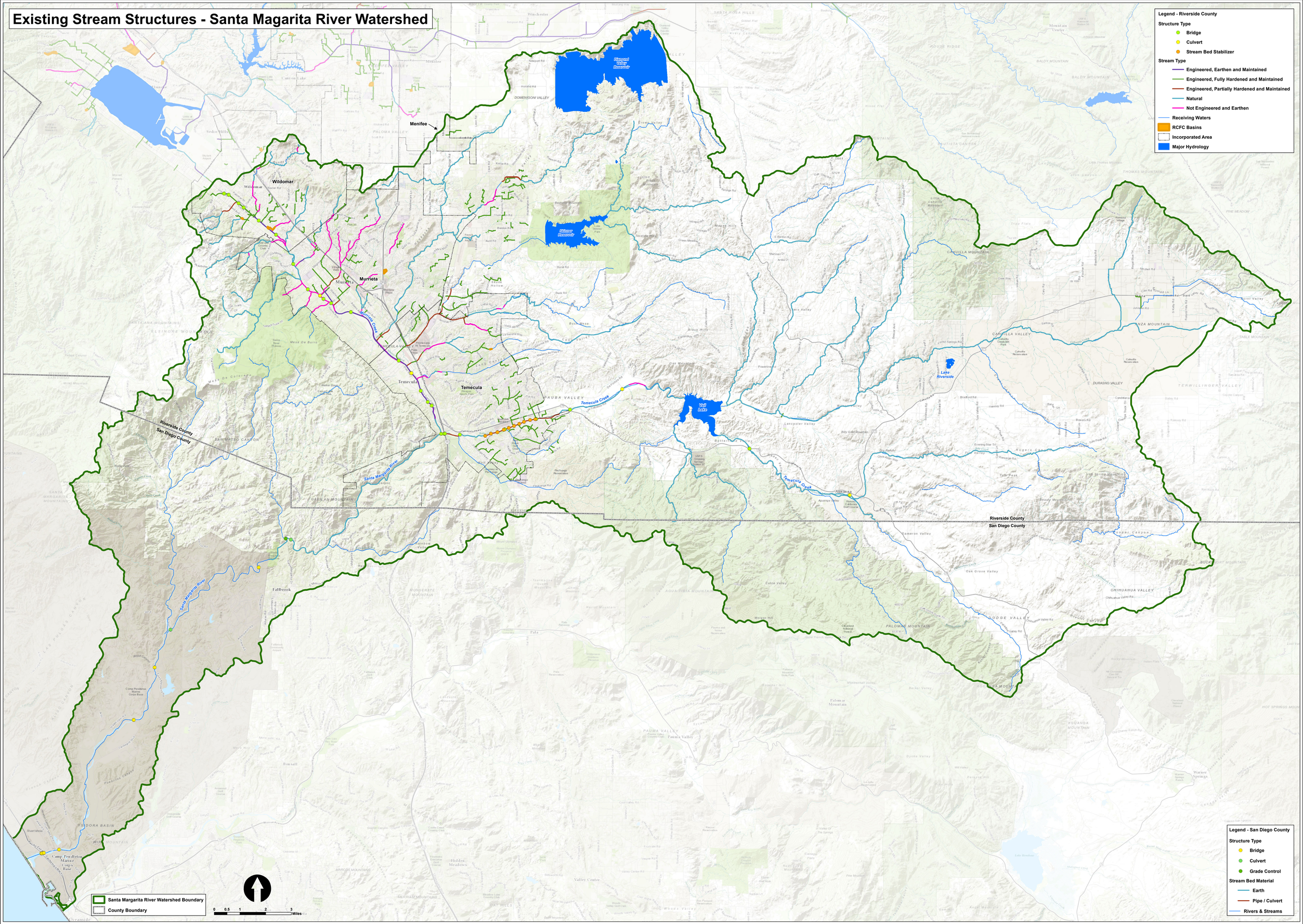
Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Attachment C. Existing Stream Structures

Existing Stream Structures - Santa Magarita River Watershed



Legend - Riverside County

Structure Type
- Bridge
- Culvert
- Stream Bed Stabilizer

Stream Type
- Engineered, Earthen and Maintained
- Engineered, Fully Hardened and Maintained
- Engineered, Partially Hardened and Maintained
- Natural
- Not Engineered and Earthen

Receiving Waters
RCFC Basins
Incorporated Area
Major Hydrology

Legend - San Diego County

Structure Type
- Bridge
- Culvert
- Grade Control

Stream Bed Material
- Earth
- Pipe / Culvert

Rivers & Streams

Attachment D. Hydrographic Category

Hydrographic Category - Santa Magarita River Watershed

Legend - Riverside County
Hydrographic Category
Intermittent Stream
Perennial Stream
Receiving Waters
Incorporated Area
Major Hydrology

Diamond Valley Reservoir
Skinner Reservoir
Lake Elsinore
Canyon Lake
Lake Riverside
Vail Lake
Menifee
Wildomar
Murrieta
Temecula
Murrieta Creek
Temecula Creek
Santa Margarita River
Riverside County
San Diego County
Fallbrook
Pala
Pauma Valley
Bonsall
Camp Pendleton Marine Corps Base
Oceanside
Valley Center
Warner Springs

Santa Margarita River Watershed Boundary
County Boundary

0 0.5 1 2 3 Miles

Legend - San Diego County
Hydrographic Category
Intermittent Stream
Perennial Stream
Receiving Water

Attachment E. Current Land Use Map

Current Land Use Map - Santa Magarita River Watershed

Menifee
Wildomar
Murrieta
Temecula
Riverside County
San Diego County
Riverside County
San Diego County

Legend - Riverside County

Land Use Types
- Agriculture
- Commercial and Services
- Education
- Facilities
- General Office
- Industrial
- Military Installations
- Mixed Commercial and Industrial
- Mixed Residential and Commercial
- Mobile Homes and Trailer Parks
- Open Space and Recreation
- Residential
- Rural Residential
- Transportation, Communications, and Utilities
- Tribal
- Under Construction
- Unknown
- Vacant
- Water
- Incorporated Area

Legend - San Diego County

Land Use Types

Residential
- Spaced Rural Residential
- Single Family Residential
- Mobile Homes
- Multi-Family Residential

Commercial And Office
- Commercial and Office

Industrial
- Light Industry
- Extractive Industry

Public Facilities And Utilities
- Transportation, Communications, Utilities
- Education
- Institutions
- Military

Parks And Recreation
- Recreation
- Open Space Parks

Agriculture
- Intensive Agriculture
- Extensive Agriculture

Other
- Water
- Federal/State/Indian Lands

Santa Margarita River Watershed Boundary
County Boundary

0 0.5 1 2 3 Miles

Attachment F. Anticipated Land Use Map

Current Land Use Map - Santa Magarita River Watershed

Menifee
Wildomar
Murrieta
Temecula
Riverside County
San Diego County
Riverside County
San Diego County

Legend - Riverside County

Land Use Types
- Agriculture
- Commercial and Services
- Education
- Facilities
- General Office
- Industrial
- Military Installations
- Mixed Commercial and Industrial
- Mixed Residential and Commercial
- Mobile Homes and Trailer Parks
- Open Space and Recreation
- Residential
- Rural Residential
- Transportation, Communications, and Utilities
- Tribal
- Under Construction
- Unknown
- Vacant
- Water
- Incorporated Area

Legend - San Diego County

Land Use Types

Residential
- Spaced Rural Residential
- Single Family Residential
- Mobile Homes
- Multi-Family Residential

Commercial And Office
- Commercial and Office

Industrial
- Light Industry
- Extractive Industry

Public Facilities And Utilities
- Transportation, Communications, Utilities
- Education
- Institutions
- Military

Parks And Recreation
- Recreation
- Open Space Parks

Agriculture
- Intensive Agriculture
- Extensive Agriculture

Other
- Water
- Federal/State/Indian Lands

Santa Margarita River Watershed Boundary
County Boundary

0 0.5 1 2 3 Miles

Attachment G. Upper Santa Margarita River Hydrologic Response Unit and Critical Coarse Sediment Yield Analysis

WESTERN RIVERSIDE COUNCIL OF GOVERNMENTS

UPPER SANTA MARGARITA RIVER

HYDROLOGIC RESPONSE UNIT AND CRITICAL COARSE SEDIMENT YIELD ANALYSIS

JUNE 29, 2018



wsp

UPPER SANTA MARGARITA RIVER

HYDROLOGIC RESPONSE UNIT AND CRITICAL COARSE SEDIMENT YIELD ANALYSIS

WESTERN RIVERSIDE COUNCIL OF GOVERNMENTS

PROJECT NO.: 12853-T01
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1 INTRODUCTION

The Western Riverside Council of Governments (WRCOG) comprises the County of Riverside and each city located within Western Riverside County. WRCOG was established to provide an agency to conduct studies and projects designed to improve and coordinate the common governmental responsibilities and services on an area-wide and regional basis. Some of the functions performed by WRCOG include serving as a forum for consideration, study and recommendation on area-wide regional problems; assembling information helpful in the consideration of problems peculiar to Western Riverside County; exploring practical avenues for intergovernmental cooperation, coordination and action in the interest of local public welfare and means of improvements in the administration of governmental services; and serving as the clearinghouse review body for Federally-funded projects in conjunction with the Southern California Association of Governments[1]. To this end, and in the spirit of respecting local control while providing a regional perspective, WRCOG is collaborating with the Riverside County Flood Control and Water Conservation District (RCFCWCD) for the development of a Watershed Management Area Analysis (WMAA) of the upper Santa Margarita River watershed which is under the jurisdiction of the San Diego Regional Water Quality Control Board (RWQCB). An exhibit that displays these jurisdictional boundaries as they relate to the Santa Margarita River watershed is provided as Figure 1.

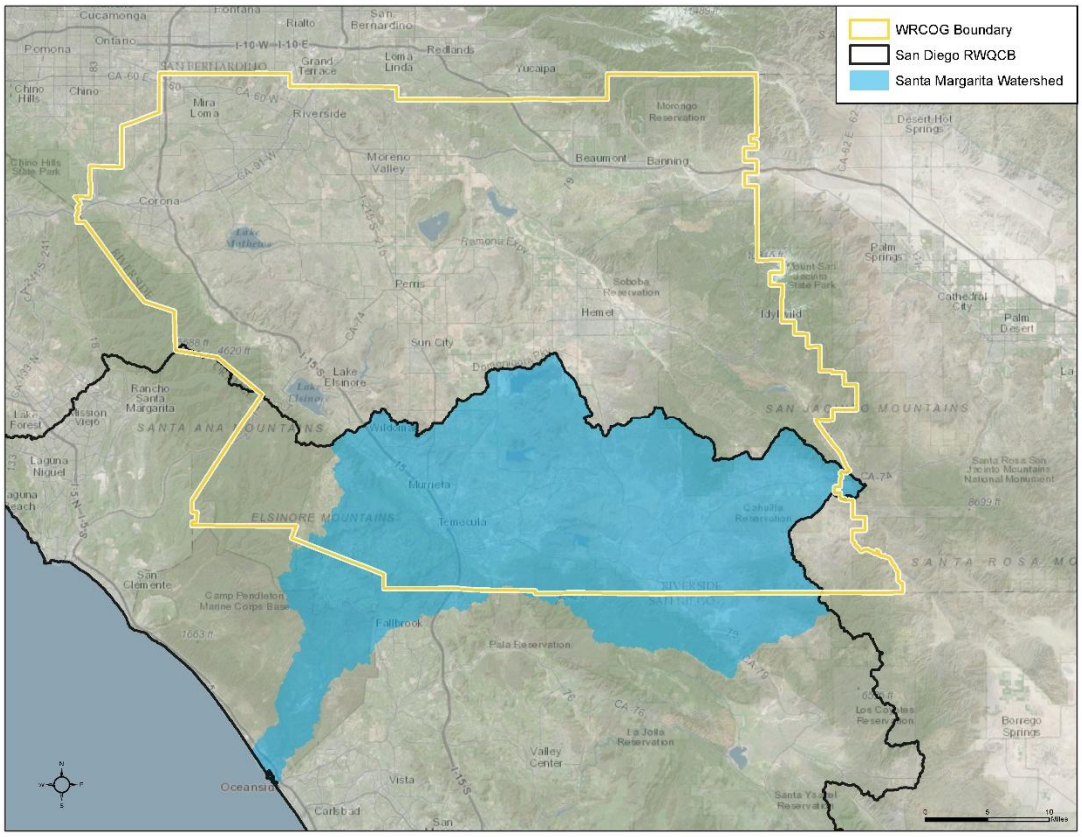

Figure 1. Jurisdictions Associated with the Santa Margarita River Watershed

This report documents the results of two macro scale, regional mapping elements developed by WRCOG. Specifically, WRCOG is evaluating potential changes in runoff and sediment discharge using a geographic information system (GIS)-based watershed-scale analysis of the upper Santa Margarita River watershed (SMR). This report includes a description of the

[1] http://www.wrcog.cog.ca.us/DocumentCenter/View/151

GIS data inputs that were utilized to determine the hydrologic response unit (HRU), the dominant hydrologic process and the potential coarse sediment yield for the SMR.

1.1 BACKGROUND

This report is being developed in response to the National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds within the San Diego Region, (MS4 Permit), which was adopted on May 8, 2013, became effective on June 27, 2013 and was amended by Order No. R9-2015-0001 and Order No. R9-2015-0100. The MS4 Permit requires a Water Quality Improvement Plan (WQIP) for each of the Watershed Management Areas under the jurisdiction of the San Diego RWQCB. The purpose of the WQIP is to further the Clean Water Act's objective to protect, preserve, enhance, and restore the water quality and designated beneficial uses of waters of the state (San Diego RWQCB 2015). A WQIP is required for each Watershed Management Area and therefore requires a Watershed Management Area Analysis (WMAA). A WMAA is a watershed-scale analysis that identifies important characteristics, such as hydrologic processes, sediment yield and stream descriptions. The WMAA is specific to the Santa Margarita Region which includes the County of Riverside, the RCFCWCD, the City of Wildomar, City of Murrieta and the City of Temecula (Copermittees). By working together and sharing resources for development of the SMR WMAA, RCFCWCD is evaluating and summarize existing streams; flood control structures; and current and anticipated land use in the SMR. As part of their contribution to the SMR WMAA, WRCOG is evaluating dominant hydrologic processes and potential coarse sediment yield. The final output of the analyses includes GIS layers to identify candidate projects as alternative compliance options. The SMR WMAA will also provide information to support exemptions from the on-site hydromodification management requirements (RCFCWCD, 2017).

The GIS analysis described herein includes two subtasks which will support development of the SMR WMAA. The SMR WMAA elements described herein leverage and build upon work and mapping already conducted, including but not limited to Technical Report 605 (Booth et al. 2010), the 2014 Santa Margarita Hydromodification Management Plan (HMP)[2] and the 2015 San Diego County Regional WMAA (SD WMAA)[3]. The SD WMAA already includes a preliminary analysis of the lower Santa Margarita River. Therefore, given that the analysis of the upper SMR will be integrated with the analysis of the lower SMR, to maintain a consistent, standardized approach among the lower and upper SMR analyses, the methodology described in in this report is the same methodology developed for the SD WMAA (Geosyntec Consultants and Rick Engineering Company, 2015).

[2] http://rcflood.org/npdes/SantaMargaritaWS.aspx#SMdocs
[3] http://www.projectcleanwater.org/index.php?option=com_content&view=article&id=248&Itemid=219

2 HYDROLOGIC RESPONSE UNIT

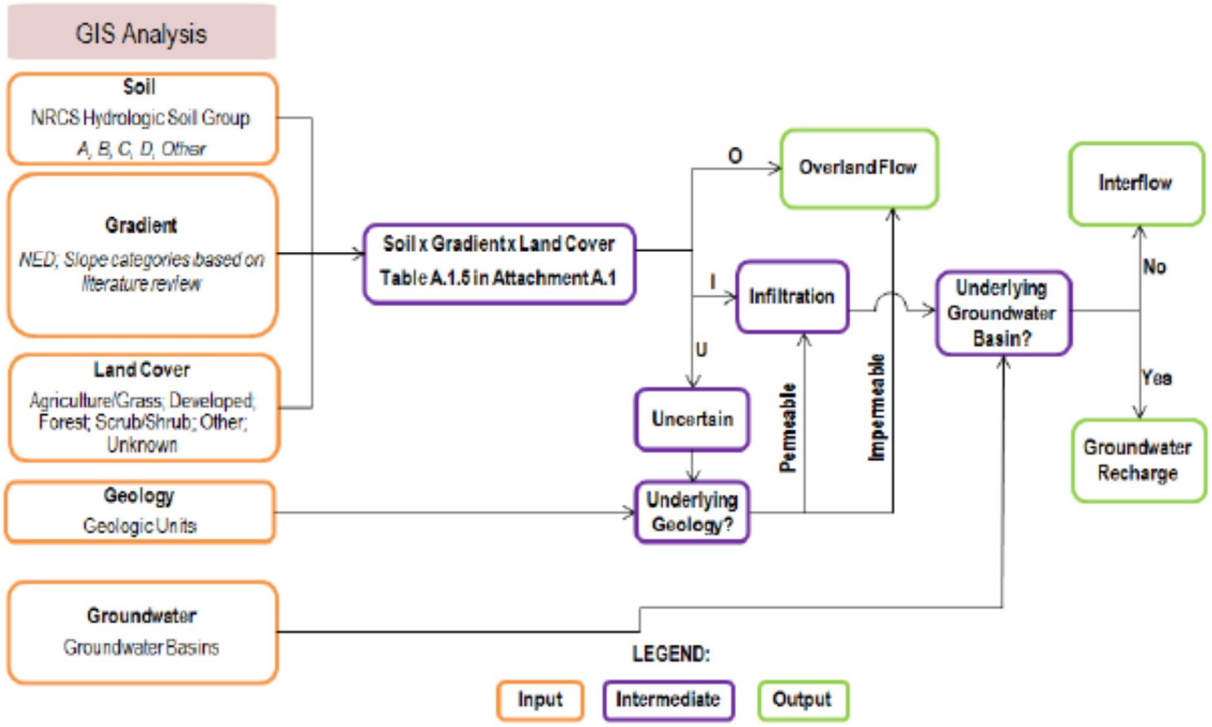

Figure 2. Hydrologic Response Unit and Hydrologic Process Flow Chart

2.1 HYDROLOGIC RESPONSE UNIT END POINTS

The MS4 Permit requires that the WMAA analysis includes a description of dominant hydrologic processes, such as areas where groundwater recharge, interflow or overland flow likely dominate (San Diego RWQCB, 2015). An evaluation of dominant hydrologic processes in the SMR watershed, however, should also consider evapotranspiration (ET). ET is the quantity of water transpired by plants, retained in plant tissues, and evaporated from plant tissues and surrounding soil surfaces (Department of Water Resources, 2005). A comparison of the estimated mean annual precipitation, (4 – 10 inches), over a thirty-year timespan in the Riverside-area watersheds with the estimated fraction of precipitation lost to evapotranspiration (90 – 99 percent) in the same area and over the same time frame, suggests that ET is the dominant hydrologic process in Riverside-area watersheds (Sanford and Selnick, 2013). Therefore, theoretically, if all the annual precipitation for the Riverside-area watersheds remained stationary where it fell and did not either infiltrate or runoff to downstream receiving waterbodies, then the precipitation would be loss to ET. Rain events, however, often produce runoff in these watersheds, especially in the urbanized areas, where the topography and land cover tend to accelerate the runoff rate downstream rather than allowing the runoff to be stored or collected and thus maximizing ET.

This analysis, however, is focused on developing information and mapping to gain an understanding of the macro-scale opportunities for locating projects that take advantage of either capturing overland flow for treatment or for supplementing the groundwater regime (Figure 2). Therefore, after considering the effects of ET and an intermediate category of infiltration,

the predicted fate of runoff within the SMR was evaluated based on the hydrologic process endpoints - overland flow, interflow[4], or groundwater recharge.

The hydrologic response endpoint (i.e., overland flow, infiltration, interflow or groundwater recharge) was derived by first integrating soil, gradient and land cover datasets into hydrologic response units (HRUs). The HRUs were then incorporated as a layer onto a basemap and the data were grouped into several discrete categories and ultimately classified across the SMR. This process is summarized as Figure 2 (Geosyntec Consultants and Rick Engineering Company, 2015).

2.2 DATA TYPES AND ACQUISITION

GIS data were acquired from public-domain sources as indicated below.

- United States Department of Agriculture/National Resources Conservation Service (USDA/NRCS) Web Soil Survey: https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm and USDA/NRCS Digital General Soil Map of the United States: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053629
- USGS National Elevation Data Set (NED) 1/3 arc-second DEM: https://catalog.data.gov/dataset/usgs-national-elevation-dataset-ned
- https://viewer.nationalmap.gov/basic/
- Land Cover/Vegetation: https://gis.countyofriverside.us/arcgis_public/rest/services/OpenData/NaturalFeaturesAndHazards/MapServer/4
- Soils - National Resource Conservation Service: http://www.ncgc.nrcs.usda.gov/products/datasets/ssurgo/
- Geologic Units: http://www.conservation.ca.gov/cgs/information/geologic_mapping
- Groundwater: Metropolitan Water District of Southern California. 2007. Groundwater assessment study

2.2.1 UPPER SANTA MARGARITA RIVER WATERSHED

The San Diego Association of Governments (SANDAG) Hydrologic Basins Layer was utilized to delineate the SMR. A vector dataset (shapefile) with basin and sub-basin delineations organized by the 8-digit hydrologic unit code from the USGS Hydrologic Unit Maps was available from CalWater. After the SMR was extracted, an examination of its boundaries was compared against a 10-m DEM hillshade. In cases where the boundary seemed inadequate, the DEM was used to improve the watershed delineation with ArcInfo Hydrology routines. After the area of analysis was sufficiently well-defined, the analysis layers were 'clipped' to its boundaries and re-projected to a common coordinate system.

2.2.2 HYDROLOGIC SOIL GROUPS

Soil categories were based on NRCS Hydrologic Soil Group (HSG) classifications, which are commonly used to describe runoff/infiltration potential of soils on a regional scale. There are four HSGs: A, B, C, and D and three dual groups: A/D, B/D and C/D. HSGs are based on the rate of water infiltration, with Group A having the highest rates and Group D having the lowest rates. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas. The following describes the methodology used to assign a single HSG rating for each of the dual groups identified.

Over two hundred polygons, equating to an area of approximately 7,000 acres in the SMR watershed GIS were rated with a dual HSG. Dual HSG ratings were evaluated based on the mapped geologic unit as determined by published geologic mapping information, a desktop evaluation and soils laboratory results. Specifically, the mapped geologic units were compiled into similar categories and then referenced with a geologic unit name. Geologic units were then categorized as either "coarse" or "fine" based on typical weathering characteristics for the bedrock unit or primary grain size of the

[4] Interflow takes place following storm events as shallow subsurface flow (usually within 3 to 6 feet of the surface) occurring in a more permeable soil layer above a less permeable substrate (Geosyntec Consultants and Rick Engineering Company 2015).

sedimentary unit. For example, some geologic units weather to a coarse material such as silty sand and were therefore classified as “coarse”. Geologic units that weather to a sandy clay were classified as “fine”. Regarding sedimentary formations that are usually associated with variable amounts of coarse and fine units, the final classification was based on the predominating composition, i.e., sandstone/silty sand versus claystone. Finally, given that silty sands drain very quickly, any geologic unit identified as coarse was considered drained and was identified as either HSG A, B, or C. Whereas, geologic units classified as “fine” were considered undrained and were rated as HSG D in the GIS database.

For HRUs considered uncertain (U), the underlying regional geology was used to evaluate whether overland flow or infiltration were dominant, consistent with the San Diego County WMAA analysis (Geosyntec Consultants and Rick Engineering Company, 2015). For HRUs considered uncertain (U), the underlying regional geology (Department of Conservation 2015) was used to evaluate whether overland flow or infiltration were dominant. If the underlying geology was considered impermeable, then these uncertain areas were considered to have overland flow as its dominant hydrologic process. If the underlying geology was considered permeable, then these uncertain areas were dominated by infiltration. The determination of whether a geologic unit is impermeable or permeable was based on desktop evaluation and the best professional judgment of a Geotechnical Engineer. This analysis was performed in GIS.

2.2.3 SLOPE CLASSES

The hillslope digital elevation model (DEM) was analyzed to produce a grid of slope values, which were subsequently classified into discrete categories. Based on the SD WMAA, the following percentage categories were used to group hillslope gradients: 0 - 2 percent; 2 - 6 percent; 6 - 10 percent; and greater than 10 percent. According to Technical Report 605 (Booth et al. 2010), the 10 percent slope threshold was used because it was determined that slopes steeper than 10 percent are assumed to be dominated by overland flow.

2.2.4 LAND COVER

Land cover categories were defined using the ecology vegetation GIS map layers developed for Western Riverside County in the Santa Margarita region. The vegetation categories in the GIS layer were grouped to match the following land cover categories used in SD WMAA: Agriculture/Grass; Developed; Forest; Scrub/Shrub, Other and Other (Water) (see Table A.1, Appendix A). Land cover categories for Agriculture/Grass, Forest, Scrub/Shrub, Unknown Other and Other (Water) were then related to land use categories using Table A.2 in Appendix A. A land use category for the Developed land cover category was not determined because this land cover was assumed to have overland flow as its dominant hydrologic process. Table A.3 in Appendix A displays the results showing how the land cover categories related to land use.

HYDROLOGY CHARACTERISTICS BASED ON LAND COVER

For each of the land cover/land use categories the ratio of precipitation lost to evapotranspiration (i.e. an evapotranspiration coefficient) was estimated using the process described below as provided in the SD WMAA (Geosyntec Consultants and Rick Engineering Company, 2015). Since precipitation is considered as the sum of the resulting runoff, infiltration, and evapotranspiration, the coefficients for these three hydrologic pathways sum to one using Equation (Eq) 1.

Runoff Coefficient + Infiltration Coefficient + Evapotranspiration Coefficient = 1 (Eq. 1)

EVAPOTRANSPIRATION ESTIMATE

To estimate the evapotranspiration (ET) coefficient for each land cover, the runoff coefficient was identified by evaluating the highest runoff potential for the most common storm conditions. Using this, the ET coefficient was calculated as the difference (i.e., ET Coefficient = 1 –Runoff Coefficient). The ET coefficient calculated for the highest runoff potential was then applied to all soil types and slopes within each land use category.

INFILTRATION ESTIMATE

The infiltration coefficient for each applicable HRU (i.e., combination of soil, gradient, and land cover) was estimated by subtracting both the runoff coefficient, and the ET coefficient, from one (i.e., Infiltration Coefficient = 1 – Runoff Coefficient – ET Coefficient).

RUNOFF ESTIMATE

For each applicable HRU, the runoff coefficient was divided by the infiltration coefficient to obtain a ratio representing the potential for runoff or infiltration. The higher the ratio, the greater the potential for runoff to be a more dominant hydrologic process than infiltration. Similarly, the lower the ratio, the greater the potential for infiltration to be a more dominant hydrologic process than runoff.

ASSOCIATE RUNOFF AND INFILTRATION HRUS

The following designations were assigned to each applicable HRU based on the runoff to infiltration ratio (i.e., runoff coefficient/infiltration coefficient). These designations were based on best engineering judgment with the underlying assumption that if a runoff or infiltration coefficient is more than 50 percent greater than its counterpart, then the prevailing process is considered dominant.

- HRUs with runoff to infiltration ratios greater than 1.5 (3:2 ratio) were assumed to have relatively high runoff and overland flow was considered its dominant hydrologic process. These HRUs are designated by the letter “O” (Overland flow is dominant process). Table A.4 in Appendix A summarizes these findings in tabular format.
- HRUs with runoff to infiltration ratios less than 0.67 (2:3 ratio) were assumed to have relatively high infiltration and its dominant hydrologic process was either interflow or groundwater recharge, based on analysis described in subsequent steps. These HRUs are designated by the letter “I” (Interflow is dominant process) in Table A.4, Appendix A.
- For HRUs with runoff to infiltration ratios ranging from 0.67 to 1.5, it was uncertain whether it was dominated by overland flow or infiltration. These HRUs are designated by the letter “U” (Dominant process is uncertain) in Table A.4, Appendix A.
- For HRUs that have a Developed land cover or a gradient greater than 10 percent, the runoff to infiltration ratios were not calculated because these HRUs were assumed to have overland flow as the dominant hydrologic process. These HRUs are designated by the letter “O” (Overland flow is dominant process) and are summarized in Table A.5, Appendix A.

2.2.5 GEOLOGIC UNIT

The geology layer was categorized based on rock types, the predominant sediment size generated upon erosion, and their associated erodibility (Booth, et al., 2010). The attribution (and thus the naming) of the geology classes included the following categories:

- Coarse Bedrock (CB),
- Coarse Sedimentary Impermeable (CSI),
- Coarse Sedimentary Permeable (CSP),
- Fine Bedrock (FB),
- Fine Sedimentary Impermeable (FSI),
- Fine Sedimentary Permeable (FSP), and
- Other (O).

The underlying geology was then evaluated to determine if it was permeable or impermeable. This determination was based on a desktop evaluation using the best professional judgment of a Certified Engineering Geologist. All geologic units identified as permeable were considered to have infiltration as the hydrologic endpoint. All impermeable layers were considered to have overland flow as the hydrologic endpoint. The Certified Engineering Geologist also performed a desktop evaluation of any HRUs that were identified as uncertain. Again, if the underlying geology was considered permeable, then

these uncertain areas were considered to be dominated by infiltration. Likewise, if the underlying geology was considered impermeable, then these uncertain areas were considered to be dominated by overland flow.

2.2.6 GROUNDWATER BASINS

For HRUs with relatively high infiltration the presence or absence of a regional groundwater basin underlying these areas determined whether the dominant hydrologic process was designated as interflow or groundwater recharge. The groundwater recharge hydrologic process was assigned as dominant for those applicable areas which have an underlying groundwater basin. The interflow hydrologic process was assigned as dominant for those applicable areas which did not have an underlying groundwater basin.

2.2.7 DOMINANT HYDROLOGIC PROCESS RESULTS

The resulting GIS map displaying the spatial distribution of dominant hydrologic processes (i.e., overland flow, interflow and groundwater recharge) within the SMR is provided in Appendix B. Based on this analysis, overland flow, is the predominant hydrologic process in the SMR, which was verified by the Copermittees as part of their review process.

3 CRITICAL COARSE SEDIMENT YIELD ANALYSIS

The Critical Coarse Sediment Yield analysis predicts the potential critical coarse sediment yield areas and is based on the Geomorphic Landscape Unit (GLU) methodology presented in Technical Report 605 (Booth et al. 2010) and the SD WMAA (Geosyntec Consultants and Rick Engineering Company, 2015). The GLU methodology characterizes the magnitude of sediment production from areas using three factors judged to exert the greatest influence on the variability of sediment-production rates: geology types, hillslope gradient, and land cover. The GLU layer was derived by overlaying hillslope, land cover, and geology, and then assigning a relative sediment-production rate (i.e., Low, Medium, and High) to each of the resulting categories. The GLU approach provided a useful, rapid framework to identify sediment-delivery attributes of the SMR. The process to integrate these factors into GLUs is indicated as a flow chart in Figure 3 (Geosyntec Consultants and Rick Engineering Company 2015).

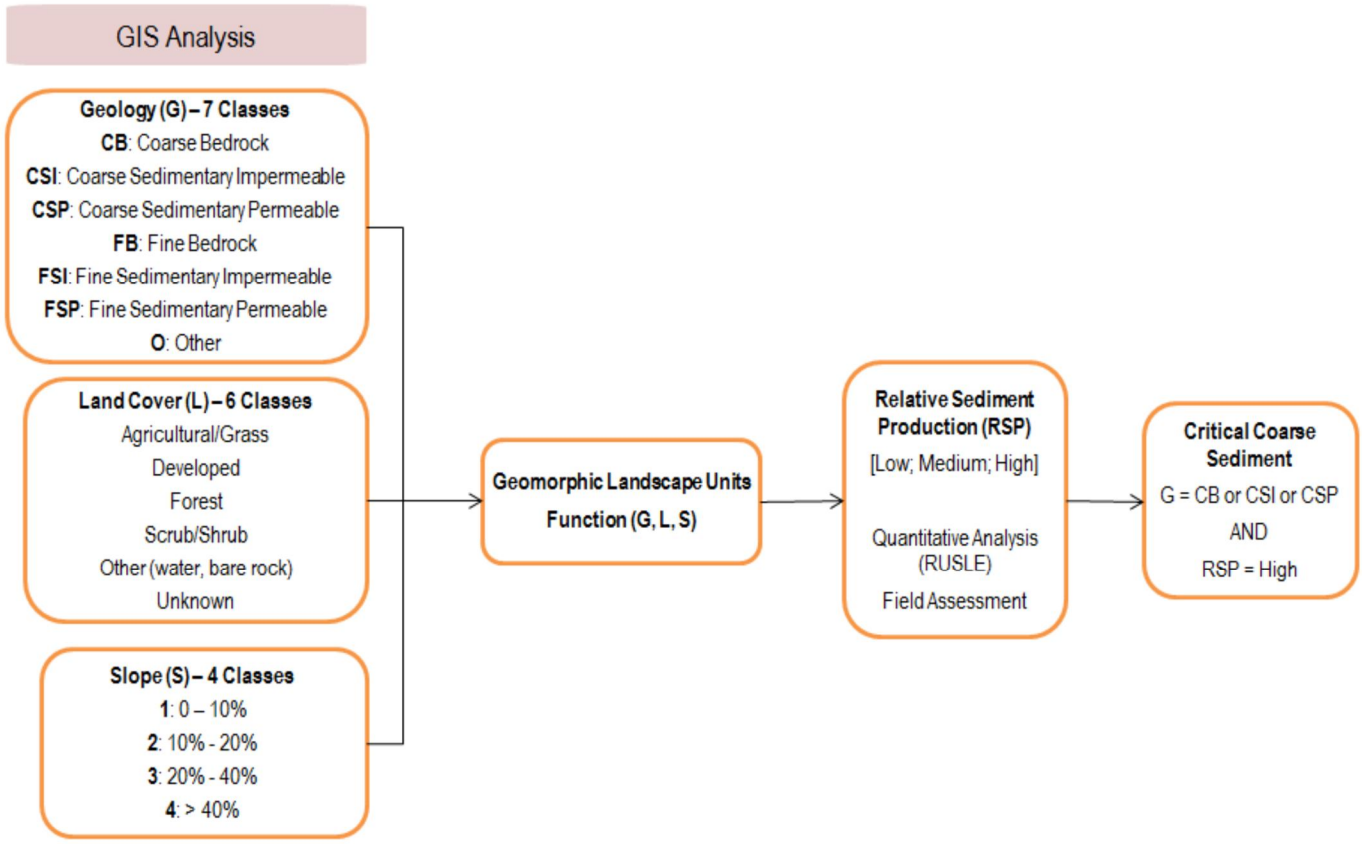

Figure 3. Potential Critical Coarse Sediment Yield Analysis

3.1 DATA TYPES AND ACQUISITION

GIS data were acquired from public-domain sources as indicated below.

- Geologic Units: http://www.conservation.ca.gov/cgs/information/geologic_mapping
- Land Cover/Vegetation: https://gis.countyofriverside.us/arcgis_public/rest/services/OpenData/NaturalFeaturesAndHazards/MapServer/4

- USGS National Elevation Data Set (NED) 1/3 arc-second DEM: https://catalog.data.gov/dataset/usgs-national-elevation-dataset-ned
- https://viewer.nationalmap.gov/basic/

3.1.1 GEOLOGIC UNITS

The geology layer was categorized based on rock types, the predominant sediment size generated upon erosion, and their associated erodibility. The attribution (and thus the naming) of the geology classes included the following categories:

- Coarse Bedrock (CB),
- Coarse Sedimentary Impermeable (CSI),
- Coarse Sedimentary Permeable (CSP),
- Fine Bedrock (FB),
- Fine Sedimentary Impermeable (FSI),
- Fine Sedimentary Permeable (FSP), and
- Other (O).

Of the 34 Geologic Units, 20 required a desktop evaluation by a Geotechnical Engineer to determine if the geologic units would weather to a coarse material such as silty sand or to a fine sandy clay. The desktop evaluation yielded results for all of the geologic units except two, Qsu and Qw. Given that these two units represented approximately 4 percent of the data, a site visit, including soil sample collection, was conducted to verify the grain size of the weathered material.

At the Qw site, the soils were classified as a yellowish brown Silty Sand with little (7 percent) gravels. The grain size of the sand varied between fine to coarse. It was determined that the sediment production from this geologic unit is considered medium to high due to its coarseness and looseness. In addition, this material is considered permeable with a hydrologic soil group rating of A.

At the Qsu site, the soils were classified as a yellowish brown Silty Sand with trace (2 percent) gravels. It was determined that the sediment production from this geologic unit is considered medium to high due to its coarseness and looseness. In addition, this material is considered permeable with a hydrologic soil group rating of A. The field and laboratory report documenting the confirmed results are provided in Appendix C. Table D.1 in Appendix D summarizes how each of the map units related to a geologic grouping.

3.1.2 LAND COVER

Land cover categories were defined using the ecology vegetation GIS map layers developed for Western Riverside County in the Santa Margarita region. The vegetation categories in the GIS layer were grouped to match the following categories used in the SD WMAA: Agriculture/Grass; Developed; Forest; Scrub/Shrub, Other (Water), and Unknown.

3.1.3 SLOPE CLASSES

The hillslope DEM was analyzed to produce a grid of slope values, which were subsequently classified into discrete categories. Based on the SD WMAA, the following category percentages were used to categorize hillslope gradients: 0 to 10 percent; 10 to 20 percent; 20 to 40 percent; and greater than 40 percent.

GLU RESULTS

The result of evaluating geology, land cover and slope equated to approximately 130 GLUs within SMR. These GLUs were then evaluated to determine their relative sediment production.

3.1.4 GEOLOGIC GROUPS

Per the SD WMAA, the geologic groups considered to have the potential to generate coarse sediment are: Coarse Bedrock (CB); Coarse Sedimentary Impermeable (CSI); and Coarse Sedimentary Permeable (CSP). An exhibit showing the regional geologic groupings is presented in Appendix E.

3.1.5 GLU AND SEDIMENT PRODUCTION

Relative sediment production was estimated for each GLU using the Revised Universal Soil Loss Equation (RUSLE) (see Eq. 2).

A = R x K x LS x C x P (Eq. 2), where

A = estimated average soil loss in tons/acre/year
R = rainfall-runoff erosivity factor
K = soil erodibility factor
LS = slope length and steepness factor
C = cover-management factor
P = support practice factor; assumed 1 for this analysis

Datasets used to estimate the average soil loss were acquired from public-domain sources as indicated below.

- RUSLE R Factor: ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_R_Factor/5
- RUSLE K Factor: State Water Resources Control Board: ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_K_Factor/
- RUSLE LS Factor: State Water Resources Control Board: ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_LS_Factor/
- RUSLE C Factor: US EPA, EMAP West Metric Browser: https://archive.epa.gov/esd/archive-nerl-esd1/web/html/wemap_download.html

GIS analysis was used to calculate the area weighted estimate of R, K, LS and C factors using the datasets listed above. For the developed land[6] cover the C factor was adjusted to 0 for the regional estimate to account for management actions implemented on developed sites (e.g., impervious surfaces). The estimated average annual soil loss ranged from 0 to 23 tons/acre/year.

To assess the amount of relative risk to stream channels resulting from watershed-scale changes in sediment yield and/or water delivery, the following opinions included in Technical Report 605 (Booth et al. 2010) were considered:

> *"The challenge in implementing this step is that presently we have insufficient basis to defensibly identify either low-risk or high-risk conditions using these metrics. For example, channels that are close to a threshold for geomorphic change may display significant morphological changes under nothing more than natural year-to-year variability in flow or sediment load.*
>
> *Acknowledging this caveat, we nonetheless anticipate that changes of less than 10 percent in either driver are unlikely to instigate, on their own, significant channel changes. This value is a conservative estimate of the year-to-year variability in either discharge or sediment flux that can be accommodated by a channel system in a state of dynamic equilibrium. It does not "guarantee," however, that channel change may not occur—either in response to yet modest alterations in water or sediment delivery, or because of other urbanization impacts (e.g., point discharge of runoff or the trapping of the upstream sediment flux; see Booth 1990) that are not represented with this analysis.*
>
> *In contrast, recognizing a condition of undisputed "high risk" must await broader collection of regionally relevant data. We note that >60 percent reductions in predicted sediment production have resulted in both minimal*

[5] R-Factor database provided by Geosyntec, January 2017.
[6] Developed (i.e., impervious) area data layer provided by WRCOG, January 2017.

(McGonigle) and dramatic (Agua Hedionda) channel changes, indicating that "more data" may never provide absolute guidance. At present, we suggest using predicted watershed changes of 50 percent or more in either runoff (as indexed by change in impervious area) or sediment production as provisional criteria for requiring a more detailed evaluation of both the drivers and the resisting factors for channel change, regardless of other screening-level assessments. Clearly, however, only more experience with the application of such "thresholds," and the actual channel conditions that accompany them, will provide a defensible basis for setting numeric standards."

Considering the thresholds indicated above, the relative sediment production rating for each GLU followed the criterion indicated below:

- Low: Soil Loss < 3.4 tons/acre/year (GLUs that have a soil loss of 0 to 3.39 tons/acre/year produce approximately 10 percent of the total potential coarse sediment soil loss from the SMR)
- Medium: 3.4 tons/acre/year < Soil Loss <9.6 tons/acre/year (GLUs that have a soil loss ranging from 3.40 to 9.55 tons/acre/year produce approximately 50 percent of the total potential coarse sediment soil loss from the SMR)
- High: >9.6 tons/acre/year (GLUs that have a soil loss greater than 9.57 tons/acre/year produce approximately 40 percent of the total potential coarse sediment soil loss from the SMR)

Results from the quantitative analysis along with GLUs that were rated as critical coarse sediment yield areas are summarized in tabular format in Appendix E.

The resulting GIS map showing the spatial distribution of the potential critical coarse sediment yield areas within the SMR is provided in Appendix G. Based on this analysis it was estimated that 28 percent of the of the SMR study area is a potential coarse sediment yield area and 9 percent of the SMR study area is a potential critical coarse sediment yield area. The majority of the potential critical coarse sediment yield areas were identified to be in the Scrub/Shrub land cover areas with hillslope gradients ranging from 20 to 40 percent.

As a result of the regional-scale datasets, and commensurate data resolution, used to map the potential critical coarse sediment yield areas, some areas may have been mapped that in reality do not produce critical coarse sediment as they are existing developed areas. As such, an opportunity for Copermittees to incorporate more refined data into the preliminary SMR WMAA GIS dataset based on local knowledge and review of current aerial images was provided. The City of Temecula, the City of Wildomar, the City of Murrietta, and RCFCWCD evaluated the data for their respective jurisdictional areas during the review process.

4 SITE ASSESSMENT

After developing the GIS that related the GLUs to a relative sediment production, WSP conducted a series of site visits within the SMR to compare GIS-based predictions with field-based observations. Forty-three sites were selected (see Figure F.1, Appendix F) for the assessment based on their accessibility and their distribution according to the following criteria:

- Geologic grouping
- Land cover
- Slope category

The following section includes a discussion of the protocol utilized for the site assessment and is based on the field assessment strategy described in the SD WMAA (Geosyntec Consultants and Rick Engineering Company, 2015).

4.1 PRE-FIELD ACTIVITIES

Prior to conducting field activities, the consultant team reviewed available published geologic information at each site location and prepared satellite imagery of each site using Google Earth. Pre-field activities consisted of evaluating site access at each location using aerial imagery and logistics were coordinated based on regional site locations to maximize field efficiency.

4.2 SITE RECONNAISSANCE

The WSP geology team performed site reconnaissance at forty-three locations on 9 and 10 May 2017. The reconnaissance consisted of:

- Visual soil classification,
- Assessing existing vegetative cover (0-100 percent),
- Qualitative assignment of existing sediment production (low, medium, and high) [based on existing vegetative cover],
- Qualitative assignment of potential sediment production (low, medium, and high) [assuming there is 0 percent vegetative cover], and
- Identifying existing erosional features.

Descriptions and visual classifications of the surficial materials were based on the Unified Soil Classification System (USCS). Underlying geologic units were confirmed where exposed formations were observed within the individual site limits.

4.3 SITE AND GEOLOGIC CONDITIONS

Site condition knowledge was developed from a review of available geologic literature, previous geologic and geotechnical investigations by the WSP team in the study region, professional experience and site reconnaissance.

4.3.1 SURFACE CONDITIONS

Site locations were selected in areas with open space with the exception of sites 1, 21, 22, 30 and 31 which were situated within developed areas with paved streets and sidewalks. The surface conditions at the site locations were typically characterized by relatively flat terrain (< 5 percent) with a few instances where slope gradients ranged from 10 to 40 percent. At the time of the site visit the natural hillsides along the areas of interest were covered by varying degrees of moderate to dense growth scrub brush, low grasses, and scattered trees. The only observed erosional feature included potential erosional gullies at Site 64 within the access road to the site where no ground cover existed. No geomorphic features were observed

and the only sources of ground disturbance were noted as active construction at Sites 54 and 55 and active construction 100-200 feet south and east of Site 59. An evaluation of the existing and potential sediment production for each site was determined based on surface conditions. Sediment production was assigned as “high, medium, or low” based on the existing conditions and the geology team’s professional experience.

4.3.2 SURFICIAL DEPOSITS

Surficial deposits observed included alluvium, colluvium, and debris (e.g., silt, sand, silty sand and fine gravel). The composition and grain size of these materials were variable (fine to medium grained; fine to coarse grained) depending on the age, parent sources, and mode of deposition. Granite boulders were also observed in portions of the study area.

4.3.3 GEOLOGIC CONDITIONS

Knowledge of the subsurface conditions at the site locations was based on a review of available published geologic information, professional experience, site reconnaissance, previous explorations and geotechnical investigations performed by the team in the study region.

4.4 RESULTS

The results of the site assessment along with photographic documentation are provided in Appendix F. Overall, there were 133 GLU’s associated with the SMR and the field team was tasked with evaluating GLUs at 43 sites. The 43 sites represented 25 unique GLUs which equated to verifying approximately 20 percent of the entire GLU dataset. Of the 129 GIS-based predictions (e.g., 43 GLUs with 3 characteristics per GLU), 116 GIS-based predictions (or 90 percent) matched the field-based observations for land cover, geologic grouping and slope category. Of the 13 GIS-based predictions that resulted in mismatches, 2 of the sites (Sites 54 and 55) were within active construction areas, making verification of the GLU impossible. Nine of the mismatches were attributed to the assignment of the geologic grouping. Specifically, 8 sites were classified as a Granitic (gr) geologic unit, whereas in the field, the geologists determined that the geologic units represented Alluvial deposits or fill. There were a few instances, (Sites 49, 53 and 58), where large granitic boulders were adjacent to the site and the field team indicated that this may have been the reason why the site was classified as granitic. For the final mismatch at Site 51, the geologic unit was classified as Granitic and the field team classified the geologic unit as Qvoa or fill. It should be noted that the Qvoa geologic unit weathers as a coarse grain which is similar to the granitic geologic unit that also weathers to a coarse grain (see Table D.1 in Appendix D). In general, these mismatches may be attributed to a function of the public domain data used which does not reflect changes to particular areas that have occurred since the underlying data was developed. The relatively high agreement (90 percent) between the GIS-based predictions and the field-based observations may be attributed to scrutinizing the land cover data by comparing some of the land cover areas with aerial images and having to concentrate the locations to ensure ease of access. Therefore, the GLU assignments were considered valid for estimating relative sediment production.

5 POTENTIAL SEDIMENT SOURCE AREA

5.1 SAN DIEGO RWQCB COMMENTS

A comparison between the potential critical coarse sediment yield areas within the Upper SMR and within the San Diego County portion of the Santa Margarita watershed management area was conducted as a response to San Diego Regional Water Quality Control Board (San Diego RWQCB) comments. Differences in potential critical coarse sediment yield areas along the county line were noted in the eastern portion of the watershed along with a lack of potential critical coarse sediment areas within the northeastern portion of the watershed management area.

To verify these differences, the San Diego RWQCB requested an evaluation of United States Geological Survey mineral resource maps online (USGS 2018). Along the border, it was noted that sand and gravel deposits were absent within a 2-mile radius north and south of the border. Sand and gravel deposits, however, were noted in areas generally downstream of CB, CSI, and CSP geologic units. These deposits were therefore considered as an area that may be a potential sediment source area and it was decided that further evaluation was warranted.

The identification of potential sediment source areas was determined using the following process:

- Overlay sand/gravel deposits onto Geology Grouping GIS layer
- Using USGS quad maps, identify the tributary drainage area for each deposit located in a CB, CSI or CSP area
- Exclude the following areas:
  - Agricultural Land
  - Developed Land
  - Non Permittee Area
    - Camp Pendleton
  - Protected Lands

The resulting GIS map showing the spatial distribution of the potential critical coarse sediment yield areas along with potential sediment source areas within the SMR is provided in Appendix H.

6 CONCLUSIONS

6.1 UPPER SANTA MARGARITA RIVER WMAA

The SMR WMAA will be developed by integrating the mapping results of the HRU and coarse sediment analyses provided in this report with the mapping results of existing streams, future land uses and physical structures developed by RCFCWCD. Under the conditions of the NPDES MS4 Permit, the Copermittees may use the integrated analyses and information provided in the SMR WMAA to support exemptions from the on-site hydromodification BMP requirements. Moreover, the Copermittees may also use the results of the SMR WMAA to identify and compile a list of candidate projects that Priority Development Projects may use as an alternative compliance option. (RCFCWCD 2017). Opportunities being considered as candidate projects are provided in the Santa Margarita Watershed Management Area Analysis dated June 2018.

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APPENDIX

A HYDROLOGIC RESPONSE UNIT TABLES

Table A.1. Land Cover Grouping

ID	Vegetation Category	Land Cover Grouping
1	Annual Grassland	Agricultural/Grass
2	Cropland, Orchard - Vineyard	Agricultural/Grass
3	Urban	Developed
4	Barren	Forest
5	Coastal Oak Woodland	Forest
6	Eucalyptus	Forest
7	Jeffrey Pine	Forest
8	Mixed Chaparral	Forest
9	Montane Hardwood	Forest
10	Montane Hardwood - Conifer	Forest
11	Montane Hardwood, Montane Hardwood - Conifer	Forest
12	Montane Riparian, Valley Foothill Riparian	Forest
13	Pinyon - Juniper	Forest
14	Sierran Mixed Conifer	Forest
15	Valley Foothill Riparian	Forest
16	White Fir, Sierran Mixed Conifer	Forest
17	Desert Riparian, Desert Wash	Other
18	Fresh Emergent Wetland	Other
19	Lacustrine	Other
20	Riverine, Lacustrine	Other
21	Wet Meadow	Other
22	Lacustrine	Other
23	Alkali Desert Scrub	Scrub/Shrub
24	Chamise-Red Shank Chaparral	Scrub/Shrub
25	Coastal Scrub	Scrub/Shrub
26	Mixed Chaparral	Scrub/Shrub
27	Sagebrush	Scrub/Shrub

Three scenerios led to an overide or modification of the Land Cover value

1. Impervious layer union resulted in a Developed value
2. Aerial shows urban development for a given area
3. Road ROW union resulted in a Developed value

Table A.2. Land Use Categories

	A			B			C			D		
Land Use	0–2%	2–6%	6%+	0–2%	2–6%	6%+	0–2%	2–6%	6%+	0–2%	2–6%	6%+
Cultivated land	0.08[a]	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
	0.14[b]	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Pasture	0.12	0.20	0.30	0.18	0.28	0.37	0.24	0.34	0.44	0.30	0.40	0.50
	0.15	0.25	0.37	0.23	0.34	0.45	0.30	0.42	0.52	0.37	0.50	0.62
Meadow	0.10	0.16	0.25	0.14	0.22	0.30	0.20	0.28	0.36	0.24	0.30	0.40
	0.14	0.22	0.30	0.20	0.28	0.37	0.26	0.35	0.44	0.30	0.40	0.50
Forest	0.05	0.08	0.11	0.08	0.11	0.14	0.10	0.13	0.16	0.12	0.16	0.20
	0.08	0.11	0.14	0.10	0.14	0.18	0.12	0.16	0.20	0.15	0.20	0.25
Residential lot	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
size 1/8 acre	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Residential lot	0.22	0.26	0.29	0.24	0.29	0.33	0.27	0.31	0.36	0.30	0.34	0.40
size 1/4 acre	0.30	0.34	0.37	0.33	0.37	0.42	0.36	0.40	0.47	0.38	0.42	0.52
Residential lot	0.19	0.23	0.26	0.22	0.26	0.30	0.25	0.29	0.34	0.28	0.32	0.39
size 1/3 acre	0.28	0.32	0.35	0.30	0.35	0.39	0.33	0.38	0.45	0.36	0.40	0.50
Residential lot	0.16	0.20	0.24	0.19	0.23	0.28	0.22	0.27	0.32	0.26	0.30	0.37
size 1/2 acre	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.48
Residential lot	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.29	0.35
size 1 acre	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Industrial	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.89	0.90
Streets	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78
	0.76	0.77	0.79	0.80	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Open space	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.15	0.21	0.28
	0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Parking	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97

[a] Runoff coefficients for storm recurrence intervals less than 25 years.

[b] Runoff coefficients for storm recurrence intervals of 25 years or longer.

Source: Table 7-9 in *Hydrologic Analysis and Design* (McCuen, 2004)

Table A.3. Land Cover and Land Use

Land Cover Categories	Land Use per Table A.2
Agriculture/Grass	Meadow
Forest	Forest
Scrub/Shrub	Average (Meadow,Forest)
Unknown/Other	Meadow

Table A.4. Hydrologic Response Unit Calculations

Land Cover	HSG	Gradient	Runoff Coefficient	ET Coefficient	Infiltration Coefficient	Runoff/ Infiltration Ratio	Hydrologic Process Designation
Agriculture/Grass	A	0-2%	0.1	0.6	0.3	0.33	I
Agriculture/Grass	A	2-6%	0.16	0.6	0.24	0.67	U
Agriculture/Grass	A	6-10%	0.25	0.6	0.15	1.67	O
Agriculture/Grass	B	0-2%	0.14	0.6	0.26	0.54	I
Agriculture/Grass	B	2-6%	0.22	0.6	0.18	1.22	U
Agriculture/Grass	B	6-10%	0.3	0.6	0.1	3	O
Agriculture/Grass	C	0-2%	0.2	0.6	0.2	1	U
Agriculture/Grass	C	2-6%	0.28	0.6	0.12	2.33	O
Agriculture/Grass	C	6-10%	0.36	0.6	0.04	9	O
Agriculture/Grass	D	0-2%	0.24	0.6	0.16	1.5	U
Agriculture/Grass	D	2-6%	0.3	0.6	0.1	3	O
Agriculture/Grass	D	6-10%	0.4	0.6	0	infinite	O
Forest	A	0-2%	0.05	0.8	0.15	0.33	I
Forest	A	2-6%	0.08	0.8	0.12	0.67	U
Forest	A	6-10%	0.11	0.8	0.09	1.22	U
Forest	B	0-2%	0.08	0.8	0.12	0.67	U
Forest	B	2-6%	0.11	0.8	0.09	1.22	U
Forest	B	6-10%	0.14	0.8	0.06	2.33	O
Forest	C	0-2%	0.1	0.8	0.1	1	U
Forest	C	2-6%	0.13	0.8	0.07	1.86	O
Forest	C	6-10%	0.16	0.8	0.04	4	O
Forest	D	0-2%	0.12	0.8	0.08	1.5	U
Forest	D	2-6%	0.16	0.8	0.04	4	O
Forest	D	6-10%	0.2	0.8	0	infinite	O
Scrub/Shrub	A	0-2%	0.08	0.7	0.23	0.33	I
Scrub/Shrub	A	2-6%	0.12	0.7	0.18	0.67	U
Scrub/Shrub	A	6-10%	0.18	0.7	0.12	1.5	U
Scrub/Shrub	B	0-2%	0.11	0.7	0.19	0.58	I
Scrub/Shrub	B	2-6%	0.17	0.7	0.14	1.22	U
Scrub/Shrub	B	6-10%	0.22	0.7	0.08	2.75	O
Scrub/Shrub	C	0-2%	0.15	0.7	0.15	1	U
Scrub/Shrub	C	2-6%	0.21	0.7	0.1	2.16	O
Scrub/Shrub	C	6-10%	0.26	0.7	0.04	6.5	O
Scrub/Shrub	D	0-2%	0.19	0.7	0.12	1.5	U
Scrub/Shrub	D	2-6%	0.23	0.7	0.07	3.29	O
Scrub/Shrub	D	6-10%	0.3	0.7	0	infinite	O

Hydrologic process designation: I = Interflow; O = Overland Flow; U = Uncertain

Table A.5. Hydrologic Response Unit Designations

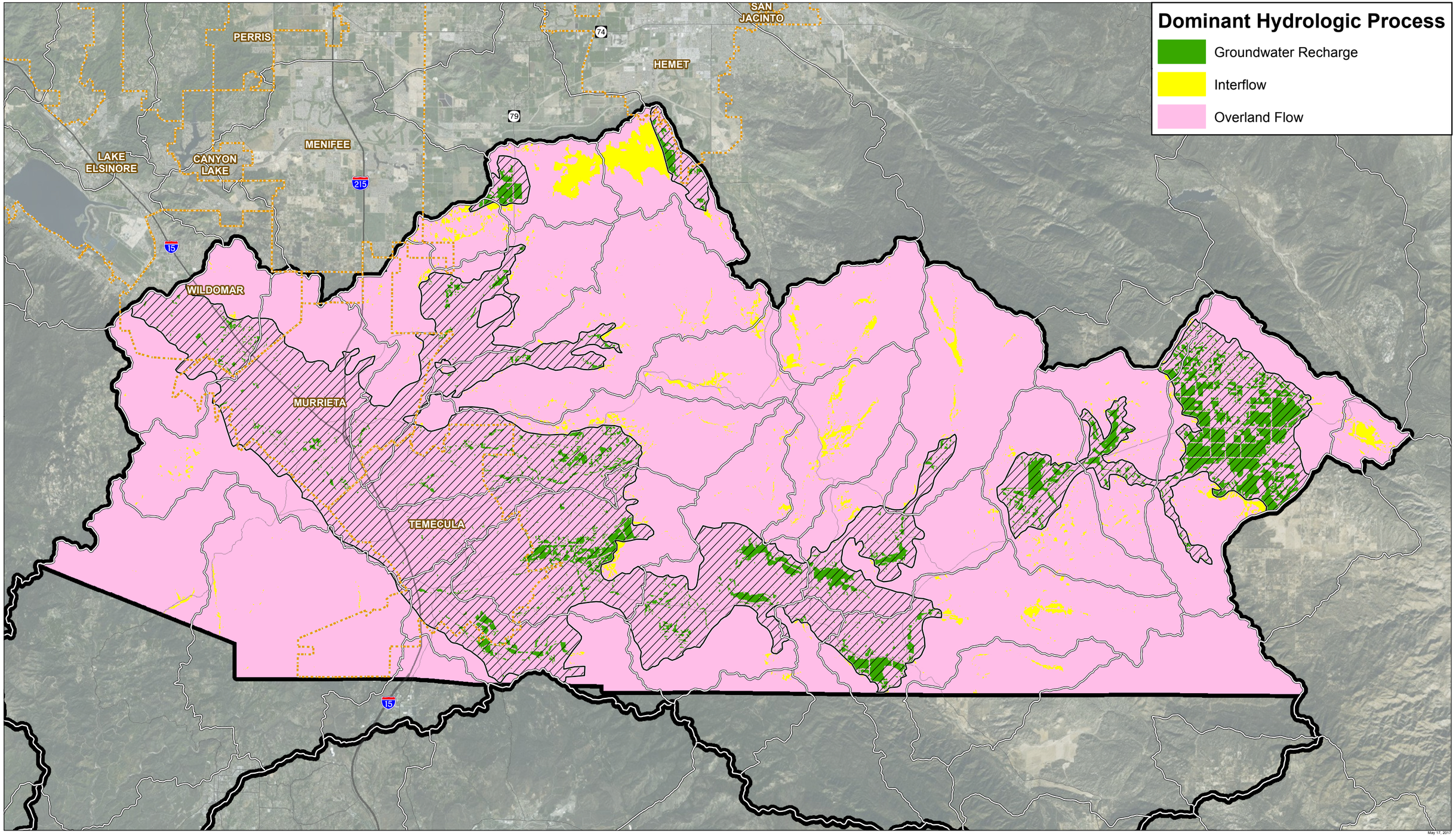
Land Cover	Slope	Soil Type				
		A	B	C	D	Other
Agricultural/Grass/ Unknown/Other	0-2%	I	I	U	U	U
	2-6%	U	U	O	O	U
	6-10%	O	O	O	O	O
	>10%	O	O	O	O	O
Developed	0-2%	O	O	O	O	O
	2-6%	O	O	O	O	O
	6-10%	O	O	O	O	O
	>10%	O	O	O	O	O
Forest	0-2%	I	U	U	U	U
	2-6%	U	U	O	O	U
	6-10%	U	O	O	O	U
	>10%	O	O	O	O	O
Scrub/Shrub	0-2%	I	I	U	U	U
	2-6%	U	U	O	O	U
	6-10%	U	O	O	O	U
	>10%	O	O	O	O	O

Hydrologic Process Designation: I = Interflow; O = Overland Flow; U = Uncertain

APPENDIX

B HYDROLOGIC RESPONSE UNIT SPATIAL DISTRIBUTION EXHIBIT

UPPER SANTA MARGARITA WATERSHED MANAGEMENT AREA ANALYSIS
DOMINANT HYDROLOGIC PROCESS



May 17, 2017

N

0 1 2
Miles

Legend

Cities | Hydrologic Basin Units | Groundwater Basins

WRCOG

RIVERSIDE COUNTY

wsp

APPENDIX

C EVALUATION OF Qw AND Qsu GEOLOGIC UNITS

Memorandum

Project #: 12853

Date: March 17, 2017

To: Veronica Seyde

From: S. V. (Jag) Jagannath, PhD, PE, GE and Ian Lau, PE

Subject: WSP I PB Site Visit Observation for SMR WMAA

Previously, we had provided geologic / geotechnical desktop study of about 20 Geologic Units within the Santa Margarita River Watershed study area with respect to nature of anticipated grain size of weathered material from these geologic units and to aid the GIS team in determination of Hydrologic Units. Based on that study, you had identified following two Geologic Units that required further evaluation.

- Qw - Wash deposits (late Holocene)-Unconsolidated boulders to sandy alluvium of active and recently active washes
- Qsu - Undifferentiated Surficial Deposits; includes colluvium, slope wash, talus deposits, and other surface deposits of all ages; mostly consolidated

Purpose of this memo is to summarize the findings of the field reconnaissance / observation conducted on March 8, 2017 for these Geologic Units, collection of soil samples and soil classification based on laboratory testing. Site maps showing the sample locations, field notes, photographs during site visit and laboratory test results of representative samples are provided in the attachments.

Field Observation:

On March 8, 2017, WSP I PB engineers conducted field observation to evaluate the above two geologic units (Qw and Qsu). The two locations were determined using aerial imagery, site access and available geologic maps. Two bulk bags of near-surface representative soil samples (one each from these Geologic Units) were collected for initial visual classification in the field and laboratory testing for grain size distribution.

Sample S-1 is selected to evaluate geologic unit Qw. The site is located west of the intersection of De Portola Road and Belle Chaine Loop (approximate latitude / longitude: N33º29'50.3", W117º2'1.5"). General topography of the site is relatively flat and is located within a developed ranch and agricultural farmland area. Minimal existing vegetation (<5%) is observed adjacent to the sampling location, although scattered trees and scrubs can be seen within several privately owned parcels nearby.

Based on the visual and laboratory test result, the soil is classified as yellowish brown Silty Sand with little (7%) gravels. Grain size of sand varies between fine to coarse. It is determined that the sediment production from this geologic unit when without ground cover is considered medium to high due to its grain coarseness and looseness. In addition, this material is considered as permeable with a Hydrologic Unit A.

Sample S-2 is selected to evaluate geologic unit Qsu. The site is generally located in the walking trails, generally southwest of the paved Butterfield Stage Road (dirt path towards Morgan Hill Trail) (approximate latitude / longitude: N33°28'11.5", W117°3'40.9"). The site is near the bottom of foothill and general topography of the site varies from relatively flat to fairly-sloped (20-30%). Majority of the area is currently covered with low lying vegetation (except the dirt covered walkways connecting to the southeasterly trails). A concrete V-ditch separated the trail area from the existing track homes development to the west of the sample location..

Based on the visual and laboratory test result, the soil is classified as yellowish brown Silty Sand (consist of mostly fine to medium sand) with trace (2%) gravels. It is determined that the sediment production from this geologic unit when without ground cover is considered medium to high due to its grain coarseness and looseness. In addition, this material is considered as permeable with a Hydrologic Unit A.

Distribution: n/a

Attachments

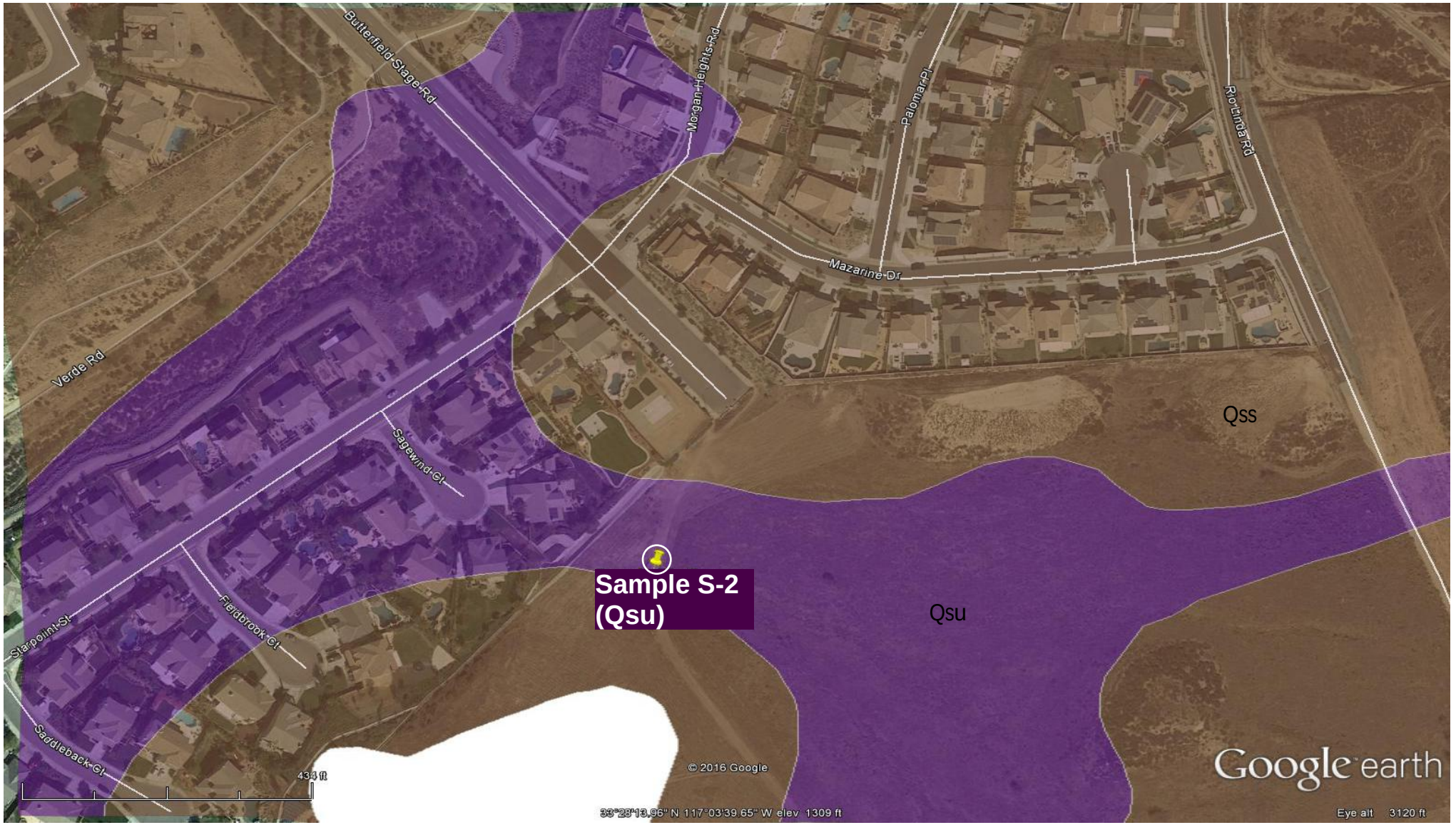
1. Site Maps
2. Field Notes
3. Photos
4. Laboratory Test Results

This document contains draft information/materials which is considered confidential and for deliberative purposes only and not for public consumption or dissemination.

Attachment 1a - Site Maps (Sample S-1)



Attachment 1b - Site Maps (Sample S-2)



Attachment 2 - Field Notes

Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 3/8/2017

Field Team: IAN LOU & JAG

Location ID: S-1 (DE PORTOLA RD & BELLE CHAINE LOOP)

GLU Classification: SEE SITE MAP

Photo ID: IMG_4864 (FACE NW)

GPS (Lat/Long): 33°2'50.3", -117°2'1.5"

Geologic Unit: QW

Surficial Material Type: YELLOWISH BROWN SILTY SAND; LITTLE GRAVELS; SCATTERED COBBLES (<4"); WELL-GRADED (F to C) SAND; SOME LOW PLASTIC to NON-PLASTIC FINES; DRY to SLIGHTLY MOIST.

Existing Vegetative Cover Estimate (Percent): <5%

Existing Sediment Risk (High, Med, Low): MED to HIGH

Potential Sediment Risk (High, Med, Low): MED to HIGH

100% Vegetative Cover Sediment Risk (High, Med, Low): LOW to MED

Notes: RELATIVELY LEVEL GROUND. DEVELOPED RANCH, FARMLAND AREA.

Attachment 2 - Field Notes (cont.)

Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 3/8/2017

Field Team: IAN LAU & JAG

Location ID: S-2 (BUTTERFIELD STAGE RD. OFF ROAD TOWARDS MORGAN HILL TRAIL)

GLU Classification: SEE SITE MAP

Photo ID: IMG_4861 (FACE E). IMG 4866 (FACE SE).

GPS (Lat/Long): 33°26'11.5, -117°3'40.9"

Geologic Unit: Qsu

Surficial Material Type: MED YELLOWISH BROWN SILTY SAND; TRACE GRAVEL; FINE to COARSE SAND; SOME LOW PLASTIC to NON-PLASTIC FINES; DRY to SL. MOIST.

Existing Vegetative Cover Estimate (Percent): 5% ALONG WALK PATH. 100% OUTSIDE OF TRAIL (GRASS)

Existing Sediment Risk (High, Med, Low): MED to HIGH

Potential Sediment Risk (High, Med, Low): MED to HIGH

100% Vegetative Cover Sediment Risk (High, Med, Low): LOW to MED

Notes: RELATIVE FLAT AREA. LOCATED BEHIND RESIDUAL AREA (END OF BUTTERFIELD STAGE RD, OFF ROAD DIRT PATH TOWARDS MORGAN HILL TRAILS).

Attachment 3a - Photos During Site Visit (Sample Location S-1 Face NW)



Attachment 3b - Photos During Site Visit (Sample Location S-2 Face SE)



Attachment 3c - Photos During Site Visit (Sample Location S-2 Face E)



Attachment 3d - Photos During Site Visit (Sample Location S-2 Face SW)

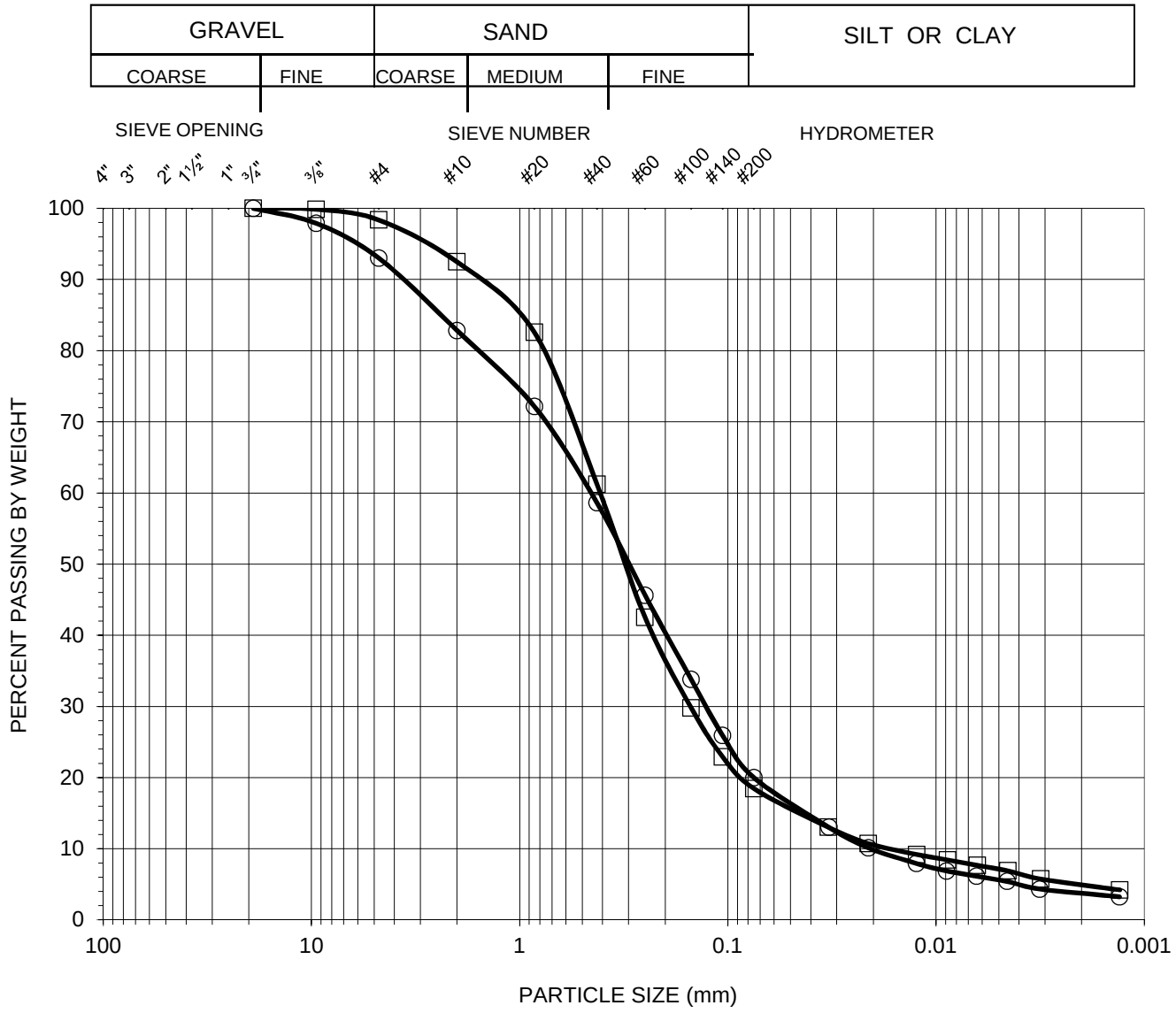


Attachment 4 - Laboratory Result

AP Engineering and Testing, Inc.
DBE|MBE|SBE
2607 Pomona Boulevard | Pomona, CA 91768
t. 909.869.6316 | f. 909.869.6318 | www.aplaboratory.com

GRAIN SIZE DISTRIBUTION CURVE
ASTM D 422

Client Name:	Parsons Brinckerhoff	Tested by:	NG	Date:	03/16/17
Project Name:	SMR WMAA	Computed by:	JP	Date:	03/16/17
Project Number:	12853	Checked by:	AP	Date:	03/16/17



Symbol	Boring No.	Sample No.	Sample Depth (feet)	Percent			Atterberg Limits LL:PL:PI	Soil Type U.S.C.S
				Gravel	Sand	Silt & Clay		
○	-	S-1	0	7	73	20	N/A	SM
□	-	S-2	0	2	80	18	N/A	SM

APPENDIX

D MAP UNITS AND GEOLOGY GROUPING

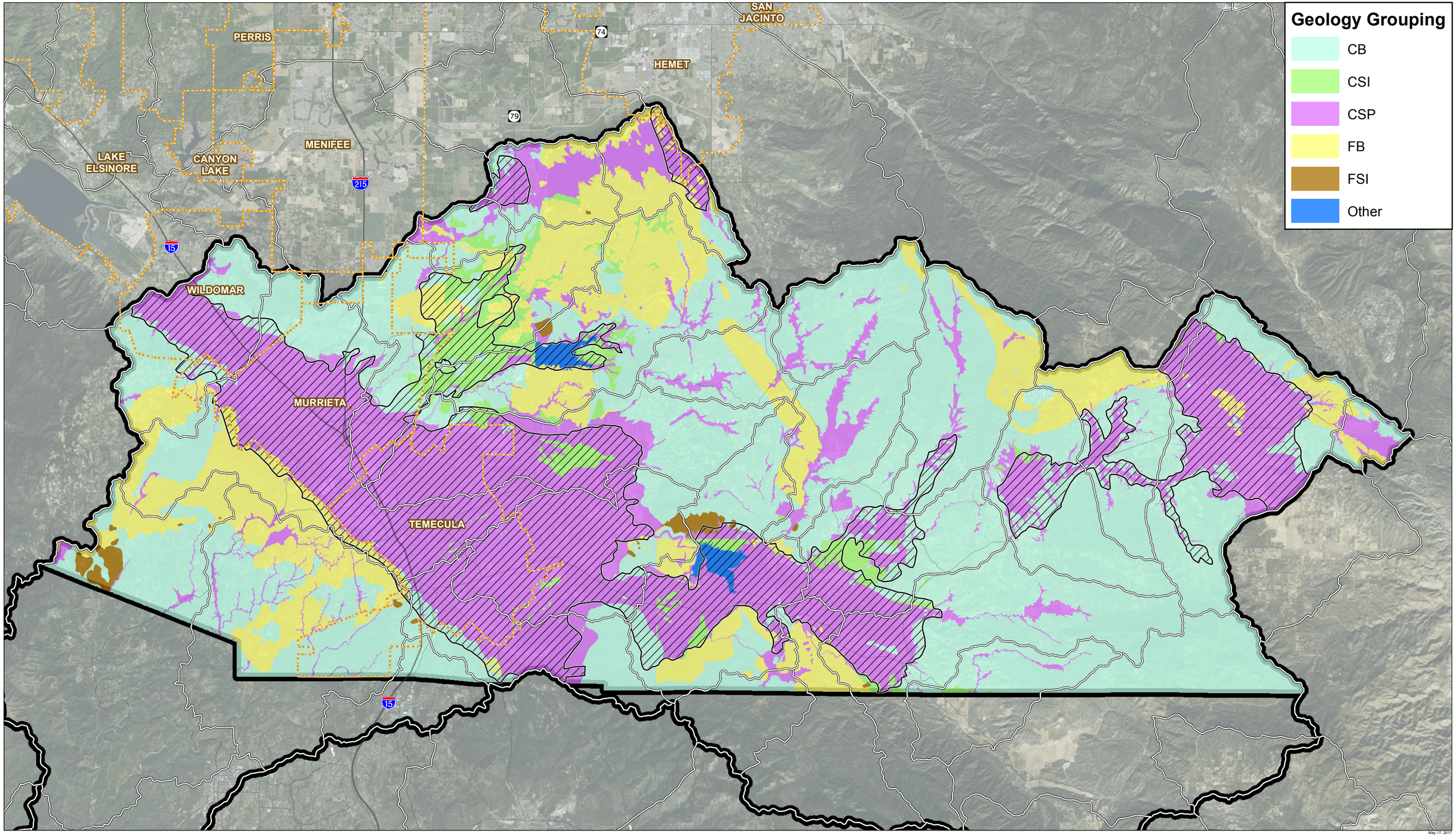
Table D.1 Geologic Grouping for Different Map Units

Map Unit	Map Name	Anticipated Grain Size of Weathered Material	Bedrock or Sedimentary	Impermeable/Permeable	Geology Grouping
gr	santa_ana_30x60_reference.pdf	Coarse	Bedrock	Impermeable	CB
gr-m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
grMz	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Kgd	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kt	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ktc	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ktc-w	San Diego & Oceanside 30' x 60	Coarse	Bedrock	Impermeable	CB
af	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Impermeable	CSI
Qvoa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvof	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tt	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qa+ Qya	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qds	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qf	palm_springs_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Qoa	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qof	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Qp	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qss	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Qsu	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Qw	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Qya	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qya+ Qoa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qyf	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Tss	santa_ana_30x60_reference.pdf	Coarse	Sedimentary	Permeable	CSP
Ttl	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Ttu	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
JTrm	San Diego & Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kat	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgb	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
pKm	palm_springs_30x60_reference.pdf	Fine	Bedrock	Impermeable	FB
Qls	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
sp	santa_ana_30x60_reference.pdf	Fine	Bedrock	Impermeable	FB
Tv	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
water	San Diego & Oceanside 30' x 60'	Water	Water	Impermeable	Other

APPENDIX

E REGIONAL GEOLOGIC GROUPING

UPPER SANTA MARGARITA WATERSHED MANAGEMENT AREA ANALYSIS
GEOLOGY GROUPING



May 17, 2017

0 1 2 Miles

Legend

Cities | Hydrologic Basin Units | Groundwater Basins

WRCOG

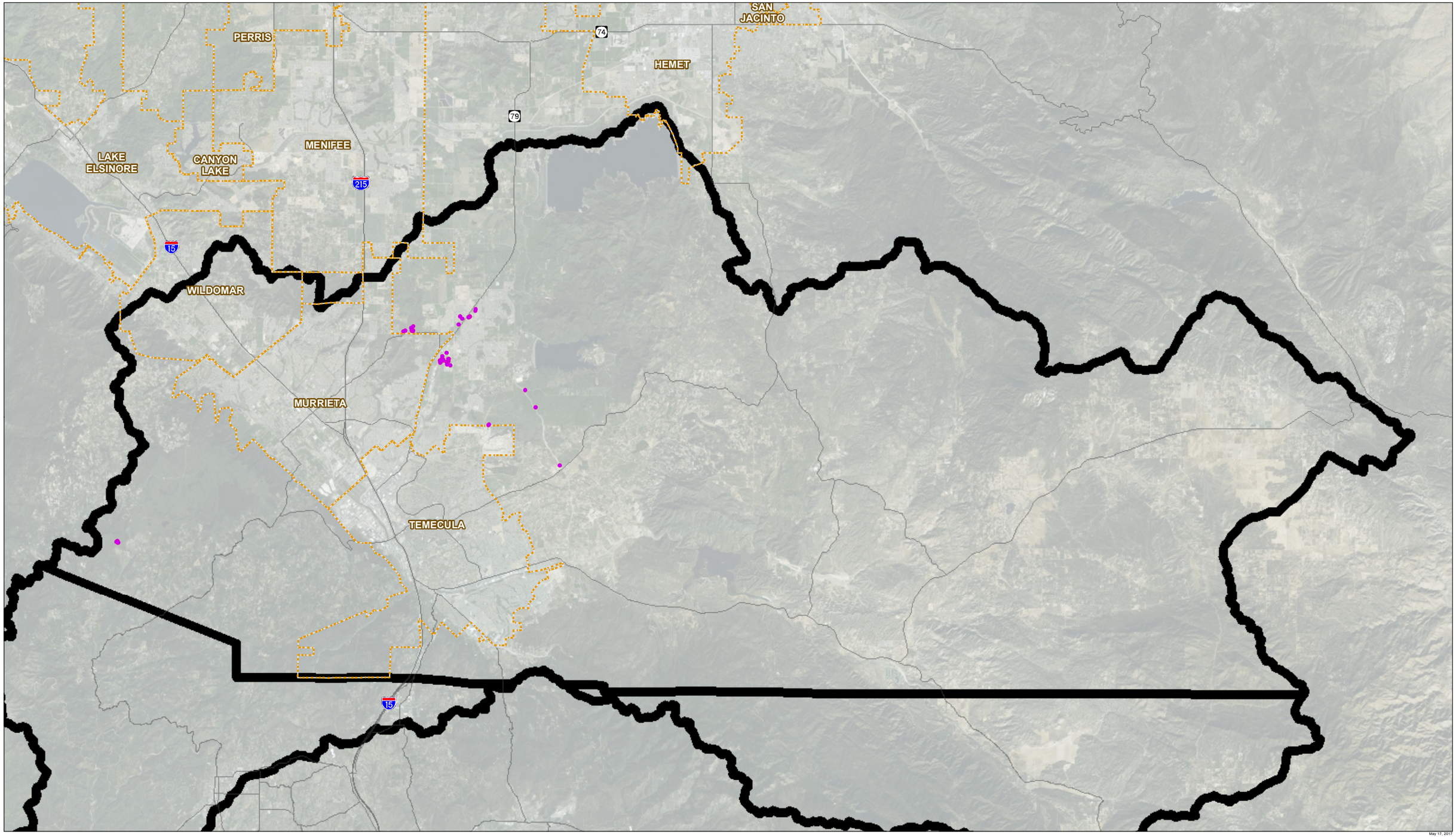
RIVERSIDE COUNTY

wsp

APPENDIX

F SITE ASSESSMENT

UPPER SANTA MARGARITA WATERSHED MANAGEMENT AREA ANALYSIS
GLU - Site Visit Locations



May 17, 2017

0 1 2 Miles

Legend

Cities

Site Visit GLU

Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 1

GLU Classification: FSI-DEVELOPED-1

Photo ID: 1 looking SE; 2 looking SE

GPS (Lat/Long):

33.49632207 -117.3111578

Geologic Unit: QIs

Surficial Material Type: Asphalt covered cul-de-sac bounded with dark brown silty SAND colluvium, covered with cobbles/boulders and shallow vegetation.

Existing Vegetative Cover Estimate (Percent): 20%

Existing Sediment Risk (High, Med, Low): Low to Med

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 2

GLU Classification: FSI-FOREST-3

Photo ID: 1 looking NE; 2 looking SE

GPS (Lat/Long):

33.49680079 -117.3105827

Geologic Unit: gr

Surficial Material Type: Granitic boulders covered with old tree branches and brushes

Existing Vegetative Cover Estimate (Percent): 75-80%

Existing Sediment Risk (High, Med, Low): Med (steepness)

Potential Sediment Risk (High, Med, Low): Low to Med

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 3

GLU Classification: CB-SCRUB/SHRUB-3

Photo ID: 1 looking NE; 2 looking NW

GPS (Lat/Long):

33.49618209 -117.3100543

Geologic Unit: gr

Surficial Material Type: Light yellowish brown colluvium / Qls debris with granite boulders 4 to 5 feet in size. Flat area with little vegetation cover.

Existing Vegetative Cover Estimate (Percent): <10%

Existing Sediment Risk (High, Med, Low): Med

Potential Sediment Risk (High, Med, Low): Med to High

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 4

GLU Classification: FSI-Scrub/Shrub-3

Photo ID: 1 looking NE; 2 looking NW

GPS (Lat/Long):

33.49616612 -117.3104793

Geologic Unit: Qls

Surficial Material Type: Light yellowish brown colluvium / Qls debris with granite boulders 4 to 5 feet in size. Flat area with little vegetation cover.

Existing Vegetative Cover Estimate (Percent): <10%

Existing Sediment Risk (High, Med, Low): Med

Potential Sediment Risk (High, Med, Low): Med to High

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 18

GLU Classification: CSI-OTHER-1

Photo ID: 1 looking S; 2 looking SW

GPS (Lat/Long):

33.58540235 -117.1255313

Geologic Unit: Qvoa Alluvium, possible shallow granite

Surficial Material Type: large boulders 20 feet south. Large group of trees south west. Brown silty SAND, fine to medium grained, covered by grass.

Existing Vegetative Cover Estimate (Percent): 10 to 15%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 19

GLU Classification: CB-OTHER-1

Photo ID: 1 looking SW; 2 looking N

GPS (Lat/Long):

33.58507168 -117.1264493

Geologic Unit: Alluvium

Surficial Material Type: large boulders/granite 200 feet West. Actual site on brown silty SAND, very moist, fine to medium grained, covered by shallow brushes (some dry, some green). Depression 20 feet North, possible creek. Slope 1% South to North

Existing Vegetative Cover Estimate (Percent): 10%. 25% in creek

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: Large Trees 100 feet NorthWest





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 20

GLU Classification: CSI-OTHER-WATER-1

Photo ID:

GPS (Lat/Long):

33.58430838 -117.122567

Geologic Unit: Qvoa (filled with at least 5 feet of water)

Surficial Material Type: Water filled area with lots of vegetation growth. Banks are well covered with brown vegetation and trees

Existing Vegetative Cover Estimate (Percent): None but with water

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:



Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 21

GLU Classification: CSI-DEVELOPED-1

Photo ID: 1 looking SW

GPS (Lat/Long):

33.58307841 -117.1221918

Geologic Unit: Asphalt

Surficial Material Type: Pavement. Parking Lot

Existing Vegetative Cover Estimate (Percent): None

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:



Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 22

GLU Classification: CB-DEVELOPED-1

Photo ID: 1 looking SW

GPS (Lat/Long):

33.58279133 -117.1203132

Geologic Unit: Qvoa (Asphalt / Parking Lot)

Surficial Material Type: Pavement

Existing Vegetative Cover Estimate (Percent): None

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:



Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 23

GLU Classification: CB-FOREST-1

Photo ID: 1 looking NE; 2 looking E

GPS (Lat/Long):

33.599266 -117.1418295

Geologic Unit: Alluvium or fill

Surficial Material Type: light brown silty SAND, moist, fine to coarse grained. Lots of brushes, trees and branches. Located in divet/depression

Existing Vegetative Cover Estimate (Percent): 50%

Existing Sediment Risk (High, Med, Low): Med to High

Potential Sediment Risk (High, Med, Low): High

100% Vegetative Cover Sediment Risk (High, Med, Low): Med to High

Notes: Line of trees on a dried up creek





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 24

GLU Classification: CSP-FOREST-1

Photo ID: 1 looking NW

GPS (Lat/Long):

33.5992614 -117.1420466

Geologic Unit: qyf

Surficial Material Type: light bron silty SAND, fine to medium grained, covered with shallow brushes and tree branches. Boulders in the south west direction. 1-2% slope west to east. 2% slope south to north

Existing Vegetative Cover Estimate (Percent): 20-30%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low-Med

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: Line of trees 40 feet East; located in divet/depression



Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 25

GLU Classification: CSP-SCRUB/SHRUB-1

Photo ID: 1 looking SE

GPS (Lat/Long):

33.59916853 -117.1422226

Geologic Unit: Qyf

Surficial Material Type: light brown silty SAND, fine to medium grained, covered with shallow brushes and tree branches. Boulders in the south east direction. 1-2% slope west to east, 2% slope south to north.

Existing Vegetative Cover Estimate (Percent): 5%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low-Med

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:



Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 26

GLU Classification: CSP-AGRICULTURAL/GRASS-1

Photo ID: 1 looking NE, 2 looking NW

GPS (Lat/Long):

33.59935027 -117.1422154

Geologic Unit: qyf

Surficial Material Type: light brown Silty SAND with gravel, fine to medium grained, covered with shallow brushes, creed 150 feet east. Construction site 250 feet north. 1-2% slope west to east.

Existing Vegetative Cover Estimate (Percent): 5-10%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low-Med

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 27

GLU Classification: CB-AGRICULTURAL/GRASS-1

Photo ID: 1 looking West, 2 looking S

GPS (Lat/Long):

33.5992189 -117.1426501

Geologic Unit: Alluvium and/or fill

Surficial Material Type: light brown silty SAND with some gravel, fine to medium grained, covered with shallow brushes and branches. 1-2% slope from west to east.

Existing Vegetative Cover Estimate (Percent): 10%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low-Med

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: Construction site 500 feet north





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 28

GLU Classification: CB-SCRUB/SHRUB-1

Photo ID: 1 looking SE

GPS (Lat/Long):

33.59917183 -117.1424015

Geologic Unit: Alluvium or Fill

Surficial Material Type: light brown silty SAND, covered with shallow brushes and weeds. 1-2% slope from west to east. 5% slope from south to north.

Existing Vegetative Cover Estimate (Percent): 15-20%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low to Med

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: 100 feet away from Los Alamos Road.



Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 29

GLU Classification: CSI-OTHER-1

Photo ID: 1 looking W; 2 looking NW

GPS (Lat/Long):

33.60241017 -117.1159333

Geologic Unit: Qvoa

Surficial Material Type: light brown silty SAND, covered with short to medium brushes. Line of trees 50 feet west. 3% slope east to west.

Existing Vegetative Cover Estimate (Percent): 5%, 20% in line of trees

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 30

GLU Classification: FB-DEVELOPED-1

Photo ID: 1 looking SE; 2 looking SE (close up)

GPS (Lat/Long):

33.60507867 -117.1137576

Geologic Unit: Qya

Surficial Material Type: Actual location on pavement. Depression about 20 feet south east. Brown silty SAND, covered by tall brushes

Existing Vegetative Cover Estimate (Percent): None

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: Actual site on pavement





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 31

GLU Classification: CSP-DEVELOPED-1

Photo ID: 1 looking W

GPS (Lat/Long):

33.60632224 -117.1150386

Geologic Unit: pKm

Surficial Material Type: Residential area

Existing Vegetative Cover Estimate (Percent): None

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: ***Site may not be accessible.***


STOP
STOP
ALL WAY

Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 32

GLU Classification: CSI-FOREST-1

Photo ID: 1 looking SE; 2 looking S

GPS (Lat/Long):

33.60587748 -117.1101113

Geologic Unit: Qvoa

Surficial Material Type: light brown silty SAND, wet, fine to medium grained, covered by medium brushes and tall grass

Existing Vegetative Cover Estimate (Percent): 80% by the grass, 10% by the trees

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 33

GLU Classification: CSP-OTHER-1

Photo ID: 1 looking S (by the tall trees)

GPS (Lat/Long):

33.60594675 -117.109581

Geologic Unit: Qya

Surficial Material Type: light brown wet silty SAND, fine to medium grained, covered by brushes and trees

Existing Vegetative Cover Estimate (Percent): 50-75%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:



Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 34

GLU Classification: CSI-OTHER-1

Photo ID: 1 looking SE; 2 looking E

GPS (Lat/Long):

33.60630641 -117.1093173

Geologic Unit: Qvoa

Surficial Material Type: light brown & brown silty SAND, wet, fine to medium grained, covered with short to tall brushes.

Existing Vegetative Cover Estimate (Percent): 10%, 20% by the yellow brushes

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 43

GLU Classification: CSI-Agricultural/Grass-1

Photo ID: 1 looking S; 2 looking SE

GPS (Lat/Long):

33.58700097 -117.1251153

Geologic Unit: Qvoa

Surficial Material Type: light brown silty SAND with fine gravel, Site is located on a mild depression, 3% slope from east to west and west to east

Existing Vegetative Cover Estimate (Percent): 5-10%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 44

GLU Classification: CSI-Agricultural/Grass-1

Photo ID: 1 looking E

GPS (Lat/Long):

33.58866329 -117.1226646

Geologic Unit: Qvoa

Surficial Material Type: light brown silty SAND with gravel, covered by shallow brushes.

Existing Vegetative Cover Estimate (Percent): 5-10%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:



Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 45

GLU Classification: CB-Scrub/Shrub-1

Photo ID: 1 looking SE; 2 looking SE (close up)

GPS (Lat/Long):

33.58492738 -117.1246554

Geologic Unit: Alluvium

Surficial Material Type: light brown silty SAND, wet, fine to medium grained. Site Populated by tall brushes and trees. 3% slope from to north west to south west.

Existing Vegetative Cover Estimate (Percent): 50-75%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 46

GLU Classification: CSI-Agricultural/Grass-1

Photo ID: 1 looking E; 2 looking SE

GPS (Lat/Long):

33.58406325 -117.1262236

Geologic Unit: Qvoa

Surficial Material Type: brown silty SAND, fine to medium grained, covered by shallow brushes. 1-2% slope from east to west.

Existing Vegetative Cover Estimate (Percent): <5%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 47

GLU Classification: CB-Agricultural/Grass-1

Photo ID: 1 looking N, 2 looking NW

GPS (Lat/Long):

33.58456966 -117.1262663

Geologic Unit: Qvoa

Surficial Material Type: brown silty SAND, fine to medium grained, covered by shallow brushes. 5-10% slope south to north.

Existing Vegetative Cover Estimate (Percent): <5%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low to Med

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 48

GLU Classification: CSI-Forest-1

Photo ID: 1 looking E, 2 looking SE (inside large tree area)

GPS (Lat/Long):

33.58531294 -117.124538

Geologic Unit: Qvoa

Surficial Material Type: Actual site highly populated by trees and brushes. Site soil likely wet. 3% slope from north west to south east.

Existing Vegetative Cover Estimate (Percent): 50-75%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 49

GLU Classification: CB-Agricultural/Grass-1

Photo ID:

GPS (Lat/Long):

33.58439784 -117.1215382

Geologic Unit: Alluvial or fill deposits

Surficial Material Type: Medium to fine grained brown silty SAND, <3% ground slope, <10% covered with brushes

Existing Vegetative Cover Estimate (Percent): <10%

Existing Sediment Risk (High, Med, Low): Med to High

Potential Sediment Risk (High, Med, Low): Med to High

100% Vegetative Cover Sediment Risk (High, Med, Low): Low to Med

Notes: Row of granitic boulders to the right of the site (10 to 15 feet wide, 8 to 12 feet tall). Perhaps this is the reason why the site was previously incorrectly classified as granitic.





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 50

GLU Classification: CB-Scrub/Shrub-1

Photo ID: _____

GPS (Lat/Long):

33.58475897 -117.121478

Geologic Unit: Alluvial or fill deposits

Surficial Material Type: Medium to fine grained brown silty SAND, <3% ground slope, <10% covered with brushes

Existing Vegetative Cover Estimate (Percent): <10%

Existing Sediment Risk (High, Med, Low): Med to High

Potential Sediment Risk (High, Med, Low): Med to High

100% Vegetative Cover Sediment Risk (High, Med, Low): Low to Med

Notes: _____





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 51

GLU Classification: CB-Agricultural/Grass-1

Photo ID: _____

GPS (Lat/Long):

33.58583659 -117.121325

Geologic Unit: Qvoa or fill

Surficial Material Type: fill or alluvium. 5 to 8% gradient toward West. Light brown Silty SAND fine to medium grained.

Existing Vegetative Cover Estimate (Percent): 80%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: _____



Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 52

GLU Classification: CSI-Agricultural/Grass-1

Photo ID: _____

GPS (Lat/Long):

33.58575539 -117.1216484

Geologic Unit: Qvoa (1 foot of water)

Surficial Material Type: 1 ft of water. Ground covered with brushes.

Existing Vegetative Cover Estimate (Percent): <5%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: _____



Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 53

GLU Classification: CB-Scrub/Shrub-1

Photo ID: 1 looking SE, 2 looking SW

GPS (Lat/Long):

33.5998075 -117.1427446

Geologic Unit: Alluvium or fill

Surficial Material Type: light brown silty SAND with gravel and some cobbles. Large boulders 300 feet west of site (possibly why site was incorrectly characterized as granitic). 10% slope north to south

Existing Vegetative Cover Estimate (Percent): 5%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low to Med

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: Bordering construction site (to the north)





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 54

GLU Classification: CB-AGRICULTURAL/GRASS-1

Photo ID: _____

GPS (Lat/Long):

33.60059087 -117.1431417

Geologic Unit: gr

Surficial Material Type: Within construction site

Existing Vegetative Cover Estimate (Percent): None

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: _____

Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 55

GLU Classification: FB-SCRUB/SHRUB-3

Photo ID: _____

GPS (Lat/Long):

33.60128715 -117.1418556

Geologic Unit: pKm

Surficial Material Type: Within construction site

Existing Vegetative Cover Estimate (Percent): None

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: _____

Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 58

GLU Classification: CB-SCRUB/SHRUB-1

Photo ID: 1 looking NW; 2 looking N

GPS (Lat/Long):

33.59920428 -117.1464568

Geologic Unit: Alluvium

Surficial Material Type: light brown silty SAND with gravel and cobbles, fine to medium grained. Boulders in the north and east direction (perhaps why site was incorrectly characterized as granitic). Creek down slope 50-70 feet away. 30% slope south to north.

Existing Vegetative Cover Estimate (Percent): 10% top of slope, 50% down slope near creek.

Existing Sediment Risk (High, Med, Low): High

Potential Sediment Risk (High, Med, Low): High

100% Vegetative Cover Sediment Risk (High, Med, Low): High

Notes: Construction site 200-300 feet south, on Clinton Keith Road.





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 59

GLU Classification: CB-SCRUB/SHRUB-1

Photo ID: 1 looking NE; 2 looking W, 3 looking S

GPS (Lat/Long):

33.598792333 -117.147565

Geologic Unit: gr

Surficial Material Type: light brown silty SAND, fine to medium grained, on top of granite, large boulders in all directions. Site covered in shallow to medium brushes. Slope 5-10% from west to east. 40% slope from south to north

Existing Vegetative Cover Estimate (Percent): 5%

Existing Sediment Risk (High, Med, Low): Low to Med

Potential Sediment Risk (High, Med, Low): Med

100% Vegetative Cover Sediment Risk (High, Med, Low): Med to High

Notes: 100 to 200 feet south and east from construction site







Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 64

GLU Classification: CSP-SCRUB/SHRUB-3

Photo ID: 1 looking N; 2 looking N (close up view)

GPS (Lat/Long):

33.55416725 -117.0982825

Geologic Unit: Qss

Surficial Material Type: 2 to 3% slopes easterly. Covered by 2 to 3 feet tall grassy brushes. Light brown silty SANDSTONE, med to fine grained, potential erosional gullies visible in access road to site where no ground cover exist.

Existing Vegetative Cover Estimate (Percent): 75 to 80%

Existing Sediment Risk (High, Med, Low): Low to Med

Potential Sediment Risk (High, Med, Low): Med to High

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: ***Site may not be accessible.***





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 65

GLU Classification: CSP-AGRICULTURAL/GRASS-3

Photo ID: 1 looking N; 2 looking NE

GPS (Lat/Long):

33.55446283 -117.0978426

Geologic Unit: Qss

Surficial Material Type: 3 to 5% westerly slope. Ground covered by 2 to 3 feet tall brushes/grass. Light brown silty SANDSTONE, medium to fine grained.

Existing Vegetative Cover Estimate (Percent): 80%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low to Med (steepness)

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: ***Site may not be accessible.***





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 66

GLU Classification: FB-AGRICULTURAL/GRASS-1

Photo ID: 1 looking N; 2 looking SW

GPS (Lat/Long):

33.56286659 -117.0713212

Geologic Unit: pKm (unit questionable)

Surficial Material Type: On either side of sandy GRAVEL access road, the ground is covered with 2 to 3 feet tall grassy brown brushes. Light brown silty SANDSTONE, trace gravel, 3 to 5% ground gradient in N-S direction.

Existing Vegetative Cover Estimate (Percent): 80%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low to Med

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: Low point of N-S drainage crosses sandy Gravel covered access road.


DIP



Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 67

GLU Classification: FB-FOREST-1

Photo ID: 1 (looking W); 2 (looking E)

GPS (Lat/Long):

33.57116408 -117.0773157

Geologic Unit: pKm (questionable unit)

Surficial Material Type: up to 5% slope and ground covered with low grass/brushes. Light yellowish brown silty SANDSTONE, trace gravel.

Existing Vegetative Cover Estimate (Percent): 80%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low to Med

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes:




MOORE

Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/9/2017

Field Team: Jag Jagannath & Dario Leekam

Location ID: 68

GLU Classification: CSI-AGRICULTURAL/GRASS-1

Photo ID: 1 looking S; 2looking SE (close up view)

GPS (Lat/Long):

33.53498683 -117.0571629

Geologic Unit: Qvoa

Surficial Material Type: Percolation pond with no ground cover. Side slopes have less than 10% vegetable cover. Silty SAND, light yellow brown, fine t o grained.

Existing Vegetative Cover Estimate (Percent): Less than 5%

Existing Sediment Risk (High, Med, Low): Med

Potential Sediment Risk (High, Med, Low): Med

100% Vegetative Cover Sediment Risk (High, Med, Low): Med

Notes:





Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 69

GLU Classification: CSP-OTHER-1

Photo ID: 1 looking NE

GPS (Lat/Long):

33.60893715 -117.1062468

Geologic Unit: Qya

Surficial Material Type: light brown silty SAND with gravel and cobbles, very moist.

Existing Vegetative Cover Estimate (Percent): 70-80%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: Site is located in a natural vegetation habitat that is currently being restored. Picture was taken about 250 feet away from actual site.



Upper Santa Margarita River Watershed
Coarse Sediment Yield Analysis

Date: 5/10/2017

Field Team: Paulina Chilingar & Dario Leekam

Location ID: 70

GLU Classification: CSP-AGRICULTURAL/GRASS-1

Photo ID: 1 looking N (actual site by yellow brush in picture)

GPS (Lat/Long):

33.60977095 -117.1061386

Geologic Unit: Qya

Surficial Material Type: light brown silty SAND with gravel and cobbles, very moist.

Existing Vegetative Cover Estimate (Percent): 70-80%

Existing Sediment Risk (High, Med, Low): Low

Potential Sediment Risk (High, Med, Low): Low

100% Vegetative Cover Sediment Risk (High, Med, Low): Low

Notes: Site is located in a natural vegetation habitat that is currently being restored. Picture was taken about 250 feet away from actual site.



APPENDIX

G CRITICAL COARSE SEDIMENT YIELD ARCMAP EXHIBIT

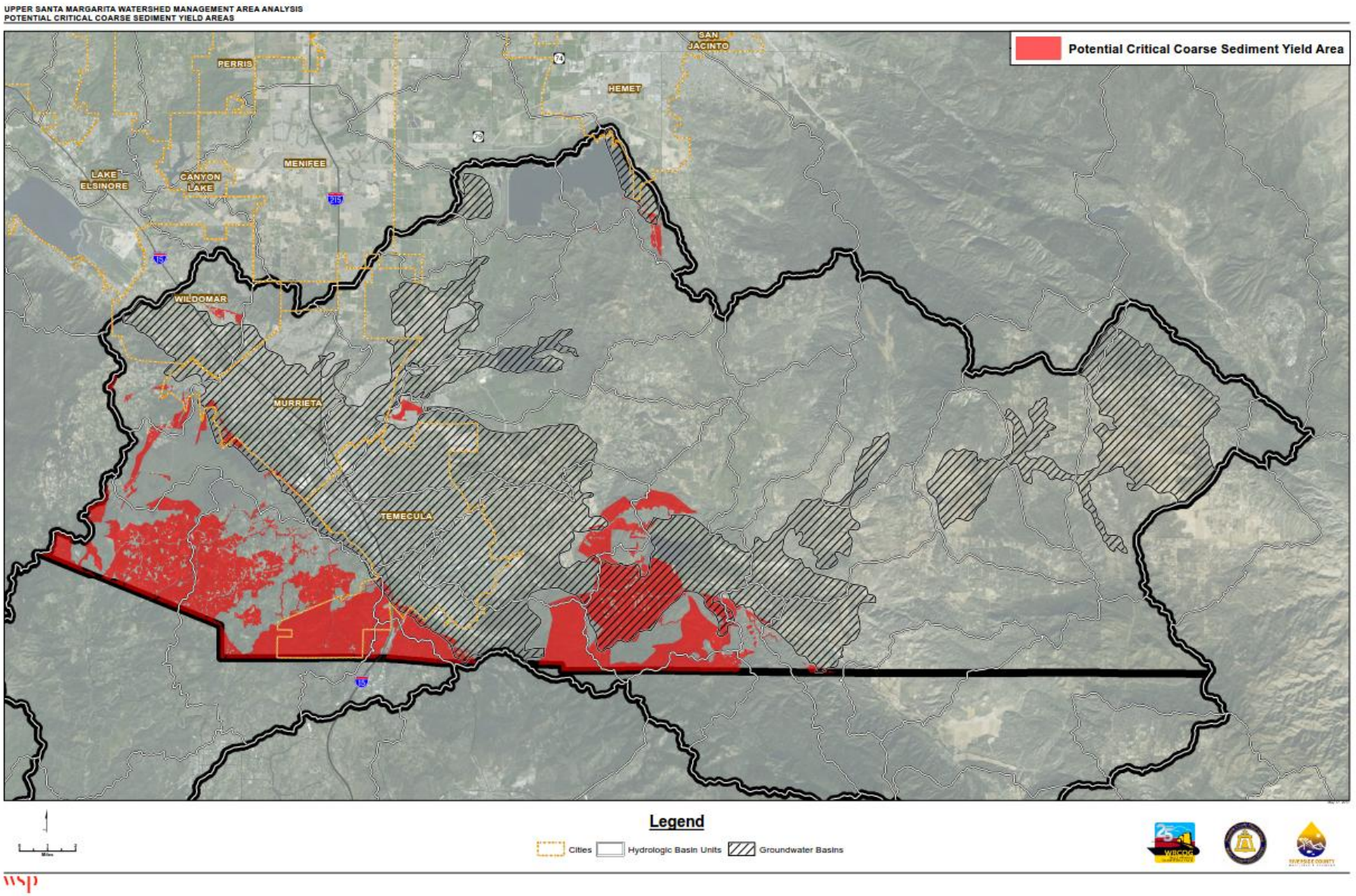
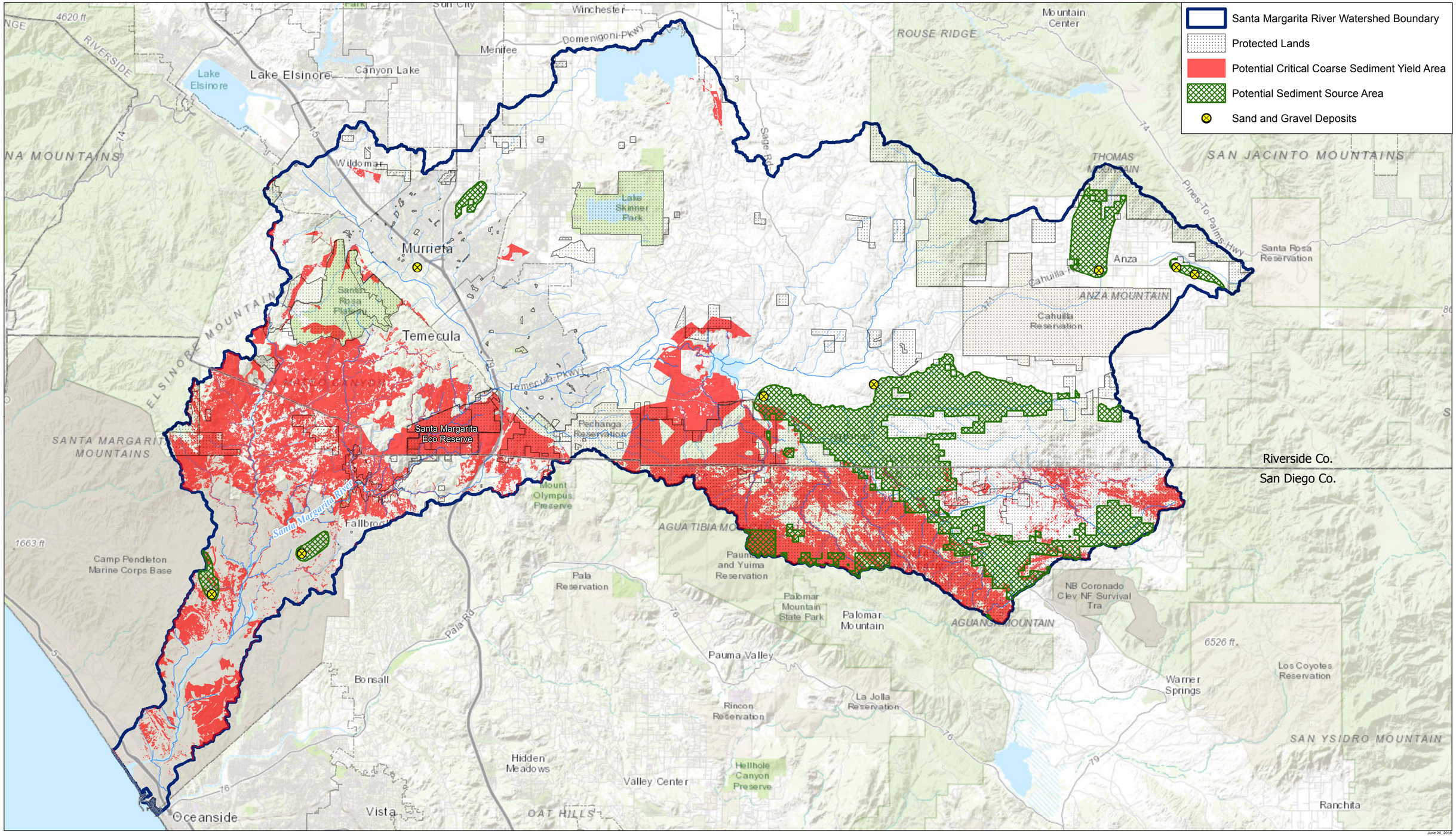


Figure G.1 Potential Critical Coarse Sediment Yield Areas in the upper Santa Margarita River Watershed

APPENDIX

H POTENTIAL SEDIMENT SOURCE AREA EXHIBIT



0 1 2 Miles

SANTA MARGARITA RIVER WATERSHED

POTENTIAL CRITICAL COARSE SEDIMENT YIELD AREAS AND POTENTIAL SEDIMENT SOURCE AREAS

Attachment H. Hydromodification Management Exemptions

Santa Margarita River

Upstream Section

Erosion Potential	1.13

Tributary Area	*A*	sq mi	352		352
Mean Annual Precip	*MAP*	in/yr	16.3		16.3
Length of Daily Flow Record	*Yr*	yr	30		30
Imperviousness	*Impav*	mi^2/mi^2	0.13200		0.1780
Maximum Flow of Record	*Qmax*	cfs	15635.9		15635.9
Minimum Flow of Record	*Qmin*	cfs	0.01		0.01
10-year peak flow	*Q10*	cfs	25114.4		25114.4
Coefficient of DDF	*day1*	days & cfs	13813.87		26061.86
Exponent of DDF	*day2*	days & cfs	-0.70		-0.75
Number of Bins	N_B	--	25		25
Bin Size	$H_{B\text{-}log}$	--	0.594		0.594

Channel Slope	0.0250	ft/ft
Critical Shear	3.042	lb/sq. ft
γ	62.4	lb/ft^3

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
B	$B_{lwr\text{-}log}$	$B_{upr\text{-}log}$	*Q*	*R*	*v*	τ	*W*	*days*	*W*days*	*days*	*W*days*
--	cfs	cfs	cfs	ft	ft/s	psf	--	days	--	days	--
1	0	25	12.50	0.34	3.30	0.530	0.000	2357.4	0.00	3875.8	0.00
2	25	50	37.50	0.52	4.34	0.811	0.000	1092.5	0.00	1691.9	0.00
3	50	100	75.00	0.67	5.16	1.045	0.000	672.5	0.00	1002.8	0.00
4	100	500	300.00	1.13	7.30	1.763	0.000	254.8	0.00	352.3	0.00
5	500	1000	750.00	1.60	9.17	2.496	0.000	134.2	0.00	176.5	0.00
6	1000	1500	1250.00	1.95	10.49	3.042	0.000	93.8	0.00	120.0	0.00
7	1500	2000	1750.00	2.28	11.64	3.557	4.299	74.1	318.76	93.1	400.38
8	2000	2500	2250.00	2.56	12.56	3.994	11.659	62.2	724.98	77.0	898.21
9	2500	3000	2750.00	2.82	13.41	4.399	21.203	54.0	1145.61	66.2	1403.93
10	3000	4000	3500.00	3.19	14.55	4.976	39.146	45.6	1786.52	55.2	2160.77
11	4000	5000	4500.00	3.61	15.81	5.632	65.884	38.3	2521.74	45.7	3008.53
12	5000	6000	5500.00	3.99	16.88	6.224	95.831	33.3	3187.24	39.2	3761.16
13	6000	8000	7000.00	4.48	18.24	6.989	143.019	28.1	4017.76	32.7	4679.34
14	8000	10000	9000.00	5.04	19.73	7.862	208.810	23.6	4919.69	27.1	5651.86
15	10000	12000	11000.00	5.53	20.99	8.627	277.028	20.5	5671.55	23.3	6444.76
16	12000	14000	13000.00	5.97	22.08	9.313	346.757	18.2	6315.60	20.5	7111.59
17	14000	16000	15000.00	6.36	23.05	9.922	415.926	16.5	6853.29	18.4	7657.12
18	16000	18000	17000.00	6.73	23.92	10.499	487.068	15.1	7352.26	16.8	8158.79
19	18000	20000	19000.00	7.07	24.72	11.029	558.008	14.0	7792.12	15.4	8594.67
20	20000	22900	21450.00	7.45	25.61	11.622	643.636	12.8	8256.24	14.1	9046.61
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StreamStats Report

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Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	738.5	square miles
PRECIP	Mean Annual Precipitation	16.3	inches

Peak-Flow Statistics Parameters [100 Percent (738 square miles) 2012 5113 Region 5 South Coast]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	738.5	square miles	0.04	850
PRECIP	Mean Annual Precipitation	16.3	inches	10	45

Peak-Flow Statistics Flow Report [100 Percent (738 square miles) 2012 5113 Region 5 South Coast]

Statistic	Value	Unit	Average standard error of prediction	Lower Prediction Interval	Upper Prediction Interval
2 Year Peak Flood	2490	ft^3/s	134.2	446	13900
5 Year Peak Flood	11200	ft^3/s	83.1	3270	38100
10 Year Peak Flood	22900	ft^3/s	64	8420	62300
25 Year Peak Flood	45700	ft^3/s	51.5	19800	106000
50 Year Peak Flood	69900	ft^3/s	47.6	32000	152000
100 Year Peak Flood	99800	ft^3/s	47.2	45500	219000
200 Year Peak Flood	138000	ft^3/s	47.7	61900	306000
500 Year Peak Flood	194000	ft^3/s	52	82700	453000

Peak-Flow Statistics Citations

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles,2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl. (http://pubs.usgs.gov/sir/2012/5113/)

Downstream Section

Erosion Potential	1.13

Tributary Area	*A*	sq mi	352		352
Mean Annual Precip	*MAP*	in/yr	16.4		16.4
Length of Daily Flow Record	*Yr*	yr	30		30
Imperviousness	*Impav*	mi^2/mi^2	0.13200		0.1780
Maximum Flow of Record	*Qmax*	cfs	15794.8		15794.8
Minimum Flow of Record	*Qmin*	cfs	0.01		0.01
10-year peak flow	*Q10*	cfs	25213.8		25213.8
Coefficient of DDF	*day1*	days & cfs	14122.77		26644.65
Exponent of DDF	*day2*	days & cfs	-0.70		-0.76
Number of Bins	N_B	--	25		25
Bin Size	$H_{B\text{-}log}$	--	0.595		0.595

Channel Slope	0.0030	ft/ft
Critical Shear	0.020	lb/sq. ft
γ	62.4	lb/ft^3

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
B	$B_{lwr\text{-}log}$	$B_{upr\text{-}log}$	*Q*	*R*	*v*	τ	*W*	*days*	*W*days*	*days*	*W*days*
--	cfs	cfs	cfs	ft	ft/s	psf	--	days	--	days	--
1	0.01	0.01	0.008	0.002	0.03	0.000	0.000	428755.8	0.00	1054070.3	0.00
2	0.01	0.02	0.014	0.002	0.04	0.000	0.000	282351.9	0.00	672015.2	0.00
3	0.02	0.03	0.03	0.003	0.05	0.001	0.000	185939.5	0.00	428438.7	0.00
4	0.03	0.06	0.05	0.004	0.06	0.001	0.000	122448.2	0.00	273148.1	0.00
5	0.06	0.11	0.08	0.006	0.07	0.001	0.000	80636.8	0.00	174143.7	0.00
6	0.11	0.20	0.15	0.008	0.09	0.001	0.000	53102.4	0.00	111024.1	0.00
7	0.20	0.35	0.28	0.012	0.12	0.002	0.000	34969.9	0.00	70782.7	0.00
8	0.35	0.64	0.50	0.017	0.15	0.003	0.000	23029.0	0.00	45127.0	0.00
9	0.64	1.16	0.90	0.024	0.19	0.004	0.000	15165.5	0.00	28770.4	0.00
10	1.16	2.11	1.64	0.035	0.24	0.007	0.000	9987.0	0.00	18342.4	0.00
11	2.11	3.83	2.97	0.049	0.30	0.009	0.000	6576.8	0.00	11694.1	0.00
12	3.83	6.93	5.38	0.07	0.38	0.013	0.000	4331.1	0.00	7455.5	0.00
13	6.93	12.57	9.75	0.10	0.48	0.018	0.000	2852.2	0.00	4753.2	0.00
14	12.57	22.78	17.67	0.14	0.61	0.026	0.000	1878.3	0.58	3030.4	0.94
15	22.78	41.29	32.03	0.20	0.77	0.037	0.002	1236.9	2.18	1932.0	3.41
16	41.29	74.83	58.06	0.28	0.96	0.053	0.006	814.6	4.61	1231.7	6.97
17	74.83	135.63	105.23	0.39	1.20	0.074	0.015	536.4	7.99	785.3	11.70
18	135.63	245.82	190.72	0.55	1.50	0.102	0.035	353.3	12.47	500.6	17.67
19	245.82	445.54	345.68	0.75	1.85	0.141	0.078	232.6	18.04	319.2	24.75
20	445.54	807.53	626.53	1.02	2.27	0.191	0.161	153.2	24.66	203.5	32.76
21	807.53	1463.62	1135.57	1.37	2.77	0.257	0.319	100.9	32.20	129.7	41.41
22	1463.62	2652.77	2058.20	1.82	3.34	0.341	0.606	66.4	40.28	82.7	50.14
23	2652.77	4808.08	3730.43	2.38	4.00	0.446	1.110	43.8	48.56	52.7	58.52
24	4808.08	8714.51	6761.30	3.08	4.75	0.576	1.968	28.8	56.71	33.6	66.17
25	8714.51	15794.81	12254.66	3.94	5.60	0.738	3.404	19.0	64.59	21.4	72.96
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StreamStats Report

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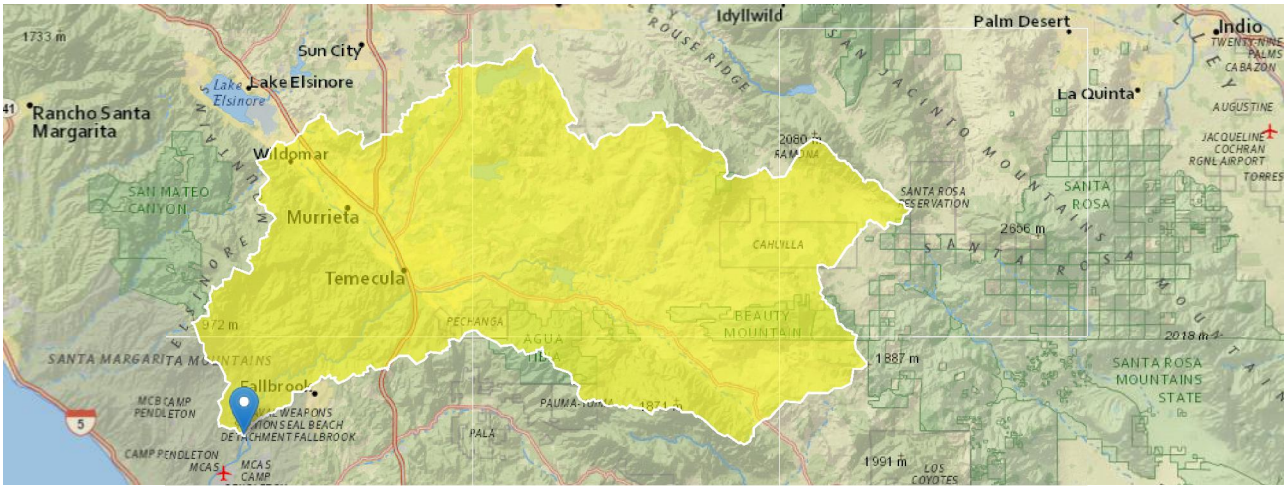

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	706.2	square miles
ELEV	Mean Basin Elevation	2394	feet
PRECIP	Mean Annual Precipitation	16.4	inches
LFPLENGTH	Length of longest flow path	62	miles

Peak-Flow Statistics Parameters [100 Percent (706 square miles) 2012 5113 Region 5 South Coast]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	706.2	square miles	0.04	850
PRECIP	Mean Annual Precipitation	16.4	inches	10	45

Peak-Flow Statistics Flow Report [100 Percent (706 square miles) 2012 5113 Region 5 South Coast]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	PIu	SEp
2 Year Peak Flood	2430	ft^3/s	436	13600	134
5 Year Peak Flood	10900	ft^3/s	3180	37000	83.1
10 Year Peak Flood	22300	ft^3/s	8190	60500	64
25 Year Peak Flood	44400	ft^3/s	19200	102000	51.5
50 Year Peak Flood	67900	ft^3/s	31100	148000	47.6
100 Year Peak Flood	96800	ft^3/s	44200	212000	47.2
200 Year Peak Flood	133000	ft^3/s	60200	296000	47.7
500 Year Peak Flood	188000	ft^3/s	80300	438000	52

Peak-Flow Statistics Citations

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles,2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl. (http://pubs.usgs.gov/sir/2012/5113/)

Murrieta Creek

Erosion Potential	#DIV/0!

Tributary Area	*A*	sq mi	149		149
Mean Annual Precip	*MAP*	in/yr	14.7		14.7
Length of Daily Flow Record	*Yr*	yr	30		30
Imperviousness	*Impav*	mi^2/mi^2	0.14400		0.2170
Maximum Flow of Record	*Qmax*	cfs	5596.6		5596.6
Minimum Flow of Record	*Qmin*	cfs	0.01		0.01
10-year peak flow	*Q10*	cfs	10992.9		10992.9
Coefficient of DDF	*day1*	days & cfs	6210.50		17007.29
Exponent of DDF	*day2*	days & cfs	-0.72		-0.80
Number of Bins	N_B	--	25		25
Bin Size	$H_{B\text{-}log}$	--	0.551		0.551

Channel Slope	0.0020	ft/ft
Critical Shear	1.200	lb/sq. ft
γ	62.4	lb/ft^3

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
B	$B_{lwr\text{-}log}$	$B_{upr\text{-}log}$	*Q*	*R*	*v*	τ	*W*	*days*	*W*days*	*days*	*W*days*
--	cfs	cfs	cfs	ft	ft/s	psf	--	days	--	days	--
1	0	25	12.50	0.30	0.59	0.037	0.000	1012.3	0.00	2228.3	0.00
2	25	50	37.50	0.38	0.70	0.047	0.000	459.8	0.00	920.5	0.00
3	50	100	75.00	0.57	0.91	0.071	0.000	279.5	0.00	527.0	0.00
4	100	300	200.00	1.02	1.34	0.127	0.000	138.2	0.00	239.3	0.00
5	300	500	400.00	1.52	1.76	0.190	0.000	84.0	0.00	137.0	0.00
6	500	1000	750.00	2.18	2.23	0.272	0.000	53.5	0.00	82.6	0.00
7	1000	1500	1250.00	2.90	2.70	0.362	0.000	37.1	0.00	54.8	0.00
8	1500	2000	1750.00	3.49	3.06	0.436	0.000	29.1	0.00	41.8	0.00
9	2000	2500	2250.00	4.24	3.48	0.529	0.000	24.3	0.00	34.1	0.00
10	2500	3000	2750.00	4.46	3.60	0.557	0.000	21.0	0.00	29.0	0.00
11	3000	3500	3250.00	4.88	3.82	0.609	0.000	18.7	0.00	25.4	0.00
12	3500	4000	3750.00	5.26	4.02	0.656	0.000	16.8	0.00	22.6	0.00
13	4000	4500	4250.00	5.62	4.20	0.701	0.000	15.4	0.00	20.5	0.00
14	4500	5000	4750.00	5.95	4.36	0.743	0.000	14.2	0.00	18.7	0.00
15	5000	6000	5500.00	6.42	4.59	0.801	0.000	12.8	0.00	16.6	0.00
16	6000	7000	6500.00	6.99	4.86	0.872	0.000	11.3	0.00	14.5	0.00
17	7000	8000	7500.00	7.51	5.10	0.937	0.000	10.2	0.00	13.0	0.00
18	8000	9000	8500.00	8.00	5.31	0.998	0.000	9.4	0.00	11.7	0.00
19	9000	10000	9500.00	8.45	5.51	1.055	0.000	8.6	0.00	10.7	0.00
20	10000	11000	10500.00	8.87	5.70	1.107	0.000	8.0	0.00	9.9	0.00
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									#DIV/0!		#DIV/0!

Murrieta StreamStats Report

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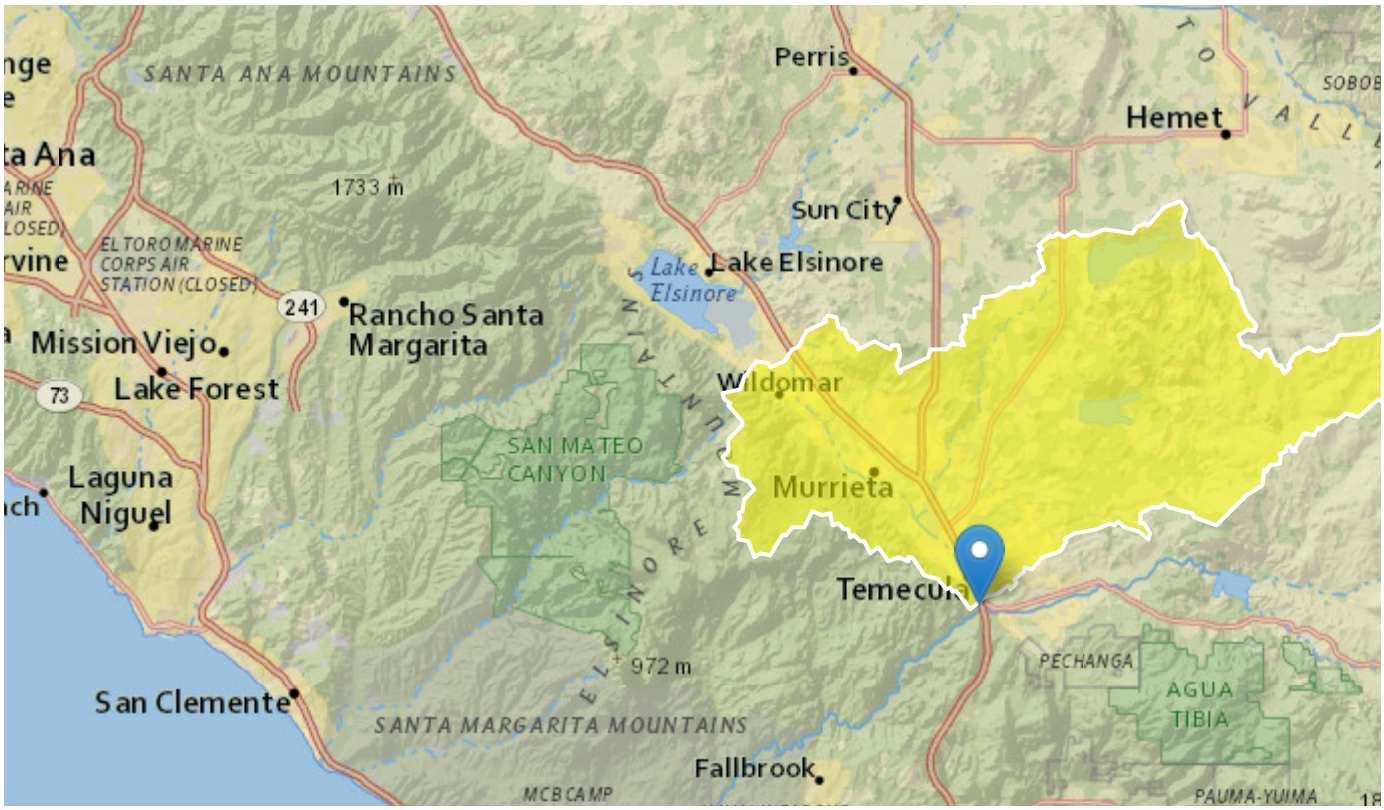

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	221.1	square miles
ELEV	Mean Basin Elevation	1710	feet
PRECIP	Mean Annual Precipitation	14.7	inches
LFPLENGTH	Length of longest flow path	31	miles

Peak-Flow Statistics Parameters [2012 5113 Region 5 South Coast]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	221.1	square miles	0.04	850
PRECIP	Mean Annual Precipitation	14.7	inches	10	45

Peak-Flow Statistics Flow Report [2012 5113 Region 5 South Coast]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PII	PIu	SEp
2 Year Peak Flood	1030	ft^3/s	185	5680	134
5 Year Peak Flood	4180	ft^3/s	1230	14200	83.1
10 Year Peak Flood	7980	ft^3/s	2960	21500	64
25 Year Peak Flood	14600	ft^3/s	6380	33400	51.5
50 Year Peak Flood	21200	ft^3/s	9810	45700	47.6
100 Year Peak Flood	28900	ft^3/s	13300	62700	47.2
200 Year Peak Flood	38300	ft^3/s	17400	84000	47.7
500 Year Peak Flood	51400	ft^3/s	22300	119000	52

Peak-Flow Statistics Citations

Gotvald, A.J., Barth, N.A., Veilleux, A.G., and Parrett, Charles,2012, Methods for determining magnitude and frequency of floods in California, based on data through water year 2006: U.S. Geological Survey Scientific Investigations Report 2012–5113, 38 p., 1 pl. (http://pubs.usgs.gov/sir/2012/5113/#)

Attachment I. San Diego County Regional Watershed Management Area Analysis

San Diego County Regional Watershed Management Area Analysis



Lake Henshaw

October 1, 2015

Prepared for:
San Diego County Copermittees

Prepared by:

Geosyntec consultants
engineers | scientists | innovators

RICK ENGINEERING COMPANY

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B.1 Additional Analysis for Hydromodification Management Exemptions
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ATTACHMENT E **METHODOLOGY FOR HYDROMODIFICATION MANAGEMENT EXEMPTION**

ACRONYMS AND ABBREVIATIONS

%	percent
>	greater than
<	less than
BMP	Best Management Practice
CB	Coarse Bedrock
CEG	Certified Engineering Geologist
CIP	Capital Improvement Project
CLRP	Comprehensive Load Reduction Plan
CSI	Coarse Sedimentary Impermeable
CSP	Coarse Sedimentary Permeable
E_P	Erosion Potential
ET	Evapotranspiration
FB	Fine Bedrock
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
FSI	Fine Sedimentary Impermeable
FSP	Fine Sedimentary Permeable
GIS	Geographic Information System
GLU	Geomorphic Landscape Unit
HA	Hydrologic Area
HCP	Hydromodification Control Plan
HMP	Hydromodification Management Plan
HRU	Hydrologic Response Unit
HSA	Hydrologic Sub Area
HSG	Hydrologic Soil Group
IRWM	Integrated Regional Water Management
JURMP	Jurisdictional Urban Runoff Management Plan
LDW	Land Development Workgroup
LID	Low Impact Development
MAP	Mean Annual Precipitation

ACRONYMS AND ABBREVIATIONS continued

MHPA	Multiple Habitat Planning Area
MS4	Municipal Separate Storm Sewer System
MSCP	Multiple Species Conservation Program
NED	National Elevation Dataset
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
PDP	Priority Development Project
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
SCAMP	Southern California Aerial Mapping Project
SCCWRP	Southern California Coastal Water Research Project
SD	San Diego
SDRWQCB	San Diego Regional Water Quality Control Board
S_P	Sediment Supply Potential
SSURGO	Soil Survey Geographic Database
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WMA	Watershed Management Area
WMAA	Watershed Management Area Analysis
WQIP	Water Quality Improvement Plan
WURMP	Watershed Urban Runoff Management Plan

1. Introduction

1.1. Background

On May 8, 2013 the California Regional Water Quality Control Board, San Diego Region adopted Order No. R9-2013-0001; NPDES No. CAS 0109266, National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds within the San Diego Region (Regional MS4 Permit). The Regional MS4 Permit, which became effective on June 27, 2013, replaces the previous MS4 Permits that covered portions of the Counties of San Diego, Orange, and Riverside within the San Diego Region. There were two main goals for the Regional MS4 Permit:

1. To have more consistent implementation, as well as improve inter-agency communication (particularly in the case of watersheds that cross jurisdictional boundaries), and minimize resources spent on the permit renewal process.
2. To establish requirements that focused on the achievement of water quality improvement goals and outcomes rather than completing specific actions, thereby giving the Copermittees more control over how their water quality programs are implemented.

To achieve the second goal, the Regional MS4 Permit requires that Water Quality Improvement Plans (WQIPs) be developed for each Watershed Management Area (WMA) within the San Diego Region. As part of the development of WQIPs, the Regional MS4 Permit provides Copermittees an option to perform a Watershed Management Area Analysis (WMAA) through which watershed-specific requirements for structural BMP implementation for Priority Development Projects can be developed for each WMA. This report presents the Copermittees' approach and results for the regional elements of the WMAA developed for the San Diego County area.

1.2. Watershed Management Area Analysis (WMAA)

The Regional MS4 Permit, through inclusion of the WMAA, provides an optional pathway for Copermittees to develop an integrated approach for their land development programs by promoting evaluation of multiple strategies for water quality improvement and development of watershed-scale solutions for improving overall water quality in the watershed. The WMAA comprises the following three components as indicated in the Regional MS4 Permit:

1. Perform analysis and develop Geographic Information System (GIS) layers (maps) by gathering information pertaining to the physical characteristics of the WMA (referred to herein as WMA Characterization). This includes, for example, identifying potential areas of coarse sediment supply, present and anticipated future land uses, and locations of physical structures within receiving streams and upland areas that affect the watershed hydrology (such as bridges, culverts, and flood management basins).
2. Using the WMA Characterization results, compile a list of candidate projects that could potentially be used as alternative compliance options for Priority Development Projects. Such projects may include, for example, opportunities for stream or riparian area

rehabilitation, opportunities for retrofitting existing infrastructure to incorporate storm water retention or treatment, or opportunities for regional BMPs, among others. Prior to implementing these candidate projects the Copermittees must demonstrate that implementing such a candidate project would provide greater overall benefit to the watershed than requiring implementation of the onsite structural BMPs. Note, compilation or evaluation of potential projects was not performed as part of this regional effort. Identification and listing of candidate projects will be performed for each WMA through the WQIP process for WMAs that elect to submit the optional WMAA as part of the WQIP.

3. Additionally, using the WMA Characterization maps, identify areas within the watershed management area where it is appropriate to allow for exemptions from hydromodification management requirements that are in addition to those already allowed by the Regional MS4 Permit for Priority Development Projects. The Copermittees shall identify such cases on a watershed basis and include them in the WMAA with supporting rationale to support claims for exemptions.

1.3. Scope of Work for Regional WMAA

In July 2013, the Copermittees elected to fund a regional effort to develop elements of the regional WMAA for the 9 San Diego-area WMAs within the County of San Diego that are currently subject to the Regional MS4 Permit, which include:

- Santa Margarita River (for portion in San Diego County)
- San Luis Rey River
- Carlsbad
- San Dieguito River
- Los Peñasquitos
- Mission Bay & La Jolla Watershed
- San Diego River
- San Diego Bay
- Tijuana River (for portion in San Diego County)

The regional-level information developed through this effort is intended to provide consistency across WMAs and serve as the foundation for developing watershed-specific information for each WMA to be developed through the WQIP process. The regional effort scope of work included:

1. Development of GIS map layers that characterize the WMAs using data previously collected, readily available, and provided by the Copermittees, including:
    a. Description of dominant hydrologic processes, such as areas where infiltration or overland flow likely dominates;
    b. Description of existing streams in the watershed, including bed material and composition, and if they are perennial or ephemeral;

c. Current and anticipated future land uses;

d. Potential coarse sediment yield areas; and

e. Locations of existing flood control structures and channel structures, such as stream armoring, constrictions, grade control structures, and hydromodification or flood management basins.

2. Development of a Microsoft® Excel (Excel) template for use by Copermittees to compile lists of candidate projects for an optional alternative compliance program.
3. Development of additional criteria and analyses to support reinstating the following proposed exemptions that were originally developed in the approved 2011 Final Hydromodification Management Plan but not included in the Regional MS4 Permit unless provided by the Copermittees in the WMAA. In addition, development of the associated Hydromodification Applicability/Exemption Mapping.
    a. Exempt River Reaches including:
        i. San Diego River;
        ii. Otay River;
        iii. San Dieguito River;
        iv. San Luis Rey River; and
        v. Sweetwater River
    b. Stabilized Conveyance Systems Draining to Exempt Water Bodies
    c. Highly Impervious/Highly Urbanized Watersheds and Urban Infill, and
    d. Tidally Influenced Lagoons (where data/study provided)

The scope of work for the regional effort excluded performing analysis within the following areas unless data was readily available, as Copermittees do not have jurisdiction over these areas:

1. State Lands;
2. U.S. Departments of Defense land;
3. U.S. National Forest land;
4. U.S. Department of Interior land and
5. Tribal land

Additional description of excluded areas, for the purposes of the Regional WMAA, is indicated in Section 2.3 Land Uses.

1.4. Project Process

The process for developing the Regional WMAA included close coordination with the Land Development Workgroup (LDW) at key points during the project. The LDW is composed of the 21 San Diego-area Copermittees and serves to develop and implement regional land development plans and programs necessary to support the requirements of the Regional MS4 Permit. The consultant team (Geosyntec Consultants and Rick Engineering Company) presented

preliminary project assumptions and methodologies proposed to be used to develop the Regional WMAA to meet the requirements of the Regional MS4 Permit in December 2013. The consultant team incorporated workgroup feedback from this meeting and subsequently presented the preliminary Regional WMAA project results to the LDW in March 2014, again to receive direction and incorporate input on the preliminary results. Subsequently, the draft report was released to the public in July 2014, by a public workshop that included Consultation Panel members from each of the WMAs on July 29, 2014. This version of the report including all of the input described above is being issued for optional inclusion into the respective WQIP Provision B.3 submittals to the SDRWQCB in December 2014.

1.5. Report Organization

This report is organized as follows:

- Chapter 1 provides the project background and purpose;
- Chapter 2 describes the technical basis for characterizing the WMAs;
- Chapter 3 describes the template that can be used by Copermittees to compile the list of candidate projects;
- Chapter 4 summarizes the analyses performed to support reinstating select exemptions from hydromodification control requirements for PDPs;
- Chapter 5 presents the Regional WMAA conclusions;
- Chapter 6 presents the references used for the Regional WMAA;
- Attachment A presents the exhibits and additional supporting information for watershed management area characterization;
- Attachment B presents the exhibits and additional supporting information for hydromodification management applicability/exemptions;
- Attachment C expands on the structure of the geodatabase that hosts the GIS data developed by the WMAA; and
- Attachment D provides a crosswalk between the Regional MS4 Permit requirements for WMAA and this report.

1.6.Terms of Reference

The work described in this report was conducted by Geosyntec Consultants (Geosyntec) and Rick Engineering Company (RICK) on behalf of the County of San Diego and the regional Copermittees.

2. Watershed Management Area Characterization

Watershed health and function are strongly influenced by hydrological and geomorphological processes occurring in the watershed. Both hydrological response and geomorphological response of the watershed are dependent on a variety of physical characteristics of the watershed. To this end, the Regional MS4 Permit specifies a set of data that is required to adequately characterize overall watershed processes as a foundation to enhancing integration and effectiveness of watershed management and water quality programs. The following GIS map layers were developed to characterize the hydrological and geomorphological processes within the 9 WMAs:

- Dominant Hydrologic Processes: A description of dominant hydrologic processes, such as areas where infiltration or overland flow likely dominates;
- Stream Characterization: A description of existing streams in the watershed, including bed material and composition, and if they are perennial or ephemeral;
- Land Uses: Current and anticipated future land uses;
- Potential Critical Coarse Sediment Yield Areas; and
- Physical Structures: Locations of existing flood control structures and channel structures, such as stream armoring, constrictions, grade control structures, and hydromodification or flood management basins.

These GIS layers can be used to:

- Identify the nature and distribution of key macro-scale watershed processes;
- Identify potential opportunities and constraints for regional and sub-regional storm water management facilities that can play a critical role in meeting water quality, hydromodification, water supply, and/or habitat goals within the watershed;
- Assist with determining the most appropriate management actions for specific portions of the watershed; and
- Suggest where further study is appropriate.

2.1. Dominant Hydrologic Processes

The Regional MS4 Permit identifies in the provisions related to the WMAA that a description of dominant hydrologic processes within the watershed must be developed, with GIS layers (maps) as output. The Permit specifically calls for processes "*such as areas where infiltration or overland flow likely dominates*." These particular aspects of the hydrological mechanics of watersheds are particularly important when attempting to understand the macro-scale opportunities for locating projects that take advantage of either capturing overland flow for treatment or for infiltration.

Investigation of the dominant hydrologic processes in the San Diego-area watersheds indicates that evapotranspiration (ET) is the most dominant hydrologic process for the region based on review of a published study (Sanford and Selnick, 2013). ET is the sum of evaporation and plant transpiration in the hydrologic cycle that transports water from land surfaces to the atmosphere. This is conclusion is supported by comparing the 30-year average annual rainfall for the study area (San Diego County east of the peninsular divide) of between 15 and 18 inches per year (San Diego County, 2005) to the average annual ET rates. According to the California Irrigation Management Information System (CIMIS) Reference Evapotranspiration Map (CIMIS, 1999), the study area (within Zones 4, 6, and 9) experiences annual reference ET of 46.6, 49.7 and 59.9 inches, respectively. Therefore, theoretically, if all of the annual precipitation for the San Diego-area watersheds remained stationary where it fell and did not either infiltrate or runoff to local waterbodies where it would be conveyed downstream ultimately to the ocean, it all would be consumed by ET. As such, the effect of ET on the overall hydrologic processes within the San Diego watersheds is a function of the temporal scale over which it acts. Precipitation events often produce runoff in these watersheds, particularly in the urbanized portions, based on the topography and land cover that tend to accelerate the conveyance of runoff downstream rather than collecting, storing, or spreading out that then would maximize the effect of ET.

Because this study is focused on developing information and mapping for the portion of the hydrologic process that informs watershed management decisions, i.e., locating beneficial projects in areas of greatest opportunity, the next tier of dominant hydrologic processes are studied and mapped by this project. As such, the study area was characterized, based on the methodology described in the following section, according to the predicted fate of runoff within the watersheds being either overland flow or infiltration after considering the effects of ET (as well as an intermediate category of interflow). Areas that were mapped as overland flow do not necessarily preclude infiltration but rather indicate the dominant expected process that runoff would experience if not intercepted for the express purpose of infiltrating storm water runoff. The Model BMP Design Manual will provide more detailed guidance and procedures for determining the potential for infiltrating captured storm water at the project level irrespective of the mapping produced in the WMAA. To reiterate, the WMAA mapping is to provide macro-scale processes for high-level analysis and to inform decisions affecting regional scales. Furthermore, the Model BMP Design Manual will indicate the degree to which site-scale BMPs can expect to benefit from ET or how ET is considered in the sizing of BMPs. In brief, typical storm water BMPs only store water for a few days and therefore are not really capable of significant volume disposal through ET. However, pervious area dispersion (i.e., directing storm water runoff to flat areas for spreading and infiltration) has appreciable benefits with regard to ET and is a practice promoted in the BMP Design Manual.

The processes of interest are further defined as follows:

Overland flow: This process can be thought of as the inverse of infiltration; precipitation reaching the ground surface that does not immediately soak in must run over the land surface (thus, "overland" flow). It reflects the relative rates of rainfall intensity and the soil's infiltration capacity: wherever and whenever the rainfall intensity exceeds the soil's infiltration capacity, some overland flow will occur. Most uncompacted, vegetated soils have infiltration capacities of one to several inches per hour at the ground surface, which exceeds the rainfall intensity of even unusually intense storms. In contrast, pavement and hard surfaces reduce the effective infiltration capacity of the ground surface to zero, ensuring overland flow regardless of the meteorological attributes of a storm, together with a much faster rate of runoff relative to vegetated surfaces.

Infiltration and groundwater recharge: These closely linked hydrologic processes are most apparent near ephemeral and perennial conveyances in the San Diego region. Their widespread occurrence is expressed by the common absence of surface-water channels on even steep (undisturbed) hillslopes. Thus, on virtually any geologic material on all but the steepest slopes (or bare rock), infiltration of rainfall into the soil is inferred to be widespread, if not ubiquitous. With urbanization, changes to the process of infiltration are also quite simple to characterize: some (typically large) fraction of that once infiltrating water is now converted to overland flow.

Interflow: Interflow takes place following storm events as shallow subsurface flow (usually within 3 to 6 feet of the surface) occurring in a more permeable soil layer above a less permeable substrate. In the storm response of a stream, interflow provides a transition between the rapid response from surface runoff and much slower stream discharge from deeper groundwater. In some geologic settings, the distinction between "interflow" and "deep groundwater" is artificial and largely meaningless; in others, however, there is a strong physical discrimination between "shallow" and "deep" groundwater movement. Development reduces infiltration and thus interflow as discussed previously, as well as reducing the footprint of the area supporting interflow volume.

The datasets used, methodology for creating the dominant hydrologic processes maps, and the results are described in the sections below.

2.1.1. Datasets Used for identifying dominant hydrologic processes

The following datasets were used in the analysis:

Dataset	Source	Year	Description
Elevation	USGS	2013	1/3rd Arc Second (~10 meter cells) digital elevation model for San Diego County
Soils Data	SanGIS	2013	NRCS (SSURGO) Database for San Diego County downloaded from SanGIS
Land Cover	SanGIS	2013	Ecology-Vegetation layer for San Diego County downloaded from SanGIS

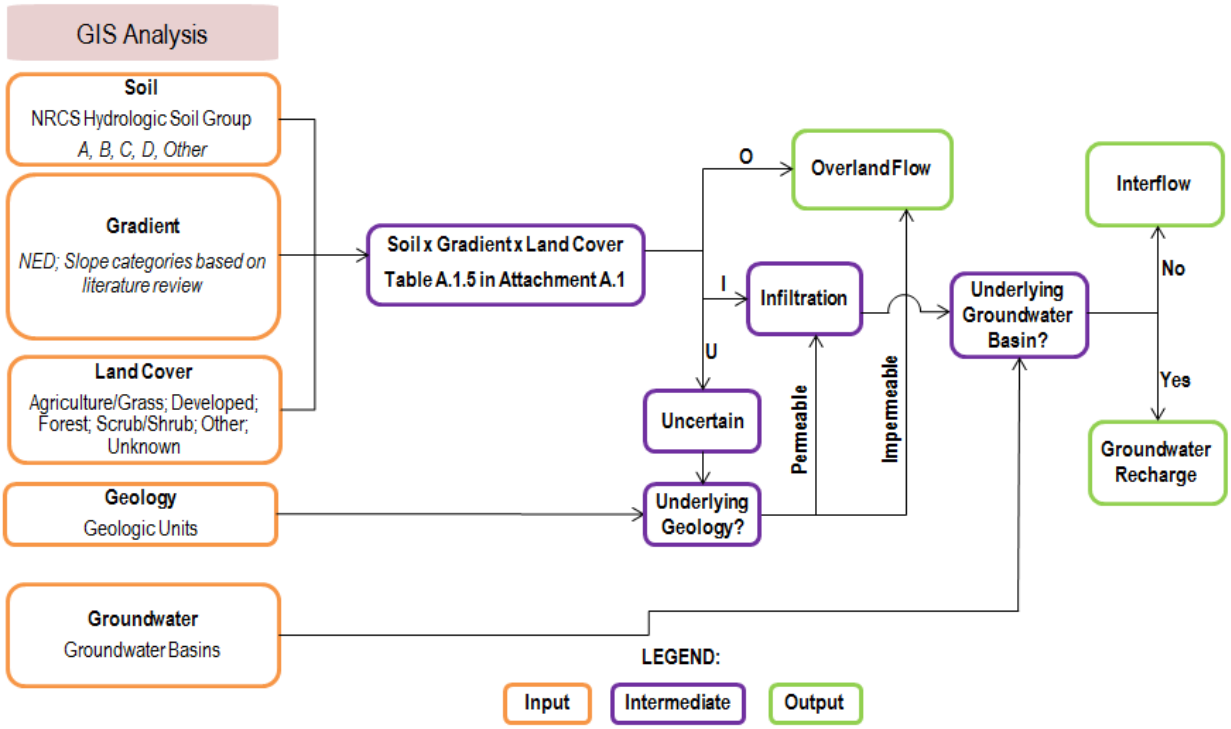
Dataset	Source	Year	Description
Geology	Kennedy, M.P., and Tan, S.S.	2002	Geologic Map of the Oceanside 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 2, 1:100,000 scale.
	Kennedy, M.P., and Tan, S.S.	2008	Geologic Map of the San Diego 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 3, 1:100,000 scale.
	Todd, V.R.	2004	Preliminary Geologic Map of the El Cajon 30'x60' Quadrangle, Southern California, United States Geological Survey, Southern California Aerial Mapping Project (SCAMP), Open File Report 2004-1361, 1:100,000 scale.
	Jennings et al.	2010	"Geologic Map of California," California Geological Survey, Map No. 2 – Geologic Map of California, 1:750,000 scale
Groundwater Basins	SanGIS	2013	Groundwater Basins in San Diego County downloaded from SanGIS

2.1.2. Methodology/Assumptions/Criteria for identifying dominant hydrologic processes

The methodology used to describe dominant hydrologic processes is based on recommendations included in the Southern California Coastal Water Research Project's (SCCWRP) Technical Report 605 titled "Hydromodification Screening Tools: GIS-Based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge" (SCCWRP, 2010). The foundation for this analysis was to incorporate the Report's concept of grouping common hydrologic attributes into Hydrologic Response Units (HRUs). The report states the following:

> *"Grouping common hydrologic attributes across a watershed into a tractable number of Hydrologic Response Units (HRUs: a term first used by England and Holtan 1969) has become a well-established approach for condensing the near-infinite variability of a natural watershed into a tractable number of different elements. The normal procedure for developing HRUs is to identify presumptively similar rainfall–runoff characteristics across a watershed by combining spatially distributed climate, geology, soils, land use, and topographic data into areas that are approximately homogeneous in their hydrologic properties (Green and Cruise 1995, Becker and Braun 1999, Beven 2001, Haverkamp et al. 2005). As noted by Beighley et al (2005), this process of merging the landscape into discrete HRUs is a common and effective method for reducing model complexity and data requirements. Using watershed characteristics to predict runoff is the explicit task of hydrologic models, and there is a host of such models available for application to hydromodification evaluation. For purposes of "screening," however, the goal is simplicity and ease of application even if the precision of the resulting analysis is crude."*

The following process describes the methodology used to define Hydrologic Response Units (HRUs) and then relate the HRUs to the dominant hydrologic processes (i.e., overland flow, interflow, and groundwater recharge) in the 9 WMAs in San Diego County.



The first step is to define the HRUs. Once these are defined, the remaining steps determine the dominant hydrologic process.

1. **Integrate data sets used to determine HRU**: Categories for soil type, gradient, and land cover were defined based on readily available GIS datasets for the region and classifications found in relevant literature, as indicated below. The different combinations of these three categories comprise the distinct HRUs.

    - **Soil Categories**: based on National Resource Conservation Service (NRCS) Hydrologic Soil Group (HSG) classifications, which are commonly used to describe runoff/infiltration potential of soils on a regional scale. These categories include: A, B, C, and D. HSG A soils have the lowest runoff potential, while HSG D soils have the highest runoff potential.

    - **Gradient Categories**: based on slope ranges found in a review of relevant literature identified in Chapter 6. The spatial processing of the slope categories utilized the United States Geologic Survey (USGS) National Elevation Dataset (NED). Slopes were grouped (bins) into the following ranges: 0% to 2%; 2% to 6%; 6% to 10%; and greater than 10%. The 2% and 6% slope thresholds were based on slope ranges included in Table A.1.1 (McCuen, 2005) presented in Attachment A.1. This table provides runoff coefficients as a function of slope, soil group, land cover, and return period and was used for subsequent steps in the mapping effort. The 10% slope threshold was used in SCCWRP's Technical

Report 605 (SCCWRP, 2010) and is a logical cutoff since slopes steeper than 10% are assumed to be dominated by overland flow.

- **Land Cover Categories**: were defined using the Ecology Vegetation GIS map layer developed by the City of San Diego, the County of San Diego and SANDAG and downloaded from SanGIS (2013). The vegetation categories in the GIS layer were grouped (Table A.1.2 in Attachment A.1) to match the following categories used in SCCWRP's Technical Report 605 (SCCWRP, 2010): Agriculture/Grass; Developed; Forest; Scrub/Shrub, Other (Water), and Unknown.

2. **Evaluate Land Cover**: Land cover categories for Agriculture/Grass, Forest, Scrub/Shrub and Other were related to land use categories defined in Table A.1.1 as shown in Table A.1.3 in Attachment A.1. Relating a land use category for the Developed land cover category was not necessary because all Developed cover was assumed to have overland flow as its dominant hydrologic process.
3. **Determine Hydrology Characteristics for Land Covers**: For each of the land cover/land use categories listed in Table A.1.3, the ratio of precipitation lost to evapotranspiration (i.e. an evapotranspiration coefficient) was estimated using Table A.1.1 using the process described below. Since precipitation is considered to be the sum of the resulting runoff, infiltration, and evapotranspiration, the coefficients for these three hydrologic pathways sum to one, as indicated below.

   Runoff Coefficient + Infiltration Coefficient + Evapotranspiration Coefficient = 1

   i) **Estimate Evapotranspiration**: To estimate the evapotranspiration (ET) coefficient for each land cover, first the runoff coefficient was identified in Table A.1.1 for the highest runoff potential (i.e., Group D soil and 6%+ slope) and most common storm conditions (i.e., storm recurrence intervals less than 25 years). The infiltration for these high runoff conditions was assumed to be negligible, resulting in an infiltration coefficient of zero. Since the sum of the three coefficients should sum to one, the ET coefficient was assumed to be the remaining difference (i.e., ET Coefficient = 1 – Runoff Coefficient). The ET coefficient calculated for the highest runoff potential was then applied to all soil types and slopes within that land use category. The calculated ET coefficient for each applicable HRU is provided in Table A.1.4 in Attachment A.1. The ET coefficient for HRUs that have a Developed land cover or a gradient greater than 10% were not calculated since these HRUs were assumed to have overland flow as the dominant hydrologic process.

   ii) **Estimate Infiltration**: The infiltration coefficient for each applicable HRU (i.e., combination of soil, gradient, and land cover) was estimated by subtracting both the runoff coefficient, provided in Table A.1.1, and the ET coefficient, calculated in step 3(i), from one (i.e., Infiltration Coefficient = 1 – Runoff Coefficient – ET Coefficient). The calculated infiltration coefficient for each applicable HRU is provided in Table A.1.4 in Attachment A.1.

   iii) **Estimate Runoff**: For each applicable HRU, the runoff coefficient was divided by

the infiltration coefficient to obtain a ratio representing the potential for runoff or infiltration. The higher the ratio, the greater the potential for runoff to be a more dominant hydrologic process than infiltration. Similarly, the lower the ratio, the greater the potential for infiltration to be a more dominant hydrologic process than runoff. The calculated runoff to infiltration ratios are provided in Table A.1.4 in Attachment A.1.

4. **Associate Runoff and Infiltration to HRUs**: The following designations were assigned to each applicable HRU based on the runoff to infiltration ratio (i.e., runoff coefficient/infiltration coefficient). These designations were based on best engineering judgment with the underlying assumption that if a runoff or infiltration coefficient is more than 50% greater than its counterpart, then the prevailing process is considered dominant.

    - HRUs with runoff to infiltration ratios greater than 1.5 (3:2 ratio) were assumed to have relatively high runoff and overland flow was considered its dominant hydrologic process. These HRUs are designated by the letter "O" (Overland flow is dominant process) in Tables A.1.4 and A.1.5 in Attachment A.1.

    - HRUs with runoff to infiltration ratios less than 0.67 (2:3 ratio) were assumed to have relatively high infiltration and its dominant hydrologic process was either interflow or groundwater recharge, based on analysis described in subsequent steps. These HRUs are designated by the letter "I" (Interflow is dominant process) in Tables A.1.4 and A.1.5.

    - For HRUs with runoff to infiltration ratios between, and including, 1.5 and 0.67 it was uncertain whether it was dominated by overland flow or infiltration. These HRUs are designated by the letter "U" (Dominant process is uncertain) in Tables A.1.4 and A.1.5.

    - For HRUs that have a Developed land cover or a gradient greater than 10%, the runoff to infiltration ratios were not calculated because these HRUs were assumed to have overland flow as the dominant hydrologic process. These HRUs are designated by the letter "O" (Overland flow is dominant process) in Table A.1.5.

5. **Uncertain HRUs Assignment**: For HRUs with an uncertain designation ("U") in Table A.1.5 in Attachment A.1, the underlying regional geology (Kennedy and Tan, 2002 & 2008; Todd, 2004 and Jennings et al., 2010) was used to evaluate whether overland flow or infiltration were dominant. If the underlying geology was considered impermeable, then these uncertain areas were considered to have overland flow as its dominant hydrologic process. If the underlying geology was considered permeable, then these uncertain areas were considered to be dominated by infiltration. The determination of whether a geologic unit is impermeable or permeable was based on desktop evaluation and the best professional judgment of a Certified Engineering Geologist (CEG). This analysis was performed in GIS and is illustrated in the flowchart above.

6. **Associate Infiltration HRUs with Known Groundwater Basins**: For HRUs with relatively high infiltration and have a designation of "I" in Table A.1.5 in Attachment A.1, the presence or absence of a regional groundwater basin (SanGIS, 2013) underlying these areas determined whether the dominant hydrologic process was designated as interflow or groundwater recharge. The groundwater recharge hydrologic process was assigned as dominant for those applicable areas which had an underlying groundwater basin. The interflow hydrologic process was assigned as dominant for those applicable areas which did not have an underlying groundwater basin directly below it. This analysis was performed in GIS and is illustrated in the flowchart above.
7. **Resulting HRU Data:** The resulting GIS map of dominant hydrologic processes was reviewed by engineering professionals familiar with the hydrology in the County of San Diego to confirm that the mapping is consistent with their experience working in the region.

2.1.3. Results for identifying dominant hydrologic processes

The resulting GIS map showing the spatial distribution of dominant hydrologic processes (i.e., overland flow, interflow, and groundwater recharge) within the 9 WMAs is provided in Attachment A.1. An ArcMap document which presents the results from each step of the methodology is included in Attachment C, as well as a Google Earth KMZ file. Based on this analysis, overland flow is the predominant hydrologic process in all 9 WMAs, which is consistent with the experience of engineering professionals familiar with the hydrology of the County of San Diego.

Summary of Deliverables for Dominant Hydrologic Processes

Format	Item	Description	Location
Report	Figure	"Dominant Hydrologic Processes"	Attachment A.1
GIS	Map Group Title	Hydrologic Processes	Attachment C
	Map Layer Title	Soil Land Cover Slope Hydrologic Response Unit Initial Rating Permeability Groundwater Basin Dominant Hydrologic Processes	
	Geodatabase Feature Dataset	HydrologicProcesses	
	Geodatabase Feature Class	HRUAnalysis	
	Geodatabase Geometry Type	Polygon	
KMZ [1]	KMZ File Name	Dominant Hydrologic Processes	Attachment C

[1] To enhance the utilization of this data, the Dominant Hydrological Processes map is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (http://www.google.com/earth/).

2.1.4. Limitations for identifying dominant hydrologic processes

The resulting GIS map layer only lists the dominant hydrological process (i.e., an HRU assigned a dominant process of overland flow can also experience small amounts of infiltration) and provides a useful, rapid framework to perform screening-level analysis that is appropriate for watershed-scale planning studies. When more precise estimates are required for a particular site and subarea it is recommended that this analysis be augmented with site-specific analysis.

2.2.Stream Characterization

For the purpose of WMAA, the Regional MS4 Permit requires a description of existing streams in the watershed, including bed material and composition, and if they are perennial or ephemeral. This analysis was prepared for 27 streams throughout the San Diego Region agreed upon by the consultant team and Copermittees. The 27 streams are listed below and are identified on the exhibit titled "Watershed Management Area Streams" located in Attachment A.2. Streams were selected to provide at least one in each WMA and at least one in each jurisdiction. There is no numeric threshold defining a "stream" for the purpose of the Regional WMAA. Throughout the Regional WMAA, the term "stream" is used as a general term to call out any of the reaches selected for analysis, regardless of watershed area, stream order, flow rate, channel size, length, or designation of "Creek" or "River" within the name.

Regional WMAA Streams:

1. Santa Margarita River
2. San Luis Rey River
3. Buena Vista Creek
4. Agua Hedionda Creek
5. San Marcos Creek
6. Encinitas Creek
7. Cottonwood Creek (Carlsbad WMA)
8. Escondido Creek
9. San Dieguito River – Reach 1
10. San Dieguito River – Reach 2
11. Lusardi Creek
12. Los Peñasquitos/Poway Creek
13. Rattlesnake Creek
14. Carroll Canyon Creek
15. Rose Creek
16. San Diego River
17. Sycamore Creek
18. Woodglen Vista Creek
19. San Vicente Creek
20. Forrester Creek
21. Chollas Creek
22. Sweetwater River – Reach 1
23. Sweetwater River – Reach 2
24. Otay River
25. Jamul/Dulzura Creek
26. Tijuana River
27. Cottonwood Creek (Tijuana WMA)

2.2.1. Datasets Used for stream characterization

The following data were referenced for the purpose of stream characterization:

- USGS National Hydrography Dataset, downloaded from USGS November 2013

- USGS 7.5-minute quadrangles, compiled image of quadrangles covering San Diego County, various dates
- Floodplains: "National Flood Hazard Layer," provided by Federal Emergency Management Agency October 2012
- Various datasets provided by Copermittees depicting existing storm water conveyance infrastructure within their jurisdictions.
- Aerial photography by Digital Globe dated 2012

2.2.2. Methodology/Assumptions/Criteria for stream characterization

The analysis was prepared by digitizing each of the 27 streams based on review of data listed above. Within the pre-existing datasets depicting streams, floodplains, or infrastructure, no single dataset included a complete, accurate alignment of each stream. Digitizing the streams based on review of all of the data listed above allowed creation of GIS linework with a continuous corrected alignment for each stream. The following data were recorded as GIS attributes for each stream as the stream was digitized:

- River name
- Reach type (engineered or natural, constrained or un-constrained)
- Bed material
- Bank material
- Hydrographic category (perennial or intermittent)

The attributes listed above were collected manually based on interpretation of the reference data. Assumptions used in making the interpretations are listed below. The ***Hydrographic Category*** section below will provide the rationale as to why perennial and intermittent were the hydrographic categories chosen for this WMAA and not perennial and ephemeral.

Note that stream classification was not prepared within areas of Federal/State/Indian lands unless data was readily available. Stream lines were prepared within these areas for continuity, but some data fields were not populated within these areas.

Reach Type

Streams were classified as either engineered or natural, and either constrained or un-constrained. See the exhibit titled, "Watershed Management Area Streams by Reach Type" in Attachment A.2. The purpose of this exercise was to identify whether the stream has been modified by human activity within the stream itself, which may include addition of crossing structures, stabilization of banks, dredging, or any other human activity. This aids the identification of physical structures including stream armoring, constrictions, grade control, and other modifications as required by the Regional MS4 Permit.

Classification of the streams as either "**engineered"** or **"natural"** was based on the following criteria:

<u>Engineered</u>

- A classification of "engineered" was assigned where the stream itself has been modified by human activity.
- All culvert/bridge/pipe crossings either provided in the Copermittees' storm water conveyance system data or clearly visible on the aerial photo have been assigned as engineered within the limits of the crossing.
- If the Copermittees did not provide storm water conveyance system data for the dirt road crossings/dip sections the streams have been assigned as engineered within the limits of the crossing. These crossings may or may not have culverts.
- If the Copermittees' storm water conveyance system data stated the facility is a detention or desilting basin, they were assigned as engineered.
- Golf courses have been assigned as engineered.
- If aerial photography showed large water bodies (lake, pond, irrigation pond, etc.) they were assigned as engineered.
- If the storm water conveyance system data provided by the Copermittees has identified the stream as "rockbs", the assumption has been made that these streams have rocks on their bottom and the sides ("bs"), and have been assigned as engineered.
- Sand mining operations have been assigned as engineered. Sand mining is an operation that is in continuous flux and does not typically result in a discrete, engineered geometry in any given channel cross section until restoration is implemented at the conclusion of the sand mining operation. It is assigned as engineered to acknowledge human alteration of the stream.

Natural

- Streams that have no apparent alteration within the stream itself by human activity have been assigned as natural.

Classification of the streams as either **"constrained"** or **"un-constrained"** was based on the following criteria:

Constrained

- All culvers/bridge/pipe crossings either provided in the Copermittees' storm water conveyance system data or clearly visible on the aerial photo have been assigned as constrained.
- If the Copermittees did not provide storm water conveyance system data for the dirt road crossings/dip sections the streams have been assigned as constrained. These crossings may or may not have culverts.
- If the Copermittees' storm water conveyance system data stated the facility is a detention or desilting basin, they were assigned as constrained.
- Golf courses have been assigned as constrained if located within the Federal Emergency Management Agency (FEMA) floodway based on the "National Flood Hazard Layer" data.

- The USGS National Hydrographic Dataset in their hydrographic category had assigned some reaches as artificial paths. In these situations and if the aerial photography shows large water bodies (lake, pond, irrigation pond, etc.) these streams have been assigned as constrained.
- Sand mining operations located within the FEMA floodway based on the "National Flood Hazard Layer" have been assigned as constrained.

Un-constrained

- Golf courses have been assigned as un-constrained if not located within the FEMA floodway based on the "National Flood Hazard Layer" data.
- Sand mining operations not located within the FEMA floodway based on the "National Flood Hazard Layer" data have been assigned un-constrained.
- If the stream is located within the FEMA floodway based on the "National Flood Hazard Layer" and there is available land in the floodway fringe (the area between the floodway and the 100-yeaer floodplain) the area has been assigned un-constrained. Note that there may be only one side or both sides of the stream with available land in the floodway fringe therefore a note was added as to which side of the stream is constrained and un-constrained.
- If the stream is located within a FEMA 100-year floodplain based on the "National Flood Hazard Layer" data with no floodway and the FEMA floodplain width is not within an existing development or bordered by roads have been assigned as un-constrained.

Bed Material and Bank Material

The following bed and bank materials were identified:

- Concrete
- Riprap
- Pipe / culvert
- Earth

The assumptions made to identify the streams bed and bank materials were based on the following criteria:

- If the data provided by the Copermittees provided information about the stream bed and bank material, the provided data was used for the bed and bank material.
- Generally the data provided by the Copermittees did not identify the crossing type (pipe, box culvert, bridge with or without piers, etc.) or the material (RCP, RCB, earth, riprap, concrete, etc.). In that case, all culvert/bridge/pipe crossings were assigned as pipe/culvert for the bed and bank material.
- If the Copermittees did not provide data for the dirt road crossings/dip sections the bed and bank material have been assigned as pipe/culvert. These crossings may or may not have culverts.

- If the Copermittees' storm water conveyance system data stated the facility is a detention or desilting basin, the bed and bank material have been assigned as earth.
- If aerial photography showed large water bodies (lake, pond, irrigation pond, etc.) they were assigned as earth bed and bank material. The USGS National Hydrographic Dataset in their hydrographic category had assigned some of these types of reaches as artificial paths.
- Sand mining operations within the stream have been assigned as earth for bed and bank material.
- If the Copermittees did not provide data for the stream material the bed and bank material have been assigned based on the aerial photography.

See exhibits titled, "Watershed Management Area Streams by Bed Material" in Attachment A.2.

After stream bed and bank material was classified, earthen reaches were further classified by geologic group. This was accomplished by intersecting the streams with the geologic group layer that had been prepared for use in the dominant hydrologic process and potential coarse sediment yield analyses. The result is displayed in exhibits titled, "Watershed Management Area Streams by Geologic Group" in Attachment A.2.

Hydrographic Category

Streams were classified as "perennial" or "intermittent." See exhibits titled, "Watershed Management Area Streams by Hydrographic Category" in Attachment A.2. Classification was obtained from the USGS National Hydrography Dataset (NHD). The definitions of these categories in the USGS National Hydrography Dataset are:

- **Perennial**: Contains water throughout the year, except for infrequent periods of severe drought.
- **Intermittent**: Contains water for only part of the year, but more than just after rainstorms and at snowmelt.

While the specific Regional MS4 Permit language requested classification of perennial or ephemeral, rather than perennial or intermittent, the data that was referenced in order to classify streams did not include "ephemeral" streams. For reference, the USGS National Hydrography Dataset definition of "ephemeral" is: "contains water only during or after a local rainstorm or heavy snowmelt." None of the stream reaches in the study were classified as ephemeral in the NHD dataset, therefore none are classified as ephemeral in the WMAA product. The City of San Diego provided a map titled "City of San Diego Stream Survey" dated April 3, 2013 prepared by AMEC that shows streams that are "dry" and streams that are "flowing". This information in conjunction with the other parameters listed in this section was used to determine if a stream was perennial or intermittent.

USGS NHD includes hydrographic category classification for many of the streams. However data was not available for all reaches of all streams. In order to classify reaches of streams that did not already contain this data in NHD, these assumptions were made:

- The USGS NHD information for the stream hydrographic category has been used when available.
- When USGS NHD has "artificial paths" for portions of the stream, the hydrographic category of the upstream portion of the stream have been assigned to the stream unless other assumptions took precedence.
- If aerial photography shows large waterbody (lake, pond, irrigation pond, etc.) perennial has been assumed for the hydrographic category.
- For ponded areas shown on the aerial photography and if the USGS 7.5-minute quadrangles shows cross hatching for the area, intermittent has been assigned unless the upstream portion of the stream was assigned as perennial pursuant to the USGS National Hydrography Dataset then assigned perennial for the ponded area.
- USGS has a dashed line for intermittent streams. USGS has a solid line for perennial streams. In some situations this information was used to assist in the determination of assigning perennial or intermittent to a stream.

2.2.3. Results for stream characterization

The 27 streams and data are contained in a GIS file titled "SD_Regional_WMAA_Streams" located in Attachment C. The streams are shown in watershed maps included in Attachment A.2.

Summary of Deliverables for Stream Characterization

Format	Item	Description	Location
Report	Title of Figures	• "Watershed Management Area Streams" • "Watershed Management Area Streams by Hydrographic Category" • "Watershed Management Area Streams by Bed Material" • "Watershed Management Area Streams by Geologic Group" • "Watershed Management Area Streams by Reach Type"	Attachment A.2
GIS	Map Group Title	Not Grouped	Attachment C
	Map Layer Title	SD_Regional_WMAA_Streams	
	Geodatabase Feature Dataset	Streams	
	Geodatabase Feature Class	SD_Regional_WMAA_Streams	
	Geodatabase Geometry Type	Line	
KMZ [1]	KMZ File Name	SD_Regional_WMAA_Streams	Attachment C

[1] To enhance the utilization of this data, the Stream Characterization map is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (http://www.google.com/earth/).

In addition to the 27 streams that were subject of detailed analysis, NHD streams have been included on maps and within the geodatabase for reference. The NHD stream alignments have not been corrected and in some cases may be inconsistent with the existing infrastructure. The NHD streams are contained in a GIS file titled, "SD_NHD_Streams."

2.2.4. Limitations for stream characterization

- Only a desktop analysis was performed and no field verification was conducted.
- Infrastructure is only based on storm water conveyance system data provided by Copermittees or clearly visible on aerial photography. If the Copermittee used a numbering or lettering system for describing bed and bank material for example, since the metadata was not provided the bed and bank material could not be verified.
- In some instances concrete channels cannot be identified on aerial photography if it is filled with sediment and/ or vegetation.

2.3.Land Uses

For the purpose of the WMAA, the Regional MS4 Permit requires a description of current and anticipated future land uses. This is presented in the final GIS deliverable as "Land Use Planning" and includes the following representations of land uses in the watersheds: existing land uses, planned land uses, developable lands, redevelopment and infill areas, floodplains, Multiple Species Conservation Program (MSCP) designated areas, and areas not within the Copermittees' jurisdictions (tribal lands, state lands, and federal lands).

2.3.1. Datasets Used for land uses

The following existing regional datasets were referenced to meet this requirement:

- Municipal boundaries: "Municipal_Boundaries" dated August 2012, available from SanGIS/SANDAG
- Ownership: "Parcels" dated December 2013, available from SanGIS/SANDAG
- Existing land use: "SANGIS.LANDUSE_CURRENT" dated December 2012, available from SanGIS/SANDAG (existing land use)
- Planned land use: "PLANLU" (Planned Land Use for the Series 12 Regional Growth Forecast (2050)), dated December 2010, available from SanGIS/SANDAG
- Developable land: "DEVABLE" (Land available for potential development for the Series 12 Regional Growth Forecast), dated December 2010, available from SanGIS/SANDAG
- Redevelopment and infill areas: "REDEVINF" (Redevelopment and infill areas for the Series 12 Regional Growth Forecast), dated December 2010, available from SanGIS/SANDAG
- Floodplains: "National Flood Hazard Layer" provided by Federal Emergency Management Agency October 2012
- Multiple Species Conservation Program (MSCP), total of four datasets available from SanGIS/SANDAG: "MHPA_SD," dated 2012, (Multiple Habitat Planning Areas for City of San Diego); "MSCP_CN," dated 2009 (designations of the County of San Diego's Multiple Species Conservation Program South County Subregional Plan); "MSCP_EAST_DRAFT_CN," dated 2009 (draft East County MSCP Plan); and "Draft_North_County_MSCP_Version_8.0_Categories," dated 2008 (draft North County MSCP Plan)

2.3.2. Methodology/Assumptions/Criteria for land uses

The existing regional datasets for existing land use, planned land use, developable land, redevelopment and infill areas, floodplains, and MSCP designated areas were referenced with no modifications. Areas not within the Copermittees' jurisdictions (tribal lands, state lands, and federal lands) were compiled from SanGIS parcel data (December 2013) based on the "ownership" value. The owners listed below were excluded from the Copermittees jurisdictions and represent the "Federal/State/Indian" layer, which is displayed on various maps included in Attachment A.2.

- Bureau of Land Management
- California Department of Fish and Game
- Indian Reservations
- Military Reservations

- Other Federal
- State
- State of California Land Commission
- State Parks
- U.S. Fish and Wildlife Service
- U.S. Forest Service

When available, relevant data from these areas was included in analyses (e.g., developable land areas within Federal/State/Indian areas). Stream lines were prepared within these areas for continuity. However, stream classification (e.g., bed and bank material) was not prepared within these areas unless data was readily available (e.g., hydrographic category data available from NHD)

2.3.3. Results for land uses

The existing regional datasets are compiled into the Geodatabase in a group titled, "Land Use Planning." Current and anticipated future land uses are depicted in watershed maps included in Attachment C. Federal/State/Indian Lands are also referenced on all other map exhibits included in Attachment A.2.

Summary of Deliverables for Land Uses

Format	Item	Description	Location
Report	Title of Figures	• "Existing Land Use" • "Planned Land Use" • "Developable Land" • "Redevelopment and Infill Areas"	Attachment A.3
GIS	Map Group Title	Land Use Planning	Attachment C
	Map Layer Title	Municipal Boundaries Federal/State/Indian Lands SanGIS_ExistingLandUse SanGIS_PlannedLandUse SanGIS_DevelopableLand SanGIS_RedevelopmentandInfill FEMA Floodplain MHPA_SD MSCP_CN MSCP_EAST_DRAFT_CN Draft_North_County_MSCP_Version_8_Categories	
	Geodatabase Feature Dataset	LandUsePlanning	
	Geodatabase Feature Class	SanGIS_MunicipalBoundaries Federal_State_Indian_Lands SanGIS_ExistingLandUse SanGIS_PlannedLandUse	

Format	Item	Description	Location
		SanGIS_DevelopableLand SanGIS_RedevelopmentandInfill FEMA_NFHL SanGIS_MHPA_SD SanGIS_MSCP_CN SanGIS_MSCP_EAST_DRAFT_CN SanGIS_Draft_North_County_MSCP_Version_8_Categories	
	Geodatabase Geometry Type	Polygon	
KMZ [1]	KMZ File Name	Municipal Boundaries Federal/State/Indian Lands Floodplains Due to file size limitations, SanGIS land use datasets were not converted to KMZ.	Attachment C

[1] To enhance the utilization of this data, the Land Uses map is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (http://www.google.com/earth/).

2.3.4. Limitations

Some jurisdictions may have compiled GIS land use layers that include more detailed or more current information than the regional datasets available from SanGIS. SanGIS layers were selected for the Regional WMAA to provide consistent land use characterization region-wide, and to provide for repeatability of GIS analyses when a land use layer is required for input data. The definition of non-Copermittee areas identified in this document as "Federal/State/Indian Lands" is for the Regional WMAA. Some WQIPs may define non-Copermittee areas differently.

2.4.Potential Critical Coarse Sediment Yield Areas

The Regional MS4 Permit identifies in the provisions related to the WMAA that potential coarse sediment yield areas within the watershed be identified, with GIS layers (maps) as output. With regard to the function and importance of coarse sediment, SCCWRP Technical Report 667 titled "Hydromodification Assessment and Management in California" states the following:

"Coarse sediment functions to naturally armor the stream bed and reduce the erosive forces associated with high flows. Absence of coarse sediment often results in erosion of in-channel substrate during high flows. In addition, coarse sediment contributes to formation of in-channel habitats necessary to support native flora and fauna."

This report identifies the potential critical coarse sediment yield areas for the 9 WMAs in compliance with this permit provision. The applied datasets and methodologies for identifying the coarse sediment yield areas, along with their respective results, are described in the sections below.

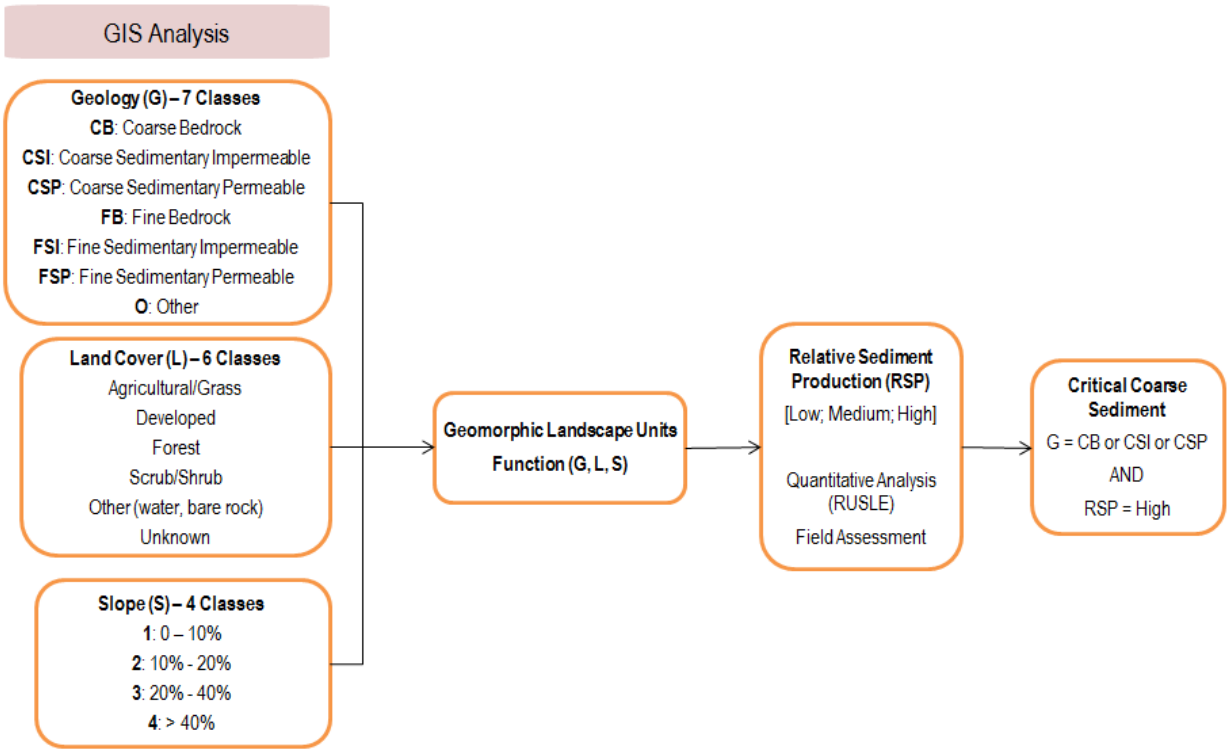
2.4.1. Datasets Used for identifying potential critical coarse sediment yield areas

The following datasets were used in the analysis

Dataset	Source	Year	Description
Elevation	USGS	2013	1/3rd Arc Second (~10 meter cells) digital elevation model for San Diego County
Land Cover	SanGIS	2013	Ecology-Vegetation layer for San Diego County downloaded from SanGIS
Geology	Kennedy, M.P., and Tan, S.S.	2002	Geologic Map of the Oceanside 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 2, 1:100,000 scale.
	Kennedy, M.P., and Tan, S.S.	2008	Geologic Map of the San Diego 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 3, 1:100,000 scale.
	Todd, V.R.	2004	Preliminary Geologic Map of the El Cajon 30'x60' Quadrangle, Southern California, United States Geological Survey, Southern California Areal Mapping Project (SCAMP), Open File Report 2004-1361, 1:100,000 scale.
	Jennings et al.	2010	"Geologic Map of California," California Geological Survey, Map No. 2 – Geologic Map of California, 1:750,000 scale

2.4.2. Methodology/Assumptions/Criteria for identifying potential critical coarse sediment yield areas

The methodology used to identify coarse sediment yield areas is based on Geomorphic Landscape Unit (GLU) methodology presented in the SCCWRP Technical Report 605 titled "Hydromodification Screening Tools: GIS-Based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge" (SCCWRP, 2010). Geomorphic Landscape Units characterize the magnitude of sediment production from areas through three factors judged to exert the greatest influence on the variability on sediment-production rates: geology types, hillslope gradient, and land cover. The GLU approach provides a useful, rapid framework to identify sediment-delivery attributes of the watershed. The process to integrate these factors into GLUs is indicated in the flow chart below.



The following steps were used to define Geomorphic Landscape Units (GLUs), which were then related to the coarse sediment and critical coarse sediment yield areas in the 9 WMAs in San Diego County.

1. **Integrate data sets used to determine GLU:** Categories for geology, gradient, and land cover were defined based on readily available GIS datasets for the region and classifications found in relevant literature listed in Chapter 6. The different combinations of these categories make up distinct GLUs.

    - **Geologic Categories**: based on methodology listed in Attachment A.4.1 of Attachment A.4. Resulting geologic categories from this analysis are: Coarse Bedrock (CB), Coarse Sedimentary Impermeable (CSI), Coarse Sedimentary Permeable (CSP), Fine Bedrock (FB), Fine Sedimentary Impermeable (FSI), Fine Sedimentary

Permeable (FSP), and Other (O). An exhibit showing the regional geology groupings is presented in Attachment A.4.

- **Land cover categories**: defined using the Ecology Vegetation GIS map layer developed by the City of San Diego, the County of San Diego and SANDAG which were downloaded from SanGIS (2013). The vegetation categories in the GIS layer were grouped (Table A.1.2 in Attachment A.1) to match the following categories used in SCCWRP's Technical Report 605 (SCCWRP, 2010): Agriculture/Grass; Developed; Forest; Scrub/Shrub, Other (Water) and Unknown.
- **Gradient Categories**: based on slope ranges found in a review of relevant literature (GLU methodology applied in California) listed in Chapter 6. The spatial processing of the slope categories utilized the USGS National Elevation Dataset (NED). Slope ranges used include: 0% to 10%, 10% to 20%, 20% to 40%, and greater than 40%.

2. **GLU Union Results**: GIS mapping exercise for the study area resulted in 166 GLUs within the 9 WMAs in San Diego County. Table A.4.2 in Attachment A.4 provides the list of the 166 GLUs.

For implementing hydromodification management performance standards in the Regional MS4 Permit, the Copermittees need to identify Critical Coarse Sediment Yield areas in the study region. To provide information on the identification of Critical Coarse Sediment yield, the study assumed that critical coarse sediment would be generated from GLUs that are composed of geologic units likely to generate coarse sediment (based on the methodology listed in Step 3) and have the potential for high relative sediment production (as estimated using the methodology listed in Step 4).

3. **Define Pertinent Geologic groups**: the geologic groups (Attachment A.4.1) considered in this study to have the potential to generate coarse sediment are Coarse Bedrock (CB), Coarse Sedimentary Impermeable (CSI), and Coarse Sedimentary Permeable (CSP). An exhibit showing the regional geologic grouping is presented in Attachment A.4.
4. **Relate GLU to Sediment Production**: For assigning GLUs with a relative sediment production, the following methodology was utilized:
    - Conducted quantitative analysis to assign relative sediment production. Analysis was performed based on the assumption that sediment production from an area is proportional to the soil loss from the area, as evaluated using standard soil loss equation. Detailed analysis steps are documented in Attachment A.4.2;
    - To validate the quantitative assignment above, a qualitative field assessment was conducted for 40 sites. Site selection and findings from the field assessment is documented in Attachment A.4.3.
    - The result of the field assessment indicated a 65% match between field conditions and the quantitative assignments. The mismatches are attributed to differences in percent land cover as assumed for the quantitative analysis and those observed in the field. As such, the quantitative assignments were considered to be valid for the purposes of assigning relative sediment production.

2.4.3. Results for identifying potential critical coarse sediment yield areas

The resulting GIS maps showing the spatial distribution of geologic grouping and critical coarse sediment yield areas within the 9 WMAs in San Diego Region are provided in Attachment A.4. An ArcMap document which presents the results from each step of the methodology is included in Attachment C. Based on this analysis it was estimated that 82% of the study area is a potential coarse sediment yield area and 20% of the study area is a potential critical coarse sediment yield area. The majority of the potential critical coarse sediment yield areas were identified to be on slopes greater than 25% and/or on federal/state lands.

As a result of the regional-scale datasets, and commensurate data resolution, used to map the potential critical coarse sediment yield areas, some areas may have been mapped that in reality do not produce critical coarse sediment as they are existing developed areas. As such, an opportunity for jurisdictions to incorporate more refined data into the preliminary WMAA GIS dataset based on local knowledge and review of current aerial images was provided. The City of Escondido, the City of Encinitas, the City of Del Mar, the City of Poway, National City, and the County of San Diego provided augmented data in their respective jurisdictional areas.

Summary of Deliverables for Potential Critical Coarse Sediment Yield Areas

Format	Item	Description	Location
Report	Figures	"Geologic Grouping" "Potential Critical Coarse Sediment Yield Areas"	Attachment A.4
GIS	Map Group Layer Name	Potential Coarse Sediment Yield	Attachment C
	Map Layer Title	Geologic Grouping Land Cover Slope Category Geomorphic Landscape Unit Potential Coarse Sediment Yield Area Relative Sediment Production Potential Critical Coarse Sediment Yield Area	
	Geodatabase Feature Dataset	PotentialCoarseSedimentYield	
	Geodatabase Feature Class	GLUAnalysis PotentialCoarseSedimentYieldAreas PotentialCriticalCoarseSedimentYieldAreas	
	Geodatabase Geometry Type	Polygon	
KMZ [1]	KMZ File Name	Potential Critical Coarse Sediment Yield Areas	Attachment C

[1] To enhance the utilization of this data, the Geomorphic Landscape Unit Analysis is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (http://www.google.com/earth/).

2.4.4. Limitations for identifying potential critical coarse sediment yield areas

The resulting GIS layers were developed using regional datasets and provide a useful, rapid

framework to perform screening-level analysis that is appropriate for watershed-scale planning studies. The methodology used to identify potential coarse sediment yield areas does not account for instream sediment supply and sediment production from mass failures like landslides which are difficult to estimate on a regional scale without performing extensive field investigation. This data set also does not account for potential existing impediments that may hinder delivery of coarse sediment to receiving waters or downstream locations within the watershed as this was beyond the scope of a regional study. Where more precise estimates are required for a particular site or subarea it is recommended that this analysis be augmented with site-specific analysis. It is also recognized that this regional data set is a function of the inherent data resolution and therefore may not conform to all site conditions, or does not reflect changes to particular areas that have occurred since the underlying data was developed. As such, the Regional WMAA data for the potential critical coarse sediment yield areas should be verified in the field according to the procedures outlined in the Model BMP Design Manual and/or jurisdiction specific BMP Design Manual.

2.5.Physical Structures

The Regional MS4 Permit requires the Copermittees to identify information regarding locations of existing flood control structures and channel structures, such as stream armoring, constrictions, grade control structures, and hydromodification or flood management basins with GIS layers (maps) as output, for each WMA being analyzed for the purpose of developing watershed-specific requirements for structural BMP implementation. This study identified the physical structures using a desktop-level analysis for the 27 streams identified in Section 2.2 in the 9 WMAs in compliance with this permit provision.

2.5.1. Approach for identifying physical structures

The intent of this portion of the WMAA project was to provide an initial assessment of the structures of interest for the 27 river reaches identified in Section 2.2. This desktop-level analysis was conducted primarily as a visual survey of aerial imagery and FEMA flood insurance study (FIS) profiles where available. The collected information was entered into a GIS layer for inclusion into the overall WMAA geodatabase containing the characterization layers required by the Regional MS4 Permit. To support overall WMA characterization, the information derived in this task provides insight into water and sediment movement through the watershed (SCCWRP, 2012), the opportunities and limitations for infrastructure retrofits and also informs efforts to identify appropriate locations for habitat or riparian area rehabilitation in relation to proximate infrastructure. Specific information regarding how the survey was performed and the attributes of the generated data is presented in Attachment A.5. Note that concrete channels, pipes/culverts, riprap or other artificial stream armoring, and basins have also been identified in the linework generated for the 27 streams (see Section 2.2).

2.5.2. Results for identifying physical structures

The resulting GIS maps showing the spatial locations of the physical structures within the 9 WMAs are provided in Attachment A.5.

Summary of Deliverables for Physical Structures

Format	Item	Description	Location
Report	Figure	Watershed Management Area Streams by Reach Type with Channel Structures	Attachment A.5
GIS	Map Group Layer Name	Channel Structures	Attachment C
	Map Layer Title	Channel Structures	
	Geodatabase Feature Dataset	ChannelStructures	
	Geodatabase Feature Class	ChannelStructures	
	Geodatabase Geometry Type	Point	
KMZ [1]	Kmz File Name	ChannelStructures	Attachment C

[1] To enhance the utilization of this data, the Physical Structures map is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (http://www.google.com/earth/).

3. Template for Candidate Project List

The Regional MS4 Permit requires each WMA to use the results from the WMA characterization to compile a list of candidate projects that could potentially be used as alternative compliance options for Priority Development Projects should an agency or jurisdiction opt to develop an alternative compliance program. Copermittees must first conclude that implementing such a candidate project would provide greater overall benefit to the watershed than requiring implementation of structural BMPs onsite prior to implementing these candidate projects as alternative compliance projects.

The Copermittees elected to identify potential candidate projects as a separate effort from this regional project, and therefore the process for identifying candidate projects is not documented in this report. Instead, this project only developed a template, in a spreadsheet format, for use by the Copermittees to compile lists of potential candidate projects. The template is intended to enhance regional consistency of the information that is gathered for candidate projects. The template spreadsheet file was distributed to the Copermittees on January 28, 2014. A table of the template components is indicated below:

Column	Primary Heading	Secondary Heading	Guidance for Completing the Project List
A	Project Identifier	-	Unique identifier for the project.
B	Watershed Management Area	-	Dropdown menu to select the watershed management area the project is located in
C	Hydrologic Area (HA)	-	Dropdown menu to select the hydrologic area the project is located in Select a WMA in column B for HA (Column C) dropdown menu to activate.
D	Hydrologic Subarea (HSA)	-	Dropdown menu to select the hydrologic subarea the project is located in. Select a HA in column C for HSA (Column D) dropdown menu to activate.
E	Jurisdiction	-	Dropdown menu to select the jurisdiction the project is located in. Select a HSA in column D for Jurisdiction (Column E) dropdown menu to activate.
F	Project Name	-	Indicate the name of the project.
G	Ownership	Type	Dropdown menu to select if the project is a public project, private project, or public-private partnership.
H	Ownership	Ownership Information	List the details for the owner.
I	Project Location	Address	List the address of the project site.
J	Project Location	APN	List the APN of the parcel.
K	Project Location	Latitude	List the latitude of the project site.
L	Project Location	Longitude	List the longitude of the project site.

Column	Primary Heading	Secondary Heading	Guidance for Completing the Project List
M	Project Origination/ Originator	Name	List the name of the report/organization/individual that provided the idea for the project. Potential origination sources: WQIP, WMAA, JURMPs, WURMPs, CLRPs, IRWM, MSCP, MHPA, Other.
N	Project Origination/ Originator	Contact Information	Link or report title if the proposed project is from a report [or] contact information if from an organization/individual.
O	Project Category	-	Drop Down menu to select the project category; In addition to the 6 project categories explicitly listed in the Regional MS4 Permit, the drop down menu also has a category "Other project types allowed by the MS4 Permit". Example for “Other” project types are agency CIP programs such as Green Streets, LID conversions (medians, parks), agency filter installation, etc.
P	Specific Project Type	-	List the subcategory of the project; for example, list Regional BMP type (i.e. infiltration basin, wetland, etc.).
Q	Potential Pollutant	-	Identify the potential pollutant(s) that can be treated by the proposed project.
R	Project Size & Parameters	Contributing Drainage Area (acres)	List the contributing drainage area to the project.
S	Project Size & Parameters	Parcel Size (acres)	List the size of the parcel the project is located on.
T	Project Size & Parameters	Project Footprint (acres)	List the size of the project footprint.
U	Project Size & Parameters	Parameters (with units as necessary)	Parameters needed to quantify benefits from the project; i.e. for an infiltration basin, list the water quality volume, long-term infiltration rate, depth of the basin, etc.
V	Regulatory Requirement	-	Indicate if the project is proposed to meet particular regulatory requirement such as TMDL, etc.
W	Project Timeline	-	Indicate if a project must be implemented by certain date to meet a grant deadline or other time commitment.
X	Other Notes	-	List any other relevant notes; for example, when retrofitting existing infrastructure project category is selected, input parameters needed to quantify benefits from existing infrastructure into this column as these will be needed to estimate additional benefits that can be used for alternative compliance. If N/A is selected in any dropdown menus, add additional explanation in here

4. Hydromodification Management Applicability/Exemptions

Hydromodification, which is caused by both altered storm water flow and altered sediment flow regimes, is largely responsible for degradation of creeks, streams, and associated habitats in the San Diego Region. The purpose of the hydromodification management requirements in the Regional MS4 Permit is to maintain or restore more natural hydrologic flow regimes to prevent accelerated, unnatural erosion in downstream receiving waters.

The Regional MS4 Permit allows exemptions at the discretion of the local agencyfor priority development projects that discharge runoff to receiving waters that are not susceptible to erosion (e.g., a reservoir, lake, enclosed embayment, or the Pacific Ocean) either directly or via hardened systems including concrete-lined channels or existing underground storm drain systems.

The March 2011 Final Hydromodification Management Plan (HMP) identified certain exemptions from hydromodification management requirements by presenting "HMP applicability criteria." The Regional MS4 Permit maintains some of these HMP applicability criteria. However, some of the applicability criteria are not included under the Regional MS4 Permit unless the area or receiving water is mapped in the WMAA. The intent of this Section is to provide supporting technical analyses for exemptions that are recommended by the WMAA, and to provide mapping of areas exempt from hydromodification management requirements.

4.1.Additional Analysis for Hydromodification Management Exemptions

This section documents additional analysis performed to further evaluate the following exemptions that were already approved by the San Diego Regional Board with the 2011 Final HMP. This study only provides additional analysis, data, and rationale for supporting or eliminating the following existing exemptions and does not propose or study any new exemptions.

- Exempt River Reaches
- Stabilized Conveyance Systems Draining to Exempt Water Bodies
- Highly Impervious Watersheds and Urban Infill and
- Tidally Influenced Lagoons

4.1.1. Exempt River Reaches

4.1.1.1. History

The March 2011 Final HMP, approved by the SDRWQCB under the 2007 MS4 Permit, provided a potential exemption from hydromodification management requirements for projects discharging runoff directly to certain major river reaches, provided that the outlet elevation of the project's outfall(s) to an identified exempt river reach are between the river bottom elevation and the 100-year floodplain elevation, and properly sized energy dissipation is provided at the outfall(s).

Exempt river systems/reaches from the 2011 Final HMP:

River	Downstream Limit	Upstream Limit
Otay River	Outfall to San Diego Bay	Lower Otay Reservoir Dam
San Diego River	Outfall to Pacific Ocean	Confluence with San Vicente Creek
San Dieguito River	Outfall to Pacific Ocean	Lake Hodges Dam
San Luis Rey River	Outfall to Pacific Ocean	Upstream river limit of Basin Plan subwatershed 903.1 upstream of Bonsall and near Interstate 15
Sweetwater River	Outfall to San Diego Bay	Sweetwater Reservoir Dam

Exemptions related to runoff discharging directly to the above river reaches were based on the flow duration analysis performed for the San Diego River in the Final HMP and the Technical Advisory Committee (formed to provide input on the development of the Final HMP) members' opinion (based on field observations and years of historical perspective) that the above river reaches have very low gradients, were depositional (aggrading), have very wide floodplain areas when in the natural condition and that the effects of cumulative watershed impacts to these reaches is minimal provided that properly sized energy dissipation is provided at outfalls to the rivers.

4.1.1.2. Status under 2013 Regional MS4 Permit

Under the Regional MS4 Permit, exempt river reaches would not qualify for exemption from hydromodification management controls unless the optional WMAA is developed with additional rationale/analyses to support reinstating exemptions to these river reaches. Additional analysis performed as part of the WMAA to evaluate hydromodification management control exemptions to the previously exempt reaches is presented below.

4.1.1.3. Research, Approach and Results

Hydromodification impacts can be caused due to increase in flows, changes in sediment transport capacity and changes in sediment supply to the streams (SCCWRP, 2012). In order to evaluate the cumulative impacts due to development and determine if hydromodification management control exemptions can be reinstated for the river reaches that were exempt in the previous permit term, erosion potential (Ep) analysis was used to evaluate the increase in flows and changes in sediment transport capacity. In addition, sediment supply potential (Sp) analysis was used to evaluate the changes in sediment supply in this study. In regards to Ep analysis

SCCWRP Technical Report 667 "Hydromodification Assessment and Management in California" states:

> *"The underlying premise of the erosion potential approach advances the concept of flow duration control by addressing in-stream processes related to sediment transport. An erosion potential calculation combines flow parameters with stream geometry to assess long term (decadal) changes in the sediment transport capacity. The cumulative distribution of shear stress, specific stream power and sediment transport capacity across the entire range of relevant flows can be calculated and expressed using an erosion potential metric, Ep (e.g., Bledsoe, 2002)."*

The approach used in this study is explained in detail in Attachment B.1.1.1. The following WMA characterization maps developed in Section 2 were used to select inputs for the exempt river reach analysis:

- Planning land use layers from Section 2.3 were used to estimate the existing impervious area and identify the developable parcels in each watershed. A GIS exercise was performed to identify the developable parcels in each watershed that will be exempt from hydromodification management requirements if the exemption is granted.
- Stream type classification analysis from Section 2.2 was used to select a conservative cross section (segments that are assigned naturally constrained) to be used in analysis for each watershed.
- GLU analysis and its associated quantitative analysis described in Section 2.4 were used to determine Sp metric for each watershed. In this study coarse sediment supply changes were limited to changes in hill slope erosion between existing condition and future condition (for parcels that are proposed to be exempt from hydromodification management) of the watershed. It was assumed that the changes in instream sediment supply between existing and future condition for these large depositional river systems are very minimal.

Selection of inputs for the analysis is explained in detail in Attachment B.1.1.2 and results from the analysis are presented in Attachment B.1.1.3 in tabular format. The Ep analysis performed in this study does not account for the following Regional MS4 permit requirements as a conservative assumption. If accounted for, it will result in a smaller Ep than what is currently reported in Attachment B.1.1.3:

- New development priority development projects including projects that are proposed to be exempt from hydromodification management requirements through this WMAA study must implement retention BMPs to the extent feasible if alternative compliance option is not selected or not available.
- Redevelopment priority development projects must mitigate to the pre-developed condition.

4.1.1.4. Recommendation

Based on the results from this study reported in Attachment B.1.1.3, the flow duration analysis performed in the Final HMP, and the Technical Advisory Committee (TAC) recommendations provided during the Final HMP development, it is recommended that hydromodification

management exemption be reinstated for projects discharging runoff directly to the following exempt river reaches:

River	Downstream Limit	Upstream Limit
Otay River	Outfall to San Diego Bay	Interstate 805
San Diego River	Outfall to Pacific Ocean	Confluence with San Vicente Creek
San Dieguito River	Upstream edge of the railroad crossing	Lake Hodges Dam
San Luis Rey River	Outfall to Pacific Ocean	Upstream river limit of Basin Plan subwatershed 903.1 upstream of Bonsall and near Interstate 15
Sweetwater River	Outfall to San Diego Bay	Sweetwater Reservoir Dam

Each municipality must define/approve "direct discharge" based on the project site conditions. To qualify for the potential exemption, the outlet elevation must be between the river bottom elevation and the 100-year floodplain elevation and properly designed energy dissipation must be provided. Mapping of these exempt river reaches is presented in Attachment B.2.

Additional studies to establish a site-specific allowable Ep metric for the Otay River from east of Interstate 805 to Lower Otay Reservoir Dam, more closely representing actual measured and observed characteristics of this river system, may result in allowing hydromodification management exemptions not currently supported by this desktop assessment which was based on an allowable Ep metric from literature. However, any future proposed HMP exemptions would need to be approved through the WQIP Annual Update process (Regional MS4 Permit Section F.1.2.c.).

4.1.1.5. Limitations

The analysis and associated recommendations as presented above were based on instream erosion as the primary consideration to support reinstatement of exemptions from hydromodification management controls for discharges directly to these river reaches. While it is recognized that other factors contribute to adverse impacts (e.g., salinity imbalance, pollutants) to instream habitat and resulting biotic integrity, hydromodification management control has traditionally been considered an "umbrella process" that encompasses most of the highest risk stressors (percent sands and fines present, channel alteration, and riparian disturbance) to physical habitat. Beyond demonstrating that instream erosion is not anticipated as a result of reinstating hydromodification management control exemptions for discharges to these river reaches, a focused method for correlating physical and biotic integrity to modified hydrological conditions has not been performed in this analysis, as an assessment method has not yet been developed.

The current assessment methods may yield inconclusive results when attempting to identify causal relationships between degraded instream habitat solely due to increased flows and erosive force from hydromodification. A causal assessment recently conducted in the lower reaches of the San Diego River, conducted as a partnership between the Southern California Coastal Water

Research Project (SCCWRP), the City of San Diego, the County of San Diego, and the San Diego RWQCB, focused on stressors potentially responsible for known biological impairment of the river. Once the data of the causal assessment become available, it may be useful in classifying the potential stressors such as altered physical habitat as likely, unlikely, or an uncertain cause to biological impairment.

With respect to adverse impacts to habitat as a result of pollutants entrained in storm water discharges, these areas will still be subject over time to the pollutant control requirements of the Regional MS4 Permit as areas develop or redevelop. The current requirements obligate development to maximize retention of the design storm volume which will mitigate a portion of the volume that would otherwise be controlled with hydromodification management BMPs. In some cases, this offsetting of volume reduction through pollutant control BMPs may exceed the HMP volumes. In addition, the development that occurs within the exempted watershed areas is still required to provide any applicable flood control measures. Risk of flooding as a result of exemption from hydromodification controls is unlikely as the control thresholds are significantly lower (order of magnitude) than flood control requirements implemented to protect life and property.

4.1.2. Stabilized Conveyance Systems Draining to Exempt Water Bodies

4.1.2.1. History

The March 2011 Final HMP, approved by the SDRWQCB under the 2007 MS4 Permit, provided a potential exemption from hydromodification management requirements for projects discharging runoff directly to hardened or rehabilitated systems that extend to exempt receiving waters. As described in the HMP, hardened or rehabilitated systems could include existing storm drain systems, existing concrete channels, or stable engineered unlined channels. To qualify for this exemption, the existing hardened or rehabilitated conveyance system must continue uninterrupted to the exempt system. In other words, the hardened or rehabilitated conveyance system cannot discharge to an unlined, non-engineered channel segment prior to discharge to the exempt system. Additionally, the project proponent must demonstrate that the hardened or rehabilitated conveyance system has capacity to convey the 10-year ultimate condition flow through the conveyance system. The 10-year flow should be calculated based upon single-event hydrologic criteria as detailed in the San Diego County Hydrology Manual.

This exemption was consistent with 2007 MS4 Permit language allowing exemption for discharges into "channels that are concrete-lined or significantly hardened (e.g., with rip-rap, sackrete, etc.) downstream to their outfall in bays or the ocean." The HMP language also allowed for channels stabilized by soft methods such as turf reinforcement mat or vegetation to be considered for exemption. Under these criteria, an engineered channel that is stabilized with riprap, turf reinforcement mat, vegetation, or other materials other than concrete could be determined to be exempt from hydromodification management requirements, pending demonstrating that it has capacity to convey the 10-year ultimate condition flow.

4.1.2.2. Status under 2013 Regional MS4 Permit

A significant change under the Regional MS4 Permit is the requirement that exempt systems draining to exempt water bodies either be "existing underground storm drain systems," or "conveyance channels whose bed and banks are concrete lined" all the way to exempt water bodies. The Regional MS4 Permit language does not include engineered channels that are stabilized with materials other than concrete, such as riprap, turf reinforcement mat, or vegetation. However, areas identified by Copermittees as appropriate for an exemption may be identified in the optional WMAA incorporated into the WQIP.

4.1.2.3. Research and Results

To provide a process for engineered channels that are stabilized with materials other than concrete, such as riprap, turf reinforcement mat, or vegetation to be identified in the WMAAs, an example study was prepared for an existing engineered channel stabilized with vegetation. The study demonstrates that a channel stabilized with materials other than concrete can be stable or have minimal potential for erosion. In order to allow for other channels that are stabilized with materials other than concrete to be identified in each WMAA, criteria for defining what is "stable" or "minimal potential for erosion" was determined.

Forrester Creek in the City of Santee was selected for the sample channel analysis. Forrester Creek is stabilized with vegetation from its confluence with the San Diego River downstream to Prospect Avenue upstream. For the purpose of this discussion, the confluence is the location where the floodplain of Forrester Creek meets the San Diego River floodplain, just west of

Gorge Avenue and Willowgrove Avenue, at the eastern side of the Carlton Oaks Golf Course. Stabilization occurred in two separate projects. The reach from the San Diego River confluence downstream to Mission Gorge Road upstream was constructed in 1990. The reach from Mission Gorge Road downstream to Prospect Avenue upstream is known as the Forrester Creek Improvement Project and was constructed in 2006-2007. Forrester Creek includes energy dissipators stabilized with riprap, concrete, and articulated concrete block at Mission Gorge Road undercrossing and Prospect Avenue undercrossing. Other than at bridge crossings, the engineered un-lined reach of Forrester Creek is stabilized with native vegetation. There is dense growth of trees in the channel.



Vegetation in Forrester Creek Downstream of Mission Gorge Road



Vegetation in Forrester Creek Upstream of Mission Gorge Road between Mission Gorge Road and State Route 52



Vegetation in Forrester Creek between State Route 52 and Olive Lane

Upstream of Prospect Avenue, Forrester Creek is a concrete-lined channel serving an urban area that is almost fully built out and served by existing underground storm drain systems and concrete-lined channels. Because of the vegetated reaches of Forrester Creek extending to the San Diego River, the concrete-lined portion of Forrester Creek and tributary underground storm drain systems and concrete-lined channels are not exempt from hydromodification management requirements unless the vegetated reaches of Forrester Creek are identified in the optional WMAA incorporated into the WQIP.

An erosion potential analysis was prepared for the vegetated reaches of Forrester Creek. An erosion potential analysis compares cumulative excess shear stress over all flows capable of transporting the channel-bed material from post-development to pre-development condition. The analysis used the same methods for determining erosion potential as presented in Section 4.1.1 and Attachment B.1.1 for the major river reaches.

For the purpose of determining flow rates and durations (hydrologic analysis), a regional scaling procedure developed by Hawley & Bledsoe in 2011 was used, the same method as presented in Section 4.1.1 and Attachment B.1.1 for the major river reaches. The method uses Duration Density Functions (DDFs) presented in the 2011 paper, "How do flow peaks and durations change in suburbanizing semi-arid watersheds? A southern California case study," to estimate cumulative durations for geomorphically-effective flows in a logarithmically-binned histogram format. Using these flows, long-term sediment transport can be subsequently estimated. The

analysis requires the following data, summarized below.

Summary of Input Data for Hydrologic Calculations for Forrester Creek Erosion Potential Analysis

Data	Units	Forrester Creek Watershed Existing Condition	Forrester Creek Watershed Future Condition
Tributary Area, A	square miles (mi^2)	23.36	23.36
Mean Annual Precipitation, MAP	inches	14	14
Length of Daily Flow Record	Years	30	30
Minimum Flow Rate	cubic feet per second	0.01	0.01
Number of Flow Bins	--	25	25
Impervious Cover	mi^2/ mi^2	0.4634	0.4792

Impervious cover for the Forrester Creek watershed was determined by assigning land-use specific imperviousness values to the land use categories presented in the SanGIS land use data sets (existing land use in 2012 and planned land use, described in Chapter 2.3). The composite imperviousness of the watershed was then calculated based on the existing condition and future condition land use distribution within the watershed. The Forrester Creek watershed is nearly fully built out therefore there is little change in imperviousness from existing to future condition. Impervious area calculations for the Forrester Creek watershed are provided in Attachment B.1.2.

For the purpose of determining shear stress in the channel (hydraulic analysis), normal depth calculations for the binned flow rates determined from the DDF analysis were prepared for two channel cross sections. One cross section was taken in the reach constructed in 1990, and one cross section in the Forrester Creek Improvement Project reach. For each reach, the cross section expected to experience the greatest shear stress was selected, based on channel width and slope. The analysis requires the following data, summarized below.

Summary of Input Data for Hydraulic Calculations for Forrester Creek Erosion Potential Analysis

Data	Units	Forrester Creek Watershed Cross Section 1300	Forrester Creek Watershed Cross Section 2475
Channel Bottom Width, b	feet	84	155
Channel Side Slopes, z1 and z2	Horizontal:Vertical	z1 = 1.5:1 z2 = 2:1	z1 = z2 = 2:1
Channel Slope	foot/foot	0.006	0.003
Channel Roughness (Manning's n)	--	0.100	0.100
Critical Shear Stress	pounds per square foot (lb/ft^2)	2.1	2.1

Critical shear stress for the reaches was estimated to be greater than or equal to 2.1 pounds per square foot (lb/ft2), based on review of permissible shear stress values presented in "Stability Thresholds for Stream Restoration Materials" (Fischenich 2001) and "Streambank Soil Bioengineering Considerations for Semi-Arid Climates" (Hoag and Fripp 2005). Based on Fischenich 2001, permissible shear stress for "live willow stakes" is approximately 2.10 to 3.10 lb/ft2.

The analysis results, presented in Attachment B.1.2, show that for both the existing and future condition, the shear stress for all geomorphically-effective flows based on the DDF analysis is less than the estimated critical shear stress of 2.1 lb/ft2. This means that no excess shear stress or "work" occurs in the channel in either the existing or future condition. Therefore, there is no increase in the duration of "work" (cumulative work), in the future condition, and erosion potential is 1.0.

Note that while the flow rates are the same in both the existing and future condition analyses, the duration of each flow rate is increased in the future condition. The flow rates in the flow bins are based on the watershed area, mean annual precipitation, and length of the synthetic record. These do not change from existing to future condition. The duration for each flow bin is related to the watershed area, mean annual precipitation, length of the synthetic record, and the impervious area. The duration increases in the future condition based on the increased impervious area. The increase in duration would result in increased cumulative work in the future condition if any of the flow rates resulted in shear stress greater than the estimated critical shear stress (excess shear stress, or "work"), because cumulative work is the product of work times duration.

The scenario that occurred in the Forrester Creek analysis, in which no work occurred in the expected range of geomorphically-effective flow rates, is a potential scenario for engineered channels because engineered conveyance systems are typically engineered for flood flows much greater and less frequent than the geomorphically-effective flows. For example, Forrester Creek is engineered to convey a 100-year single-storm event flow rate of approximately 12,450 to 13,840 cubic feet per second (cfs) within the channel. ForresterThe maximum geomorphically-effective flow rate for Forrester Creek based on the DDF analysis is 836 cfs.

4.1.2.4. Recommendation

Based on the study that was prepared for this Regional WMAA, the vegetated reaches of Forrester Creek from its confluence with the San Diego River downstream to Prospect Avenue upstream are recommended to be exempt from hydromodification management requirements. The analysis has shown that future increases in impervious area within the watershed are not expected to increase the erosion potential in Forrester Creek. The concrete-lined portion of Forrester Creek and existing storm drain systems draining directly to the concrete-lined portion of Forrester Creek should also be exempt. Storm drain systems draining directly to the vegetated reaches of Forrester Creek would also be exempt if there is no evidence of localized erosion issues at the storm drain outfall.

Because engineered conveyance systems are typically engineered to convey flood flows much greater than the geomorphically-effective flows, some engineered conveyance systems may be capable of conveying all geomorphically-effective flows at very low depths with shear stress less than critical shear stress, as was the case for Forrester Creek. Based on this, other engineered conveyance systems that are stabilized with materials other than concrete, such as riprap, turf reinforcement mat, or vegetation, including rehabilitated stream systems, and/or existing natural

stream systems that appear stable based on visual inspection may be studied using the exemption methodology presented in Attachment E. Systems evaluated using this methodology and that meet the criteria presented below, may be recommended as exempt systems in the optional WMAA incorporated into the WQIP. However, any future proposed HMP exemptions would need to be approved through the WQIP Update process (Regional MS4 Permit Section F.2.c.).

The following are additional requirements and criteria for the qualifying for potential exemption:

- To qualify for exemption, the studied conveyance system must discharge to an exempt system (i.e., an exempt water body, an exempt river reach, or an existing storm drain system or concrete-lined channel that extends all the way to an exempt water body or exempt river reach). In other words, the studied conveyance system cannot discharge to a non-exempt channel segment prior to discharge to the exempt system.
- The river reach exemptions were established based on assumptions that certain stabilized conveyance systems were exempt and associated tributary developments were exempt from hydromodification management flow control requirements. Therefore if a conveyance system that is being studied for exemption is tributary to an exempt river reach, exemption of the studied conveyance system is only feasible if the conveyance system was included in the analysis of the exempt river reach (see Attachment B.1.1), or pending submittal of an updated analysis for the exempt river reach to include the additional stabilized conveyance system.
- Channel cross section(s) must be selected to represent the condition where the greatest shear stress is expected in the channel(s).

4.1.3. Highly Impervious/Highly Urbanized Watersheds and Urban Infill

4.1.3.1. History

The March 2011 Final HMP, approved by the SDRWQCB under the 2007 MS4 Permit, provided a potential exemption from hydromodification management requirements for projects discharging runoff to a highly urbanized watershed (defined as an existing, pre-project impervious percentage greater than 70 percent) (herein "highly impervious / highly urbanized watersheds exemption") and another potential exemption for urban infill projects discharging runoff to an existing hardened or rehabilitated conveyance system, where the existing impervious area percentage in the watershed exceeds 40 percent (herein "urban infill exemption").

To qualify for the highly impervious / highly urbanized watersheds exemption, watershed impervious area calculations must be measured between the project site discharge location and the connection to a downstream exempt system. If a tributary area connects with the main line drainage path between the project site and the exempt system, then the entire watershed area contributing to the tributary shall be included in the calculation.

To apply the urban infill exemption for a project, the domain of analysis must be determined and the existing hardened or rehabilitated conveyance system must extend beyond the downstream terminus of the domain of analysis. The hardened or rehabilitated conveyance system must discharge to a receiving channel with a Low potential for channel susceptibility for this exemption to be granted (channel susceptibility determined using SCCWRP tool). Additionally, the exemption could only be granted if the potential future development impacts in the watershed would increase the watershed's impervious area percentage by less than 3 percent (as compared to the existing condition in the year 2010). If the potential future cumulative impacts in the watershed could increase the impervious area percentage by more than 3 percent (as compared to existing condition), then no exemption could be granted based on this item. Watershed impervious area calculations for this potential exemption must be measured upstream from the outfall of the urban conveyance system (to a non-concrete, non-riprap-lined or non-engineered channel) to the contributing watershed boundary (the entire watershed contributing to the discharge outfall).

4.1.3.2. Status under 2013 Regional MS4 Permit

Under the Regional MS4 Permit, highly impervious / highly urbanized watersheds and urban infill areas would fall under the category of areas identified by Copermittees as appropriate for an exemption. These areas may be identified in the optional WMAA incorporated into the WQIP.

4.1.3.3. Research and Results

The highly impervious / highly urbanized watersheds exemption was based on 2007 MS4 Permit language that exempted "construction of projects where the sub-watersheds below the projects' discharge points are highly impervious (e.g., >70%) and the potential for single-project and/or cumulative impacts is minimal." No modeling was prepared in support of this exemption during development of the March 2011 Final HMP – the exemption was provided by the 2007 MS4 Permit.

The urban infill exemption was based on a sensitivity analysis presented in Appendix F of the March 2011 Final HMP. The analysis was prepared using continuous simulation modeling of synthetic unit watersheds. The level of imperviousness was progressively increased for each synthetic unit watershed to simulate infill development. The flow duration statistics were examined to determine at what level of increased development the statistics became noticeably altered. Based on the study it was determined that urban infill projects have a relatively minor effect on the overall watershed's flow duration curve if the future cumulative additional impacts have the potential to increase the existing watershed impervious area by less than 3 percent. "Relatively minor effect" was not defined with a numeric threshold in Appendix F of the March 2011 Final HMP.

The sensitivity analysis prepared for the urban infill exemption examined synthetic unit watersheds with 40, 50, and 60 percent imperviousness. The extent of the spread in the results of the 40, 50, and 60-percent models demonstrated that unchecked development within urbanized watershed would have a noticeable effect on the peak flows and flow durations observed within the receiving waters. While watersheds 70% impervious and above were not modeled, unchecked development within these "highly impervious / highly urbanized watersheds" may also have a noticeable effect on the peak flows and flow durations observed within the receiving waters.

Since the adoption of the March 2011 Final HMP, a study titled, "Channel Enlargement in Semiarid Suburbanizing Watersheds: A Southern California Case Study," prepared by R.J. Hawley and B.P. Bledsoe, was published in Journal of Hydrology 496 (2013). The study presented a numeric threshold at which channel enlargement could be expected. In the study, "the threshold corresponding to the presence/absence of headcutting varied based on substrate type, and was roughly quantified as a sediment-transport ratio greater than ~1.20 in systems with a median grain size > 16 mm, and Lr ~1.05 when d50 < 16 mm." Sediment-transport ratio or Lr is the ratio of the cumulative excess shear stress over all flows capable of transporting the channel-bed material from post-development to pre-development condition. This is also known as "effective work index" or "erosion potential."

Using thresholds of 1.20 for systems with a median grain size > 16 mm, and 1.05 for systems with a median grain size < 16 mm, Geosyntec Consultants prepared a study in support of the Ventura County Hydromodification Control Plan (Ventura County HCP) to evaluate thresholds for additional impervious cover, from existing conditions (at the time of the HCP effective date) to build-out conditions, for the area tributary to a susceptible receiving water below which the risk of hydromodification impacts is considered negligible for that channel. The study is titled, "Basis for Designating Negligible Risk Based on Cumulative Future Buildout," and is presented in Appendix D of the Ventura County HCP (Final Draft dated September 2013). A copy of Appendix D of the Ventura County HCP (Final Draft dated September 2013) is provided in Attachment B.1.3. The following are the results of the study, presented as a function of a susceptible channel's tributary area (A) and median grain size (D50):

- If A > 1 square mile and D50 < 16 mm, then the threshold of additional imperviousness is evaluated using a nomograph that is based on empirical flow duration equations (Hawley and Bledsoe, 2011), empirical channel geometry relationships (Coleman et al, 2005 and County of San Diego, 2009), and Erosion Potential analyses. The results range

from 0.46% to 1.00% additional imperviousness, depending on watershed size and mean annual precipitation (MAP).

- If A < 1 square mile and D50 < 16 mm, then the threshold of additional imperviousness is 0.44%.
- If D50 > 16 mm, then the threshold of additional imperviousness is 1.65%.

The thresholds of additional imperviousness presented in the Ventura County HCP (ranging from 0.44% to 1.65%) are lower than the 3% allowable limit presented in the San Diego County Final HMP dated March 2011.

4.1.3.4. Recommendation

Based on evaluation of the exemptions presented in the March 2011 Final HMP and comparison with more recent research prepared for the Ventura County HCP, resurrection of the highly impervious / highly urbanized and urban infill exemptions from the March 2011 Final HMP is not recommended. The research prepared in support of the Ventura County HCP determined lower thresholds of additional impervious area (ranging from 0.44% to 1.65%) than the limit presented in the San Diego County Final HMP dated March 2011 (3%).

4.1.4. Tidally Influenced Lagoons

4.1.4.1. History

The March 2011 Final HMP, approved by the SDRWQCB under the 2007 MS4 Permit, provided a potential exemption from hydromodification management requirements for projects discharging runoff directly to a tidally-influenced lagoon. To qualify for the potential exemption, additional analysis would be required to assess the effects of the freshwater / saltwater balance and the resultant effects on lagoon-system biology. This assessment, which would be required by other permitting processes such as the Army Corps of Engineers, California Department of Fish and Game, etc., must be provided by a certified biologist or other specialist as approved by the governing municipality. Additionally, project discharges must include an energy dissipation system (riprap, etc.) designed to mitigate 100-year outlet velocities based upon a free outfall condition.

4.1.4.2. Status under 2013 Regional MS4 Permit

The Regional MS4 Permit language discussing exemptions from hydromodification management does not specifically include the terminology that was used in the Final HMP including, "tidally influenced lagoons" or "tidally influenced areas." The Permit does indicate that exemptions from hydromodification management may be granted for discharges from existing underground storm drains and concrete lined conveyance channels to “enclosed embayments” (lagoons). However, other drainage systems not meeting the above definition may be identified by Copermittees as appropriate for an exemption in the optional WMAA incorporated into the WQIP.

4.1.4.3. Recommendation

Engineered conveyance systems discharging to lagoons that are stabilized with materials other than concrete, such as riprap, turf reinforcement mat, or vegetation, including rehabilitated stream systems, and/or existing natural stream systems that appear stable based on visual inspection may be studied using the exemption methodology presented in Attachment E. Systems evaluated using this methodology and that meet the criteria presented below, may be recommended as exempt systems in the optional WMAA incorporated into the WQIP. However, any future proposed HMP exemptions would need to be approved through the WQIP Update process (Regional MS4 Permit Section F.2.c.).

The following are additional requirements and criteria for the qualifying for potential exemption:

- To qualify for exemption, the studied conveyance system must discharge to an exempt system (i.e., an exempt water body, an exempt river reach, or an existing storm drain system or concrete-lined channel that extends all the way to an exempt water body or exempt river reach). In other words, the studied conveyance system cannot discharge to a non-exempt channel segment prior to discharge to the exempt system.
- Channel cross section(s) must be selected to represent the condition where the greatest shear stress is expected in the channel(s)

5. Conclusions

5.1. Watershed Management Area Characterization

The WMA Characterization data was developed using available regional data to further understand the macro-scale watershed characteristics and processes in the San Diego permit region. The Regional MS4 Permit allows for flexibility in complying with land development requirements when using the information developed in the WMAA to improve water quality planning and implementation associated with land development. This dataset will assist with identifying the opportunities and constraints for projects and management decisions based on a watershed-scale (rather than piecemeal project identification without context within the watershed) and provides Copermittees the ability to exercise the option to create an alternative compliance program that offers the opportunity to develop watershed-specific alternatives to universal onsite structural BMP implementation. The characterization data includes:

Characterization Data	Utilization Potential
Dominant Hydrologic Process: • Overland flow • Infiltration • Interflow	• Identify areas for enhanced infiltration or collection of storm water for treatment • Implement management measures that correspond to pre-development conditions – promotes long-term channel stability and health • Increases understanding of the natural functioning of the watershed and what has been (or is at risk of being) altered by urbanization.
Stream Characterization: • Reach type • Bed material • Bank material • Hydrographic category • Channel infrastructure	• Preliminary dataset that can be used to conduct stream power evaluations • Identify channel systems for preservation or restoration • Identification of appropriate space for channel processes to occur (e.g., flood plain connectivity) • Insight to sensitivity of receiving stream reach • Indicates the features within channels that affect water and sediment movement through the watershed

Characterization Data	Utilization Potential
Land Use: • Existing • Future	• Foresight (identifies relative risks, opportunities, or constraints) in comparing future to existing land uses, i.e., areas that may be more/less vulnerable to adverse impacts to changes in storm water runoff associated with development • Encourage infill development
Potential Critical Coarse Sediment Yield Areas	• Preservation of areas or function that contributes critical sediment within the watershed to stream armoring/stability • Assist with identifying potentially susceptible stream reaches that require uninterrupted coarse sediment supplies to remain stable • Dual goal of open space conservation

Regarding the identification of the potential critical coarse sediment yield areas in the Regional WMAA using readily available regional datasets, it is anticipated that when more precise estimates for potential critical coarse sediment yield areas are required for a particular site or subarea that this regional study will be augmented with site-specific analysis. Development projects must avoid critical sediment yield areas or implement measures that allow critical coarse sediment to be discharged to receiving waters, such that there is no net impact to the receiving water to meet the requirements of the Regional MS4 permit. As such, projects should consult the Model BMP Design Manual and/or jurisdiction specific BMP Design manual for options to meet the Regional MS4 permit requirements. It is anticipated that the data will not be static but will be enhanced over time through future studies or field assessments that will refine what is currently a macro-level data set.

5.2. Template for Candidate Project List

It is anticipated the Copermittees that elect to develop alternative compliance programs will conduct a separate exercise to nominate potential candidate projects for inclusion into the WQIPs using the template developed for this project.

5.3. Hydromodification Management Exemptions

Attachment B.2 presents hydromodification management applicability/exemption mapping. The mapping includes receiving waters that are exempt based on the Regional MS4 Permit or recommended exempt based on studies.

Receiving waters that are **exempt** based on the Regional MS4 Permit include:

- The Pacific Ocean
- San Diego Bay
- Mission Bay
- Lakes and Reservoirs
- Existing underground storm drains or concrete-lined channels draining directly to bays or the ocean

Receiving waters or conveyance systems that are recommended exempt based on studies that were prepared as part of the Regional WMAA or prepared by others and provided for this purpose include:

- Otay River from Outfall at San Diego Bay to Interstate 805
- San Diego River from Pacific Ocean to confluence with San Vicente Creek
- San Dieguito River from upstream edge of the railroad crossing to Lake Hodges Dam
- San Luis Rey River from Pacific Ocean to upstream river limit of Basin Plan subwatershed 903.1 upstream of Bonsall and near Interstate 15
- Sweetwater River from San Diego Bay to Sweetwater Reservoir Dam
- Forrester Creek stabilized reach from the confluence with the San Diego River to Prospect Avenue

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San Diego County Regional Watershed Management Area Analysis ATTACHMENTS



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October 2015

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ATTACHMENT A

WATERSHED MANAGEMENT AREA CHARACTERIZATION

ATTACHMENT A.1
DOMINANT HYDROLOGICAL PROCESS

A.1 Dominant Hydrological Process

Table A.1.1: Runoff Coefficients versus Land Use, Hydrologic Soil Group (A, B, C, D), and Slope Range

	A			B			C			D		
Land Use	0–2%	2–6%	6%+	0–2%	2–6%	6%+	0–2%	2–6%	6%+	0–2%	2–6%	6%+
Cultivated land	0.08[a]	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
	0.14[b]	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Pasture	0.12	0.20	0.30	0.18	0.28	0.37	0.24	0.34	0.44	0.30	0.40	0.50
	0.15	0.25	0.37	0.23	0.34	0.45	0.30	0.42	0.52	0.37	0.50	0.62
Meadow	0.10	0.16	0.25	0.14	0.22	0.30	0.20	0.28	0.36	0.24	0.30	0.40
	0.14	0.22	0.30	0.20	0.28	0.37	0.26	0.35	0.44	0.30	0.40	0.50
Forest	0.05	0.08	0.11	0.08	0.11	0.14	0.10	0.13	0.16	0.12	0.16	0.20
	0.08	0.11	0.14	0.10	0.14	0.18	0.12	0.16	0.20	0.15	0.20	0.25
Residential lot size 1/8 acre	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Residential lot size 1/4 acre	0.22	0.26	0.29	0.24	0.29	0.33	0.27	0.31	0.36	0.30	0.34	0.40
	0.30	0.34	0.37	0.33	0.37	0.42	0.36	0.40	0.47	0.38	0.42	0.52
Residential lot size 1/3 acre	0.19	0.23	0.26	0.22	0.26	0.30	0.25	0.29	0.34	0.28	0.32	0.39
	0.28	0.32	0.35	0.30	0.35	0.39	0.33	0.38	0.45	0.36	0.40	0.50
Residential lot size 1/2 acre	0.16	0.20	0.24	0.19	0.23	0.28	0.22	0.27	0.32	0.26	0.30	0.37
	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.48
Residential lot size 1 acre	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.29	0.35
	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Industrial	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.89	0.90
Streets	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78
	0.76	0.77	0.79	0.80	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Open space	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.15	0.21	0.28
	0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Parking	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97

[a] Runoff coefficients for storm recurrence intervals less than 25 years.

[b] Runoff coefficients for storm recurrence intervals of 25 years or longer.

Source: Table 7-9 in *Hydrologic Analysis and Design* (McCuen, 2005)

Table A.1.2: Land Cover Grouping

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
1	42000 Valley and Foothill Grassland	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Agricultural/Grass
2	42100 Native Grassland		Agricultural/Grass
3	42110 Valley Needlegrass Grassland		Agricultural/Grass
4	42120 Valley Sacaton Grassland		Agricultural/Grass

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
5	42200 Non-Native Grassland	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Agricultural/Grass
6	42300 Wildflower Field		Agriculture/Grass
7	42400 Foothill/Mountain Perennial Grassland		Agriculture/Grass
8	42470 Transmontane Dropseed Grassland		Agriculture/Grass
9	45000 Meadow and Seep		Agriculture/Grass
10	45100 Montane Meadow		Agriculture/Grass
11	45110 Wet Montane Meadow		Agriculture/Grass
12	45120 Dry Montane Meadows		Agriculture/Grass
13	45300 Alkali Meadows and Seeps		Agriculture/Grass
14	45320 Alkali Seep		Agriculture/Grass
15	45400 Freshwater Seep		Agriculture/Grass
16	46000 Alkali Playa Community		Agriculture/Grass
17	46100 Badlands/Mudhill Forbs		Agriculture/Grass
18	Non-Native Grassland		Agriculture/Grass
19	18000 General Agriculture	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Agriculture/Grass
20	18100 Orchards and Vineyards		Agriculture/Grass
21	18200 Intensive Agriculture		Agriculture/Grass
22	18200 Intensive Agriculture - Dairies, Nurseries, Chicken Ranches		Agriculture/Grass
23	18300 Extensive Agriculture - Field/Pasture, Row Crops		Agriculture/Grass
24	18310 Field/Pasture		Agriculture/Grass
25	18310 Pasture		Agriculture/Grass
26	18320 Row Crops		Agriculture/Grass
27	12000 Urban/Developed		Developed
28	12000 Urban/Develpoed		Developed
29	81100 Mixed Evergreen Forest	Forest	Forest
30	81300 Oak Forest		Forest
31	81310 Coast Live Oak Forest		Forest
32	81320 Canyon Live Oak Forest		Forest
33	81340 Black Oak Forest		Forest
34	83140 Torrey Pine Forest		Forest
35	83230 Southern Interior Cypress Forest		Forest
36	84000 Lower Montane Coniferous Forest		Forest
37	84100 Coast Range, Klamath and Peninsular Coniferous Forest		Forest

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
38	84140 Coulter Pine Forest	Forest	Forest
39	84150 Bigcone Spruce (Bigcone Douglas Fir)-Canyon Oak Forest		Forest
40	84230 Sierran Mixed Coniferous Forest		Forest
41	84500 Mixed Oak/Coniferous/Bigcone/Coulter		Forest
42	85100 Jeffrey Pine Forest		Forest
43	11100 Eucalyptus Woodland	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Forest
44	60000 RIPARIAN AND BOTTOMLAND HABITAT	Riparian and Bottomland Habitat	Forest
45	61000 Riparian Forests		Forest
46	61300 Southern Riparian Forest		Forest
47	61310 Southern Coast Live Oak Riparian Forest		Forest
48	61320 Southern Arroyo Willow Riparian Forest		Forest
49	61330 Southern Cottonwood-willow Riparian Forest		Forest
50	61510 White Alder Riparian Forest		Forest
51	61810 Sonoran Cottonwood-willow Riparian Forest		Forest
52	61820 Mesquite Bosque		Forest
53	62000 Riparian Woodlands		Forest
54	62200 Desert Dry Wash Woodland		Forest
55	62300 Desert Fan Palm Oasis Woodland		Forest
56	62400 Southern Sycamore-alder Riparian Woodland		Forest
57	70000 WOODLAND	Woodland	Forest
58	71000 Cismontane Woodland		Forest
59	71100 Oak Woodland		Forest
60	71120 Black Oak Woodland		Forest
61	71160 Coast Live Oak Woodland		Forest
62	71161 Open Coast Live Oak Woodland		Forest
63	71162 Dense Coast Live Oak Woodland		Forest
64	71162 Dense Coast Love Oak Woodland		Forest

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
65	71180 Engelmann Oak Woodland	Woodland	Forest
66	71181 Open Engelmann Oak Woodland		Forest
67	71182 Dense Engelmann Oak Woodland		Forest
68	72300 Peninsular Pinon and Juniper Woodlands		Forest
69	72310 Peninsular Pinon Woodland		Forest
70	72320 Peninsular Juniper Woodland and Scrub		Forest
71	75100 Elephant Tree Woodland		Forest
72	77000 Mixed Oak Woodland		Forest
73	78000 Undifferentiated Open Woodland		Forest
74	79000 Undifferentiated Dense Woodland		Forest
75	Engelmann Oak Woodland		Forest
76	52120 Southern Coastal Salt Marsh	Bog and Marsh	Other
77	52300 Alkali Marsh		Other
78	52310 Cismontane Alkali Marsh		Other
79	52400 Freshwater Marsh		Other
80	52410 Coastal and Valley Freshwater Marsh		Other
81	52420 Transmontane Freshwater Marsh		Other
82	52440 Emergent Wetland		Other
83	44000 Vernal Pool	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Other
84	44320 San Diego Mesa Vernal Pool		Other
85	44322 San Diego Mesa Claypan Vernal Pool (southern mesas)		Other
86	13100 Open Water	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Other
87	13110 Marine		Other
88	13111 Subtidal		Other
89	13112 Intertidal		Other
90	13121 Deep Bay		Other
91	13122 Intermediate Bay		Other
92	13123 Shallow Bay		Other
93	13130 Estuarine		Other
94	13131 Subtidal		Other
95	13133 Brackishwater		Other

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
96	13140 Freshwater	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Other
97	13200 Non-Vegetated Channel, Floodway, Lakeshore Fringe		Other
98	13300 Saltpan/Mudflats		Other
99	13400 Beach		Other
100	21230 Southern Foredunes	Dune Community	Scrub/Shrub
101	22100 Active Desert Dunes		Scrub/Shrub
102	22300 Stabilized and Partially-Stabilized Desert Sand Field		Scrub/Shrub
103	24000 Stabilized Alkaline Dunes		Scrub/Shrub
104	29000 ACACIA SCRUB		Scrub/Shrub
105	63000 Riparian Scrubs	Riparian and Bottomland Habitat	Scrub/Shrub
106	63300 Southern Riparian Scrub		Scrub/Shrub
107	63310 Mule Fat Scrub		Scrub/Shrub
108	63310 Mulefat Scrub		Scrub/Shrub
109	63320 Southern Willow Scrub		Scrub/Shrub
110	63321 Arundo donnax Dominant/Southern Willow Scrub		Scrub/Shrub
111	63330 Southern Riparian Scrub		Scrub/Shrub
112	63400 Great Valley Scrub		Scrub/Shrub
113	63410 Great Valley Willow Scrub		Scrub/Shrub
114	63800 Colorado Riparian Scrub		Scrub/Shrub
115	63810 Tamarisk Scrub		Scrub/Shrub
116	63820 Arrowweed Scrub		Scrub/Shrub
117	31200 Southern Coastal Bluff Scrub	Scrub and Chaparral	Scrub/Shrub
118	32000 Coastal Scrub		Scrub/Shrub
119	32400 Maritime Succulent Scrub		Scrub/Shrub
120	32500 Diegan Coastal Sage Scrub		Scrub/Shrub
121	32510 Coastal form		Scrub/Shrub
122	32520 Inland form (> 1,000 ft. elevation)		Scrub/Shrub
123	32700 Riversidian Sage Scrub		Scrub/Shrub
124	32710 Riversidian Upland Sage Scrub		Scrub/Shrub
125	32720 Alluvial Fan Scrub		Scrub/Shrub
126	33000 Sonoran Desert Scrub		Scrub/Shrub
127	33100 Sonoran Creosote Bush Scrub		Scrub/Shrub
128	33200 Sonoran Desert Mixed Scrub		Scrub/Shrub
129	33210 Sonoran Mixed Woody Scrub		Scrub/Shrub

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
130	33220 Sonoran Mixed Woody and Succulent Scrub	Scrub and Chaparral	Scrub/Shrub
131	33230 Sonoran Wash Scrub		Scrub/Shrub
132	33300 Colorado Desert Wash Scrub		Scrub/Shrub
133	33600 Encelia Scrub		Scrub/Shrub
134	34000 Mojavean Desert Scrub		Scrub/Shrub
135	34300 Blackbush Scrub		Scrub/Shrub
136	35000 Great Basin Scrub		Scrub/Shrub
137	35200 Sagebrush Scrub		Scrub/Shrub
138	35210 Big Sagebrush Scrub		Scrub/Shrub
139	35210 Sagebrush Scrub		Scrub/Shrub
140	36110 Desert Saltbush Scrub		Scrub/Shrub
141	36120 Desert Sink Scrub		Scrub/Shrub
142	37000 Chaparral		Scrub/Shrub
143	37120 Southern Mixed Chaparral		Scrub/Shrub
144	37120 Southern Mixed Chapparal		Scrub/Shrub
145	37121 Granitic Southern Mixed Chaparral		Scrub/Shrub
146	37121 Southern Mixed Chaparral		Scrub/Shrub
147	37122 Mafic Southern Mixed Chaparral		Scrub/Shrub
148	37130 Northern Mixed Chaparral		Scrub/Shrub
149	37131 Granitic Northern Mixed Chaparral		Scrub/Shrub
150	37132 Mafic Northern Mixed Chaparral		Scrub/Shrub
151	37200 Chamise Chaparral		Scrub/Shrub
152	37210 Granitic Chamise Chaparral		Scrub/Shrub
153	37220 Mafic Chamise Chaparral		Scrub/Shrub
154	37300 Red Shank Chaparral		Scrub/Shrub
155	37400 Semi-Desert Chaparral		Scrub/Shrub
156	37500 Montane Chaparral		Scrub/Shrub
157	37510 Mixed Montane Chaparral		Scrub/Shrub
158	37520 Montane Manzanita Chaparral		Scrub/Shrub
159	37530 Montane Ceanothus Chaparral		Scrub/Shrub
160	37540 Montane Scrub Oak Chaparral		Scrub/Shrub
161	37800 Upper Sonoran Ceanothus Chaparral		Scrub/Shrub
162	37830 Ceanothus crassifolius Chaparral		Scrub/Shrub
163	37900 Scrub Oak Chaparral		Scrub/Shrub
164	37A00 Interior Live Oak Chaparral		Scrub/Shrub

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
165	37C30 Southern Maritime Chaparral	Scrub and Chaparral	Scrub/Shrub
166	37G00 Coastal Sage-Chaparral Scrub		Scrub/Shrub
167	37K00 Flat-topped Buckwheat		Scrub/Shrub
168	39000 Upper Sonoran Subshrub Scrub		Scrub/Shrub
169	Diegan Coastal Sage Scrub		Scrub/Shrub
170	Granitic Northern Mixed Chaparral		Scrub/Shrub
171	Southern Mixed Chaparral		Scrub/Shrub
172	11000 Non-Native Vegetation	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Unknown
173	11000 Non-Native VegetionVegetation		Unknown
174	11200 Disturbed Wetland		Unknown
175	11300 Disturbed Habitat		Unknown
176	13000 Unvegetated Habitat		Unknown
177	Disturbed Habitat		Unknown

Table A.1.3: Related Land Cover and Land Use Categories

Land Cover per San Diego County	Land Use per Table A.1.1
Agriculture/Grass	Meadow
Forest	Forest
Scrub/Shrub	Average (Meadow, Forest)
Unknown/Other	Meadow

Table A.1.4: Applicable Hydrologic Response Unit Calculations

Land Cover	Soil	Gradient	Runoff Coeff.	ET Coeff.	Infiltration Coeff.	Runoff/ Infiltration Ratio	Hydrologic Process Designation
Agriculture/Grass	A	0-2%	0.10	0.60	0.30	0.33	I
Agriculture/Grass	A	2-6%	0.16	0.60	0.24	0.67	U
Agriculture/Grass	A	6-10%	0.25	0.60	0.15	1.67	O
Agriculture/Grass	B	0-2%	0.14	0.60	0.26	0.54	I
Agriculture/Grass	B	2-6%	0.22	0.60	0.18	1.22	U
Agriculture/Grass	B	6-10%	0.30	0.60	0.10	3.00	O
Agriculture/Grass	C	0-2%	0.20	0.60	0.20	1.00	U
Agriculture/Grass	C	2-6%	0.28	0.60	0.12	2.33	O
Agriculture/Grass	C	6-10%	0.36	0.60	0.04	9.00	O
Agriculture/Grass	D	0-2%	0.24	0.60	0.16	1.50	U
Agriculture/Grass	D	2-6%	0.30	0.60	0.10	3.00	O
Agriculture/Grass	D	6-10%	0.40	0.60	0.00	infinite	O

Land Cover	Soil	Gradient	Runoff Coeff.	ET Coeff.	Infiltration Coeff.	Runoff/ Infiltration Ratio	Hydrologic Process Designation
Forest	A	0-2%	0.05	0.80	0.15	0.33	I
Forest	A	2-6%	0.08	0.80	0.12	0.67	U
Forest	A	6-10%	0.11	0.80	0.09	1.22	U
Forest	B	0-2%	0.08	0.80	0.12	0.67	U
Forest	B	2-6%	0.11	0.80	0.09	1.22	U
Forest	B	6-10%	0.14	0.80	0.06	2.33	O
Forest	C	0-2%	0.10	0.80	0.10	1.00	U
Forest	C	2-6%	0.13	0.80	0.07	1.86	O
Forest	C	6-10%	0.16	0.80	0.04	4.00	O
Forest	D	0-2%	0.12	0.80	0.08	1.50	U
Forest	D	2-6%	0.16	0.80	0.04	4.00	O
Forest	D	6-10%	0.20	0.80	0.00	infinite	O
Scrub/Shrub	A	0-2%	0.08	0.70	0.23	0.33	I
Scrub/Shrub	A	2-6%	0.12	0.70	0.18	0.67	U
Scrub/Shrub	A	6-10%	0.18	0.70	0.12	1.50	U
Scrub/Shrub	B	0-2%	0.11	0.70	0.19	0.58	I
Scrub/Shrub	B	2-6%	0.17	0.70	0.14	1.22	U
Scrub/Shrub	B	6-10%	0.22	0.70	0.08	2.75	O
Scrub/Shrub	C	0-2%	0.15	0.70	0.15	1.00	U
Scrub/Shrub	C	2-6%	0.21	0.70	0.10	2.16	O
Scrub/Shrub	C	6-10%	0.26	0.70	0.04	6.50	O
Scrub/Shrub	D	0-2%	0.19	0.70	0.12	1.50	U
Scrub/Shrub	D	2-6%	0.23	0.70	0.07	3.29	O
Scrub/Shrub	D	6-10%	0.30	0.70	0.00	infinite	O

Hydrologic Process Designation: I = Interflow; O = Overland Flow; U = Uncertain

Table A.1.5: Hydrologic Response Unit Designations

Land Cover	Slope	Soil Type				
		A	B	C	D	Other (fill/water)
Agriculture/ Grass/Unknown/ Other	0-2%	I	I	U	U	U
	2-6%	U	U	O	O	U
	6-10%	O	O	O	O	O
	>10%	O	O	O	O	O
Developed	0-2%	O	O	O	O	O
	2-6%	O	O	O	O	O
	6-10%	O	O	O	O	O
	>10%	O	O	O	O	O
Forest	0-2%	I	U	U	U	U
	2-6%	U	U	O	O	U
	6-10%	U	O	O	O	U
	>10%	O	O	O	O	O
Scrub/Shrub	0-2%	I	I	U	U	U
	2-6%	U	U	O	O	U
	6-10%	U	O	O	O	U
	>10%	O	O	O	O	O

Hydrologic Process Designation: I = Interflow; O = Overland Flow; U = Uncertain

REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams
- Groundwater Basins

Dominant Hydrologic Processes

- Groundwater Recharge
- Interflow
- Overland Flow

Aerial Imagery Source: DigitalGlobe, 06/2012

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Dominant Hydrologic Processes

Regional San Diego County Watersheds

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ATTACHMENT A.2
STREAM CHARACTERIZATION

REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams

Aerial Imagery Source: DigitalGlobe, 06/2012

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Watershed Management Area Streams

Regional San Diego County Watersheds

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REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams

Hydrographic Category
- Intermittent
- Perennial

Aerial Imagery Source: DigitalGlobe, 06/2012

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Watershed Management Area Streams by Hydrographic Category

Regional San Diego County Watersheds

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REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams

Bed Material

- Concrete
- Earth
- Pipe / Culvert
- Riprap
- Regional WMAA Streams within Federal/State/Indian Lands (not characterized, displayed for continuity)

Aerial Imagery Source: DigitalGlobe, 06/2012

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Watershed Management Area Streams by Bed Material

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014

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REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Santee Lakes
18	Forester Creek
19	Chollas Creek
20	Sweetwater River - Reach 1
21	Sweetwater River - Reach 2
22	Otay River
23	Jamul / Dulzura Creek
24	Tijuana River
25	Cottonwood Creek (Tijuana WMA)
26	
27	

Legend

- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams
- Regional WMAA Streams within Federal/State/Indian Lands (not characterized, displayed for continuity)

Other Streams (Non-Earthen)

- Pipe / Culvert
- Concrete
- Riprap

Geologic Group of Earthen Streams

- Coarse Bedrock
- Coarse Sedimentary Impermeable
- Coarse Sedimentary Permeable
- Fine Bedrock
- Fine Sedimentary Impermeable
- Fine Sedimentary Permeable

Aerial Imagery Source: DigitalGlobe, 06/2012

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Watershed Management Area Streams by Geologic Group

Regional San Diego County Watersheds

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REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Watershed Boundaries
- Municipal Boundaries
- Regional WMAA Streams within Federal/State/Indian Lands (not characterized, displayed for continuity)
- Rivers & Streams

Reach Type

- Engineered Constrained
- Engineered Un-constrained
- Natural Constrained
- Natural Un-constrained

Aerial Imagery Source: DigitalGlobe, 06/2012

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Watershed Management Area Streams by Reach Type

Regional San Diego County Watersheds

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ATTACHMENT A.3
LAND USES

REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Federal/State/Indian Lands
- Rivers & Streams

Existing Land Use

Residential
- Spaced Rural Residential
- Single Family Residential
- Mobile Homes
- Multi-Family Residential
- Mixed Use

Commercial and Office
- Shopping Centers
- Commercial and Office

Industrial
- Heavy Industry
- Light Industry
- Extractive Industry

Public Facilities and Utilities
- Transport., Comm., Utilities
- Education
- Institutions
- Military

Parks and Recreation
- Recreation
- Open Space Parks

Agriculture
- Intensive Agriculture
- Extensive Agriculture

Other
- Indian Reservations
- Water
- Road Rights of Way
- Railroad Rights of Way

Aerial Imagery Source: DigitalGlobe, 06/2012

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Existing Land Use

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014

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REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Federal/State/Indian Lands
- Rivers & Streams

Planned Land Use

Residential
- Spaced Rural Residential
- Single Family Residential
- Mobile Homes
- Multi-Family Residential
- Mixed Use

Commercial and Office
- Shopping Centers
- Commercial and Office

Industrial
- Heavy Industry
- Light Industry
- Extractive Industry

Public Facilities and Utilities
- Transport., Comm., Utilities
- Education
- Institutions
- Military

Parks and Recreation
- Recreation
- Open Space Parks

Agriculture
- Intensive Agriculture
- Extensive Agriculture

Other
- Indian Reservations
- Water
- Road Rights of Way
- Railroad Rights of Way

Aerial Imagery Source: DigitalGlobe, 06/2012

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Planned Land Use

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014

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RICK ENGINEERING COMPANY

REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams

Developable Land

Residential
- Spaced Rural Residential
- Single Family Residential
- Mobile Homes
- Multi-Family Residential
- Mixed Use

Commercial and Office
- Shopping Centers
- Commercial and Office

Industrial
- Heavy Industry
- Light Industry
- Extractive Industry

Public Facilities and Utilities
- Transport., Comm., Utilities
- Education
- Institutions
- Military

Parks and Recreation
- Recreation
- Open Space Parks

Agriculture
- Intensive Agriculture
- Extensive Agriculture

Other
- Indian Reservations
- Water
- Road Rights of Way
- Railroad Rights of Way

Aerial Imagery Source: DigitalGlobe, 06/2012

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Developable Land

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014

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REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams

Redevelopment and Infill

Infill

- Employment
- Single Family
- Multi-Family

Redevelopment

- Residential to Employment
- Single Family to Multi-Family
- Mobile Home to Other
- Employment to Residential
- Employment to Employment
- Residential to Road or Freeway
- Employment to Road or Freeway
- Employment/Residential to Mixed Use

Aerial Imagery Source: DigitalGlobe, 06/2012

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Redevelopment and Infill Areas

Regional San Diego County Watersheds

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ATTACHMENT A.4
POTENTIAL COARSE SEDIMENT YIELD AREAS

A.4.1 Geology Grouping

Geologic grouping was based on the mapped geologic unit as determined by published geologic mapping information. The following describes the methodology utilized to determine bedrock or sedimentary characteristics, anticipated grain size, and suitability for infiltration. A complete list of the various geologic maps used in this evaluation is listed in Chapter 6.

Due to the various mapped scales of the published data and differing mapped unit names, the geologic units were initially compiled into similar categories where possible. For example, the Lindavista Formation is mapped as unit Ql on geologic maps at a scale of 1:24,000 but correlates to the same unit Qvop8 on geologic maps at a scale of 1:100,000. Following the compilation of geologic unit names, the units were differentiated between crystalline bedrock and sedimentary formations based on geologic characterization and material behavior. The Point Loma Formation for example, is a Cretaceous-age sandstone, but it was classified as a "coarse bedrock" unit due to its indurated and resistant nature.

For each site location, the predominant geologic units were then described as "coarse" or "fine" based on typical weathering characteristics of the bedrock units, or primary grain size of the sedimentary units. For example, granodiorite or tonalite crystalline rock typically weathers to a coarse material such as a silty sand and therefore was classified as "coarse," compared to a gabbro which generally weathers to a sandy clay and was characterized as "fine." Sedimentary formations can be more variable, such as the Mission Valley Formation. In this case, the Mission Valley Formation was characterized as "coarse" since the unit is predominantly comprised of sandstone even if it does contain localities of siltstone and claystone within the unit.

To further characterize the sedimentary formations, these units were evaluated for suitability of infiltration. Since no field investigations were performed for this evaluation to determine permeability, the differentiation between impermeable and permeable were based on the age of the geologic unit with the assumption that relatively younger sedimentary units of Pleistocene-age or younger (<1.6 mya) would be more susceptible to surface water infiltration. Geology grouping of different map units is presented in Table A.4.1

Table A.4.1 Geologic grouping for different map units

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
gr-m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
grMz	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Jcr	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Jhc	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Jsp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ka	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kbm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kbp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcc	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcm	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kd	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kdl	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgbf	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgd	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgdf	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgh	San Diego 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm1	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm2	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm3	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm4	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgr	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgu	San Diego 30' x 60'	Coarse	Bedrock	Impermeable	CB
Khg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ki	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kis	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kjd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
KJem	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
KJld	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kjv	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Klb	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Klh	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Klp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Km	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmgp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kpa	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kpv	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kqbd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Krm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Krr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kt	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ktr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kvc	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwsr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Mzd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzq	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzs	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
sch	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Kp	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ql	El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
QTf	El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Ec	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI
K	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI
Kccg	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Kcs	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Kl	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Ku	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Qvof	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop8a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop9a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmsc	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmss	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tp	San Diego & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tpm	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsc	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tscu	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsd	San Diego & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsdcg	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsdss	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsm	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tso	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tst	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tt	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tta	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmv	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsi	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa11	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa12	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa13	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoc	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop1	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop10	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop10a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop11	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Qvop11a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop12	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop13	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop2	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop3	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop4	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop5	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop6	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop7	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop8	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop9	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsa	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qof	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qof1	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qof2	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Q	Jennings; CA	Coarse	Sedimentary	Permeable	CSP
Qa	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qd	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qf	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qmb	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qw	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qyf	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qt	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa1-2	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa2-6	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa5	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa6	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa7	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Qoc	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop1	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qc	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qu	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop2-4	San Diego 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop3	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop4	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop6	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop7	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qya	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qyc	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Mzu	San Diego & Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
gb	Jennings; CA	Fine	Bedrock	Impermeable	FB
JTRm	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kat	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kc	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgb	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
KJvs	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kmv	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Ksp	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kvsp	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kwmt	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Qv	Jennings; CA	Fine	Bedrock	Impermeable	FB
Tba	San Diego 30' x 60'	Fine	Bedrock	Impermeable	FB
Tda	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Tv	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Tvsr	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgdfg	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Ta	San Diego 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tcs	Oceanside 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Td	San Diego & Oceanside	Fine	Sedimentary	Impermeable	FSI

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
	30' x 60'				
Td+Tf	San Diego 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Qls	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tm	Oceanside 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tf	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tfr	El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
To	San Diego & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Qpe	San Diego & Oceanside 30' x 60'	Fine	Sedimentary	Permeable	FSP
Mexico	San Diego 30' x 60'	NA	NA	Permeable	Other
Kuo	San Diego 30' x 60'	NA (Offshore)	NA	Permeable	Other
Teo	San Diego & Oceanside 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
Tmo	Oceanside 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
Qmo	San Diego 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
QTso	San Diego 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
af	San Diego & Oceanside 30' x 60'	Variable, dependent on source material	Sedimentary		Other

A.4.2 Quantitative Analysis

Soil loss estimates for each Geomorphic Landscape Unit were estimated using the Revised Universal Soil Loss Equation (RUSLE; Renard et al. 1997) listed below:

$$A = R \times K \times LS \times C \times P$$

Where

A = estimated average soil loss in tons/acre/year

R = rainfall-runoff erosivity factor

K = soil erodibility factor

LS = slope length and steepness factor

C = cover-management factor

P = support practice factor; assumed 1 for this analysis

Regional datasets used to estimate the inputs required to estimate the soil loss from each GLU are listed in table below:

Dataset	Source	Download year	Description
RUSLE – R Factor	SWRCB	2014	Regional R factor map was downloaded from ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_R_Factor/
RUSLE – K Factor	SWRCB	2014	Regional K factor map was downloaded from ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_K_Factor/
RUSLE – LS Factor	SWRCB	2014	Regional LS factor map was downloaded from ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_LS_Factor/
RUSLE – C Factor	USEPA	2014	Regional C factor map was downloaded from http://www.epa.gov/esd/land-sci/emap_west_browser/pages/wemap_mm_sl_rusle_c_qt.htm#mapnav

GIS analysis was used to calculate the area weighted estimate of R, K, LS and C factors using the regional datasets listed in the table above. For the developed land cover the C factor was then adjusted to 0 from the regional estimate to account for management actions implemented on developed sites (e.g. impervious surfaces). Soil loss estimates ranged from 0 to 15.2 tons/acre/year.

For evaluating the degree of relative risk to a stream solely arising from changes in sediment and/or water delivery SCCWRP Technical Report 605, 2010 states:

> *"The challenge in implementing this step is that presently we have insufficient basis to defensibly identify either low-risk or high-risk conditions using these metrics. For example, channels that are close to a threshold for geomorphic change may display significant morphological changes under nothing more than natural year-to-year variability in flow or sediment load.*

- *Acknowledging this caveat, we nonetheless anticipate that changes of less than 10% in either driver are unlikely to instigate, on their own, significant channel changes. This value is a conservative estimate of the year-to-year variability in either discharge or sediment flux that can be accommodated by a channel system in a state of dynamic equilibrium. It does not "guarantee," however, that channel change may not occur—either in response to yet modest alterations in water or sediment delivery, or because of other urbanization impacts (e.g., point discharge of runoff or the trapping of the upstream sediment flux; see Booth 1990) that are not represented with this analysis.*
- *In contrast, recognizing a condition of undisputed "high risk" must await broader collection of regionally relevant data. We note that >60% reductions in predicted sediment production have resulted in both minimal (McGonigle) and dramatic (Agua Hedionda) channel changes, indicating that "more data" may never provide absolute guidance. At present, we suggest using predicted watershed changes of 50% or more in either runoff (as indexed by change in impervious area) or sediment production as provisional criteria for requiring a more detailed evaluation of both the drivers and the resisting factors for channel change, regardless of other screening-level assessments. Clearly, however, only more experience with the application of such "thresholds," and the actual channel conditions that accompany them, will provide a defensible basis for setting numeric standards."*

The following criterion was developed using the suggestions listed above and then used to assign relative sediment production rating to each GLU:

- Low: Soil Loss < 5.6 tons/acre/year [GLUs that have a soil loss of 0 to 5.6 tons/acre/year produces around 10% of the total coarse sediment soil loss from the study area]
- Medium: 5.6 tons/acre/year < Soil Loss < 8.4 tons/acre/year
- High: > 8.4 tons/acre/year [GLUs that have a soil loss greater than 8.4 tons/acre/year produces around 42% of the total coarse sediment soil loss from the study area]

Results from the quantitative analysis are summarized in Table A.4.2.

Table A.4.2 Relative Sediment Production for different Geomorphic Landscape Units

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
CB-Agricultural/Grass-1	52883	0.20	4.67	0.14	50	6.5	Medium	No
CB-Agricultural/Grass-2	40633	0.21	5.19	0.14	56	8.3	Medium	No
CB-Agricultural/Grass-3	32617	0.22	6.04	0.14	57	10.6	High	Yes
CB-Agricultural/Grass-4	11066	0.23	7.38	0.14	57	13.5	High	Yes
CB-Developed-1	39746	0.22	3.77	0	49	0	Low	No
CB-Developed-2	32614	0.22	4.28	0	50	0	Low	No
CB-Developed-3	15841	0.22	4.86	0	49	0	Low	No
CB-Developed-4	1805	0.22	5.63	0	48	0	Low	No
CB-Forest-1	32231	0.20	6.38	0.14	39	6.8	Medium	No
CB-Forest-2	38507	0.20	7.20	0.13	45	8.8	High	Yes
CB-Forest-3	55303	0.20	8.14	0.13	48	10.6	High	Yes
CB-Forest-4	38217	0.20	9.95	0.14	50	13.6	High	Yes
CB-Other-1	1036	0.20	5.52	0.13	45	6.5	Medium	No
CB-Other-2	317	0.20	6.46	0.13	45	7.9	Medium	No
CB-Other-3	296	0.20	6.96	0.14	43	8.3	Medium	No
CB-Other-4	111	0.21	6.84	0.14	41	8.2	Medium	No
CB-Scrub/Shrub-1	88135	0.20	5.66	0.14	33	5.3	Low	No
CB-Scrub/Shrub-2	143694	0.20	6.51	0.14	37	6.8	Medium	No
CB-Scrub/Shrub-3	246703	0.21	7.33	0.14	41	8.4	Medium	No
CB-Scrub/Shrub-4	191150	0.21	8.28	0.14	42	9.8	High	Yes
CB-Unknown-1	1727	0.21	5.32	0.13	44	6.3	Medium	No
CB-Unknown-2	1935	0.21	5.95	0.13	44	7.1	Medium	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
CB-Unknown-3	1539	0.22	6.21	0.13	44	7.7	Medium	No
CB-Unknown-4	278	0.22	6.61	0.13	44	8.4	High	Yes
CSI-Agricultural/Grass-1	14609	0.34	2.72	0.14	39	4.8	Low	No
CSI-Agricultural/Grass-2	9059	0.37	3.61	0.14	47	8.7	High	Yes
CSI-Agricultural/Grass-3	10096	0.38	3.99	0.14	47	9.8	High	Yes
CSI-Agricultural/Grass-4	2498	0.37	4.33	0.14	47	10.5	High	Yes
CSI-Developed-1	82371	0.28	2.51	0	39	0	Low	No
CSI-Developed-2	22570	0.30	2.66	0	41	0	Low	No
CSI-Developed-3	13675	0.30	2.89	0	40	0	Low	No
CSI-Developed-4	3064	0.27	3.20	0	39	0	Low	No
CSI-Forest-1	449	0.27	4.26	0.13	43	6.6	Medium	No
CSI-Forest-2	611	0.25	5.11	0.13	44	7.5	Medium	No
CSI-Forest-3	716	0.29	4.43	0.13	44	7.4	Medium	No
CSI-Forest-4	348	0.30	4.49	0.13	43	7.6	Medium	No
CSI-Other-1	319	0.31	2.50	0.13	32	3.2	Low	No
CSI-Other-2	83	0.27	3.01	0.13	39	4.3	Low	No
CSI-Other-3	45	0.28	3.03	0.13	39	4.5	Low	No
CSI-Other-4	13	0.24	4.01	0.14	39	5.2	Low	No
CSI-Scrub/Shrub-1	9051	0.26	3.53	0.13	39	4.7	Low	No
CSI-Scrub/Shrub-2	10802	0.27	4.36	0.13	41	6.3	Medium	No
CSI-Scrub/Shrub-3	28220	0.26	4.82	0.13	41	6.7	Medium	No
CSI-Scrub/Shrub-4	20510	0.26	5.52	0.13	41	7.8	Medium	No
CSI-Unknown-1	5292	0.28	2.38	0.13	36	3.1	Low	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
CSI-Unknown-2	2074	0.29	2.98	0.13	40	4.5	Low	No
CSI-Unknown-3	2171	0.27	3.04	0.13	39	4.2	Low	No
CSI-Unknown-4	676	0.26	3.04	0.13	38	3.8	Low	No
CSP-Agricultural/Grass-1	59327	0.22	3.01	0.14	44	4.0	Low	No
CSP-Agricultural/Grass-2	8426	0.23	3.81	0.14	42	5.2	Low	No
CSP-Agricultural/Grass-3	2377	0.24	4.05	0.14	41	5.6	Low	No
CSP-Agricultural/Grass-4	291	0.22	6.28	0.14	52	10.1	High	Yes
CSP-Developed-1	85283	0.27	2.10	0	42	0	Low	No
CSP-Developed-2	7513	0.26	2.77	0	42	0	Low	No
CSP-Developed-3	2317	0.27	2.70	0	40	0	Low	No
CSP-Developed-4	272	0.27	2.76	0	38	0	Low	No
CSP-Forest-1	14738	0.22	4.52	0.14	44	6.0	Medium	No
CSP-Forest-2	3737	0.22	5.99	0.14	45	8.2	Medium	No
CSP-Forest-3	1858	0.21	6.42	0.14	45	8.5	High	Yes
CSP-Forest-4	484	0.21	7.62	0.14	48	10.2	High	Yes
CSP-Other-1	7404	0.23	2.61	0.14	39	3.2	Low	No
CSP-Other-2	343	0.24	3.68	0.13	40	4.8	Low	No
CSP-Other-3	126	0.24	3.76	0.13	40	4.9	Low	No
CSP-Other-4	17	0.24	4.19	0.13	39	5.3	Low	No
CSP-Scrub/Shrub-1	22583	0.23	3.75	0.14	41	4.8	Low	No
CSP-Scrub/Shrub-2	8938	0.24	5.63	0.14	40	7.1	Medium	No
CSP-Scrub/Shrub-3	7186	0.23	6.15	0.13	39	7.5	Medium	No
CSP-Scrub/Shrub-4	2609	0.22	7.16	0.14	43	9.3	High	Yes

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
CSP-Unknown-1	6186	0.25	2.63	0.13	40	3.4	Low	No
CSP-Unknown-2	744	0.27	3.49	0.13	39	4.8	Low	No
CSP-Unknown-3	350	0.28	3.32	0.13	38	4.5	Low	No
CSP-Unknown-4	78	0.28	3.26	0.13	40	4.5	Low	No
FB-Agricultural/Grass-1	6103	0.25	5.49	0.14	49	9.2	High	No
FB-Agricultural/Grass-2	7205	0.25	5.87	0.14	51	10.1	High	No
FB-Agricultural/Grass-3	6730	0.24	6.43	0.14	53	11.3	High	No
FB-Agricultural/Grass-4	2586	0.22	8.62	0.14	57	15.2	High	No
FB-Developed-1	10116	0.28	3.94	0	46	0	Low	No
FB-Developed-2	9075	0.28	4.41	0	45	0	Low	No
FB-Developed-3	5499	0.27	4.72	0	44	0	Low	No
FB-Developed-4	785	0.27	5.08	0	43	0	Low	No
FB-Forest-1	3780	0.21	7.24	0.13	39	8.0	Medium	No
FB-Forest-2	7059	0.21	7.53	0.13	43	8.8	High	No
FB-Forest-3	13753	0.22	8.02	0.13	43	9.7	High	No
FB-Forest-4	8899	0.26	9.63	0.13	35	11.5	High	No
FB-Other-1	172	0.26	5.72	0.13	44	8.6	High	No
FB-Other-2	75	0.26	5.97	0.13	38	7.7	Medium	No
FB-Other-3	76	0.28	6.27	0.13	34	7.6	Medium	No
FB-Other-4	36	0.31	6.70	0.13	33	8.6	High	No
FB-Scrub/Shrub-1	10297	0.24	6.94	0.14	36	8.3	Medium	No
FB-Scrub/Shrub-2	25150	0.25	7.24	0.14	38	9.0	High	No
FB-Scrub/Shrub-3	70895	0.25	7.89	0.13	38	10.0	High	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
FB-Scrub/Shrub-4	70679	0.26	9.05	0.14	39	12.1	High	No
FB-Unknown-1	654	0.30	5.33	0.13	37	7.6	Medium	No
FB-Unknown-2	829	0.29	5.26	0.13	40	7.9	Medium	No
FB-Unknown-3	1062	0.29	5.54	0.13	39	8.2	Medium	No
FB-Unknown-4	299	0.28	6.02	0.13	38	8.4	High	No
FSI-Agricultural/Grass-1	8462	0.32	3.91	0.13	24	3.9	Low	No
FSI-Agricultural/Grass-2	4979	0.33	4.29	0.13	31	5.7	Medium	No
FSI-Agricultural/Grass-3	4808	0.34	4.26	0.13	34	6.3	Medium	No
FSI-Agricultural/Grass-4	1055	0.35	4.11	0.13	36	6.7	Medium	No
FSI-Developed-1	9953	0.29	3.09	0	34	0	Low	No
FSI-Developed-2	4972	0.31	3.22	0	37	0	Low	No
FSI-Developed-3	3350	0.29	3.30	0	36	0	Low	No
FSI-Developed-4	763	0.28	3.31	0	37	0	Low	No
FSI-Forest-1	186	0.33	4.62	0.13	37	7.2	Medium	No
FSI-Forest-2	217	0.35	4.47	0.13	39	7.9	Medium	No
FSI-Forest-3	262	0.37	4.71	0.13	40	9.2	High	No
FSI-Forest-4	111	0.36	4.73	0.13	40	9.2	High	No
FSI-Other-1	266	0.31	3.11	0.13	24	2.9	Low	No
FSI-Other-2	81	0.30	3.29	0.13	25	3.1	Low	No
FSI-Other-3	56	0.31	3.04	0.13	27	3.2	Low	No
FSI-Other-4	15	0.29	3.57	0.13	33	4.4	Low	No
FSI-Scrub/Shrub-1	2241	0.27	4.46	0.13	29	4.5	Low	No
FSI-Scrub/Shrub-2	3911	0.28	4.96	0.13	31	5.7	Medium	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
FSI-Scrub/Shrub-3	7590	0.29	5.05	0.13	34	6.3	Medium	No
FSI-Scrub/Shrub-4	3502	0.30	5.14	0.13	37	7.5	Medium	No
FSI-Unknown-1	1117	0.29	2.83	0.13	27	3.0	Low	No
FSI-Unknown-2	780	0.30	3.44	0.13	32	4.3	Low	No
FSI-Unknown-3	855	0.29	3.41	0.13	31	4.0	Low	No
FSI-Unknown-4	285	0.28	3.21	0.13	32	3.7	Low	No
FSP-Agricultural/Grass-1	13	0.22	2.22	0.13	40	2.5	Low	No
FSP-Agricultural/Grass-2	3	0.22	2.59	0.13	40	3.0	Low	No
FSP-Agricultural/Grass-3	2	0.22	2.69	0.13	40	3.2	Low	No
FSP-Agricultural/Grass-4	0	0.20	2.94	0.12	40	2.9	Low	No
FSP-Developed-1	180	0.26	2.85	0	40	0	Low	No
FSP-Developed-2	13	0.25	2.69	0	40	0	Low	No
FSP-Developed-3	8	0.21	2.25	0	40	0	Low	No
FSP-Developed-4	0	0.21	2.29	0	40	0	Low	No
FSP-Forest-1	8	0.22	2.29	0.14	40	2.9	Low	No
FSP-Forest-2	5	0.20	2.22	0.14	40	2.5	Low	No
FSP-Forest-3	0	0.20	2.22	0.14	40	2.5	Low	No
FSP-Other-1	1307	0.20	2.38	0.14	40	2.7	Low	No
FSP-Other-2	34	0.21	2.36	0.14	40	2.7	Low	No
FSP-Other-3	8	0.22	2.56	0.13	40	3.0	Low	No
FSP-Other-4	0	0.43	4.35	0.12	40	9.3	High	No
FSP-Scrub/Shrub-1	147	0.23	2.68	0.14	40	3.3	Low	No
FSP-Scrub/Shrub-2	18	0.23	2.55	0.14	40	3.3	Low	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
FSP-Scrub/Shrub-3	4	0.20	2.23	0.14	40	2.6	Low	No
FSP-Scrub/Shrub-4	0	0.20	1.70	0.12	40	1.7	Low	No
FSP-Unknown-1	40	0.20	1.87	0.13	40	1.9	Low	No
FSP-Unknown-2	5	0.20	1.99	0.12	40	2.0	Low	No
FSP-Unknown-3	1	0.20	2.39	0.12	40	2.4	Low	No
O-Agricultural/Grass-1	2433	0.20	2.93	0.14	34	2.8	Low	No
O-Agricultural/Grass-2	112	0.21	3.44	0.14	32	3.2	Low	No
O-Agricultural/Grass-3	30	0.23	3.89	0.13	32	3.8	Low	No
O-Agricultural/Grass-4	1	0.26	6.47	0.13	37	7.9	Medium	No
O-Developed-1	8327	0.27	1.37	0	39	0	Low	No
O-Developed-2	474	0.25	2.12	0	40	0	Low	No
O-Developed-3	157	0.26	3.07	0	41	0	Low	No
O-Developed-4	26	0.24	3.89	0	41	0	Low	No
O-Forest-1	235	0.22	6.15	0.13	43	7.6	Medium	No
O-Forest-2	67	0.21	5.07	0.13	45	6.6	Medium	No
O-Forest-3	45	0.21	5.43	0.13	47	7.3	Medium	No
O-Forest-4	20	0.20	5.95	0.13	59	9.0	High	No
O-Other-1	9362	0.25	3.86	0.13	36	4.3	Low	No
O-Other-2	344	0.24	3.32	0.13	35	3.5	Low	No
O-Other-3	120	0.23	4.86	0.13	35	5.0	Low	No
O-Other-4	37	0.22	5.64	0.13	39	6.6	Medium	No
O-Scrub/Shrub-1	688	0.22	4.83	0.13	40	5.7	Medium	No
O-Scrub/Shrub-2	224	0.22	5.80	0.13	36	6.3	Medium	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
O-Scrub/Shrub-3	209	0.22	6.47	0.13	41	7.5	Medium	No
O-Scrub/Shrub-4	96	0.22	6.62	0.13	44	8.2	Medium	No
O-Unknown-1	1236	0.28	1.60	0.12	26	1.5	Low	No
O-Unknown-2	62	0.27	1.48	0.13	36	1.8	Low	No
O-Unknown-3	15	0.29	3.52	0.13	38	4.9	Low	No
O-Unknown-4	7	0.34	3.87	0.12	40	6.6	Medium	No

GLU Nomenclature: Geology – Land Cover – Slope Category

Geology Categories:

CB Coarse Bedrock

CSI Coarse Sedimentary Impermeable

CSP Coarse Sedimentary Permeable

FB Fine Bedrock

FSI Fine Sedimentary Impermeable

FSP Fine Sedimentary Permeable

O Other

Slope Categories:

1 0%-10%

2 10% - 20%

3 20% - 40%

4 > 40%

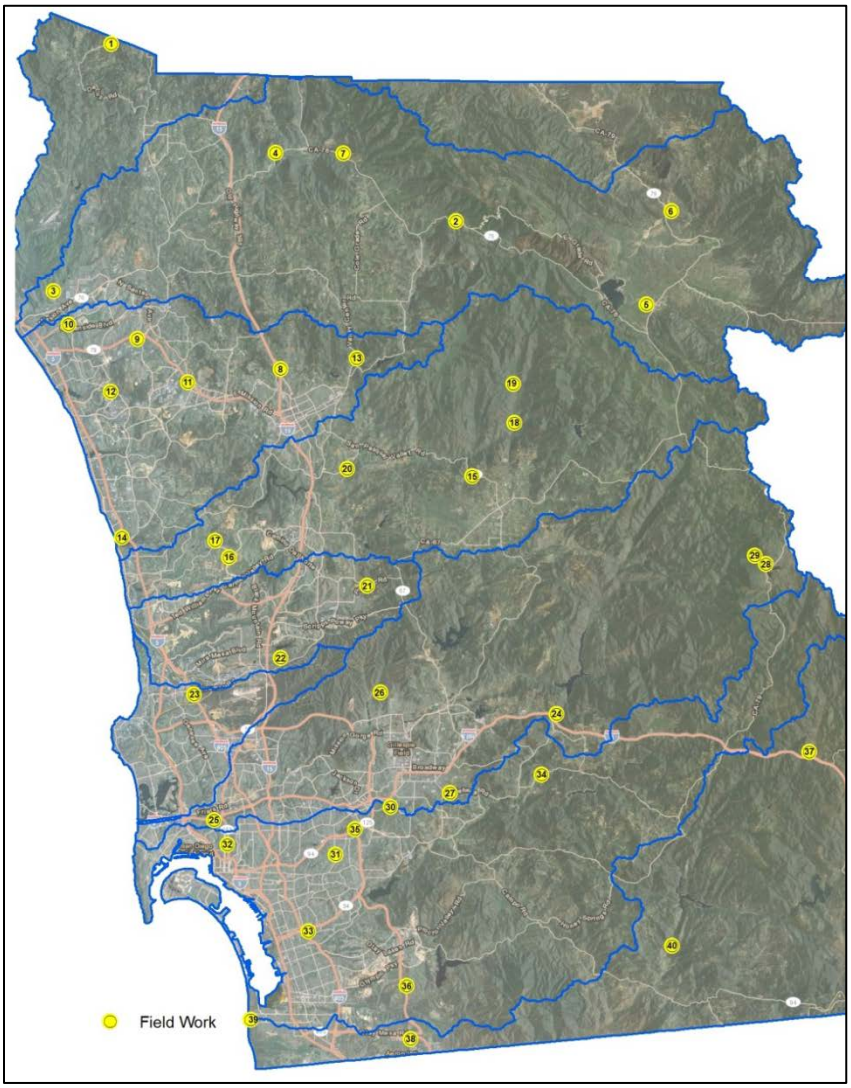
A4.3 Field Assessment

Site Selection:

Forty locations were selected from the study region for field assessment. Sites were selected such that they are accessible by existing road network based on review of satellite imagery and are uniformly distributed considering the following criteria:

- Geologic grouping
- Land cover
- Slope category
- WMA
- Jurisdiction

Yellow circles in the figure below shows the 40 locations for which field assessment was performed.



Pre-Field Activities

Prior to conducting field activities, the consultant team reviewed available published geologic information at each site location and prepared satellite imagery of each site using Google Earth™. Pre-field activities consisted of evaluating site access at each location using aerial imagery and logistics were coordinated based on regional site location to maximize field efficiency.

Site Reconnaissance

Site reconnaissance was performed at forty locations between 22 January and 7 February 2014 by a team of geologists. The reconnaissance consisted of:

- Visual soil classification,
- Assessing existing vegetative cover (0-100%),
- Qualitative assignment of existing sediment production (low, medium, and high) [based on existing vegetative cover],
- Qualitative assignment of potential sediment production (low, medium, and high)[assuming there is 0% vegetative cover], and
- Identifying existing erosional features.

Descriptions and visual classifications of the surficial materials were based on the Unified Soil Classification System (USCS). Underlying geologic units were confirmed where exposed formations were observed within the individual site limits.

SITE AND GEOLOGIC CONDTIONS

Our knowledge of the site conditions has been developed from a review of available geologic literature, previous geologic and geotechnical investigations by the consultant team in the study region, professional experience, site reconnaissance, and field investigations performed for this study.

Surface Conditions

Site locations were sited in open space with the exception of sites ID-27, -30, and -31 which were situated within developed areas with paved streets and sidewalks. The surface conditions at the site locations were characterized by sloping terrain varying from relatively flat (< 5%) to very steep slopes (> 40%). At the time of our reconnaissance the natural hillsides along the areas of interest were covered by varying degrees of moderate to dense growth scrub brush, low grasses, and scattered trees.

Existing erosional and geomorphic features at each site location were identified where possible. The observed erosional features included notable drainages, rilling, scour, and sediment accumulation. Observed geomorphic features included areas of minor slope instability and surficial slumping. Several sources of ground disturbance were identified during the site reconnaissance included active grading operations and bioturbation.

An evaluation of the existing and potential sediment production for each site was determined based on surface conditions. Sediment production was assigned as “high, medium, or low” based on the existing conditions and consultant team’s professional experience.

Surficial Deposits

Surficial deposits, including topsoil, alluvium, colluvium, slopewash, and residual soils are present in portions of the study area within the natural drainages and mantling the slope areas. The composition and grain size of these materials are variable depending on the age, parent sources, and mode of deposition.

Geologic Conditions

Our knowledge of the subsurface conditions at the site locations is based on a review of available published geologic information, professional experience, site reconnaissance, previous explorations and geotechnical investigations performed by the consultant team in the study region.

Field Assessment Photo Log



Field Visit ID-1

GLU: CB-Scrub/Shrub-4

View: Looking southwest

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 90%



Field Visit ID-2

GLU: CB-Forest-4

View: Looking north

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 95%



Field Visit ID-3

GLU: CSI-Agricultural/ Grass-3

View: Looking southwest

Existing sediment production: Low to Med

Potential sediment production:

Med to High

Existing veg. cover:

95-100%



Field Visit ID-4

GLU: CSI-Scrub/Shrub-2

View: Looking north

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 70%



Field Visit ID-5

GLU: CSP-Agricultural/ Grass-1

View: Looking southwest

Existing sediment production: Low to Med

Potential sediment production: Med

Existing veg. cover: 90%



Field Visit ID-6

GLU: CSP-Agricultural/ Grass-3

View: Looking east

Existing sediment production: Low to Med

Potential sediment production:

Low to Med

Existing veg. cover:
Southeast slope ~50%

Northeast slope ~70%



Field Visit ID-7

GLU: CSP-Forest-3

View: Looking east

Existing sediment production: Med to High

Potential sediment production: High

Existing veg. cover: 75-80%



Field Visit ID-8

GLU: CB-Scrub/Shrub-3

View: Looking southeast

Existing sediment production: Low to Med

Potential sediment production:

Med to High

Existing veg. cover: 90-95%



Field Visit ID-9

GLU: CB-Agricultural/ Grass-2

View: Looking northwest

Existing sediment production: Low to Med

Potential sediment production: Med

Existing veg. cover: 70%



Field Visit ID-10

GLU: CSI-Unknown-2

View: Looking north

Existing sediment production: Med to High

Potential sediment production: High

Existing veg. cover: 75%



Field Visit ID-11

GLU: CSI-Agricultural/ Grass-2

View: Looking east

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 85%



Field Visit ID-12

GLU: CSP-Unknown-2

View: Looking southwest

Existing sediment production: Low

Potential sediment production:

Low to Med

Existing veg. cover: 50%



Field Visit ID-13

GLU: CSP-Scrub/Shrub-2

View: Looking southeast

Existing sediment production: Med

Potential sediment production:

Med to High

Existing veg. cover: 80-85%



Field Visit ID-14

GLU: FSP-Scrub/Shrub-1

View: Looking northeast

Existing sediment production: Low

Potential sediment production:

Low to Med

Existing veg. cover:

95-100%



Field Visit ID-15

GLU: CB-Agricultural/ Grass-4

View: Looking west

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 95%

.



Field Visit ID-16

GLU: CB-Agricultural/ Grass-3

View: Looking south

Existing sediment production: High*

Potential sediment production: High

Existing veg. cover: 90-95%

* Area was burned in 2014 fires after the field assessment so existing sediment production was adjusted to High (based on potential sediment production) from Medium



Field Visit ID-17

GLU: CSI-Scrub/Shrub-4

View: Looking west

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 95%



Field Visit ID-18

GLU: CSP-Forest-1

View: Looking southwest

Existing sediment production: Low to Med

Potential sediment production: Med

Existing veg. cover: 80%



Field Visit ID-19

GLU: CSP-Scrub/Shrub-3

View: Looking southwest

Existing sediment production: Low to Med

Potential sediment production:

Med to High

Existing veg. cover: 60%



Field Visit ID-20

GLU: CSP-Unknown-1

View: Looking southeast

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 95%



Field Visit ID-21

GLU: CB-Unknown-3

View: Looking northwest

Existing sediment production: Low to Med

Potential sediment production:

Med to High

Existing veg. cover: 50-60%



Field Visit ID-22

GLU: CSI-Forest-3

View: Looking east

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 60%



Field Visit ID-23

GLU: CSI-Scrub/Shrub-1

View: Looking north

Existing sediment production: Low

Potential sediment production: Low

Existing veg. cover: 80%



Field Visit ID-24

GLU: CB-Unknown-4

View: Looking northeast

Existing sediment production: Low to Med

Potential sediment production: High

Existing veg. cover: 80%



Field Visit ID-25

GLU: CSI-Agricultural/ Grass-4

View: Looking east

Existing sediment production: Low

Potential sediment production: Med-High

Existing veg. cover: 95%



Field Visit ID-26

GLU: CSI-Scrub/Shrub-3

View: Looking east

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 100%

.



Field Visit ID-27

GLU: CSP-Developed-2

View: Looking north

Existing sediment production: Low

Potential sediment production: Low

Existing veg. cover: 30-35%

.



Field Visit ID-28

GLU: CSP-Agricultural/ Grass-2

View: Looking north

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 90-95%

.



Field Visit ID-29

GLU: FB-Forest-3

View: Looking northwest

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 80-85%



Field Visit ID-30

GLU: CB-Developed-4

View: Looking northeast

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 70%

.



Field Visit ID-31

GLU: CSI-Developed-3

View: Looking north

Existing sediment production: Low

Potential sediment production: Low

Existing veg. cover: 30-35%



Field Visit ID-32

GLU: CSI-Unknown-3

View: Looking west

Existing sediment production: Low to Med

Potential sediment production: Med

Existing veg. cover: 70-75%



Field Visit ID-33

GLU: CSP-Scrub/Shrub-1

View: Looking northeast

Existing sediment production: Low to Med

Potential sediment production:

Med to High

Existing veg. cover: 70%



Field Visit ID-34

GLU: CSP-Developed-2

View: Looking south

Existing sediment production: Low

Potential sediment production: Low

Existing veg. cover: 95%



Field Visit ID-35

GLU: FB-Scrub/Shrub-3

View: Looking northeast

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 90-95%



Field Visit ID-36

GLU: FSI-Agricultural/ Grass-2

View: Looking northeast

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 95%



Field Visit ID-37

GLU: CB-Forest-3

View: Looking southeast

Existing sediment production: Med-High

Potential sediment production: High

Existing veg. cover: 75-80%



Field Visit ID-38

GLU: CSI-Agricultural/ Grass-1

View: Looking northeast

Existing sediment production: Low

Potential sediment production: Med

Existing veg. cover: 85%



Field Visit ID-39

GLU: CSP-Developed-1

View: Looking west

Existing sediment production: Low

Potential sediment production: Low

Existing veg. cover: 30-35%



Field Visit ID-40

GLU: CSP-Scrub/Shrub-4

View: Looking south

Existing sediment production: Med

Potential sediment production: High

Existing veg. cover: 90-95%

REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams

Geologic Group

- Coarse Bedrock
- Coarse Sedimentary Impermeable
- Coarse Sedimentary Permeable
- Fine Bedrock
- Fine Sedimentary Impermeable
- Fine Sedimentary Permeable
- Other

Aerial Imagery Source: DigitalGlobe, 06/2012

Miles 0 5 10 15

NORTH

Geologic Groups

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

RICK ENGINEERING COMPANY

REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams
- Potential Critical Coarse Sediment Yield Areas

Aerial Imagery Source: DigitalGlobe, 06/2012

Miles 0 5 10 15

NORTH

Potential Critical Coarse Sediment Yield Areas

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

RICK ENGINEERING COMPANY

ATTACHMENT A.5
PHYSICAL STRUCTURES

A.5 Physical Structures

The desktop-level analysis to identify existing physical structures within the nine watershed management areas within the San Diego region utilized the following GIS data sources:

- ESRI ArcMap, Google Earth, and Google Maps products
- Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) Flood Profiles and FEMA Flood Insurance Rate Map (FIRM)
- National Flood Hazard Layer (NFHL)
- Municipal master drainage plans (as provided)
- San Diego Geographic Information Source (SanGIS) Municipal Boundaries and Hydrologic Basins
- United States Geological Survey (USGS) National Hydrography Dataset (NHD) California data
- Stream data generated as indicated in Section 2.2

The following documents the process used to identify the physical structures along the reaches and the resulting GIS data:

- The process began by importing the data sources indicated above into a single ArcMap document that served as a master map file from which all further analysis proceeded.
- The data were screened and selected for inclusion as appropriate to the project scope.
- Point features were placed along river reach line segments to coincide with visually identified structures, utilizing different feature symbols according to the type of infrastructure.
- In the case of levees, the point was placed at the downstream-most end of the FEMA NFHL Shapefile. All point features generated in this task appear in the GIS shapefile.
- Municipal boundaries intersecting river reaches were identified to identify the applicable municipal drainage plan data.
- Point feature attributes and associated information for Physical Structures GIS shapefile is indicated in Table A.5.1 below.

Table A.5.1: Structure Identification Point Feature Attribute Development and Information

Attribute	Description
Struct_ID	The Structure ID field provides a six-digit identification number based upon the structure's specific location within a watershed. The first three digits in the code reflect the structure's Hydrologic Unit (HU) Basin number (ranging between 902-911 for Region 9, as defined in the Water Quality Control Plan for the San Diego Basin). The subsequent three digits reflect the structure's location along the reach, ascending along the channel from the headwaters to tailwaters (ranging between 001-999, beginning at the confluence and increasing in the upstream direction).

Attribute	Description
WMA	The Watershed Management Area field provides the name of the watershed in which the structure exists. The WMA corresponds with the HU identified in the first three digits in the Struct_ID (e.g., 911, Tijuana Watershed).
Channel_ID	The Channel ID field provides the name of the channel in which the structure exists.
Struct_Typ	The Structure Type field classifies known structures as one of the following types:, Bridge, Culvert, Dam, Energy Dissipater, Flood Management Basin, Flood Wall, Grade Control, Levee, Pipeline, Weir.
Struct_Dtl	The Structure Detail field provides known quantitative information for multi-section culverts.
Struct_Mtl	The Structure Material field provides known qualitative information for structure material composition.
Struct_Shp	The Structure Shape field provides known geometric information for culvert shapes, and is classified as one of the following types: Arch, Box, Pipe.
Jurisd_ID	The Jurisdiction ID field, when applicable, provides the known separate structure identification number developed and utilized by the jurisdiction or entity responsible for creating and distributing the coinciding structure Shapefile data used for this analysis. This number was copied from the coinciding external Shapefile data attribute field best representing a unique jurisdiction or entity-based identification number (external Shapefile data received from regional WMAA data call; for jurisdictional information, see "Other" attribute field). Coinciding external Shapefile data was used to determine various structure attributes.
Plan_ID	The Plan ID field, when applicable, provides the known structure plan number corresponding with the Jurisdiction ID. This number was copied from the coinciding external Shapefile data attribute field best representing a unique plan number received from the regional WMAA data call (external Shapefile data received from regional WMAA data call; for jurisdictional information, see "Other" field). Coinciding external Shapefile data was used to determine various structure attributes.
Diameter	The Diameter field, when applicable, provides the known diameter (in US feet) for culverts.
Length	The Length field, when applicable, provides the known length (in US feet) for select structure types. When lengths were determined using FEMA FIS Flood Profiles, the scaled horizontal distances along the indicated roadway or channel slope were used.
Width	The Width field, when applicable, provides the known width (in US feet) for select structure types.
Height	The Height field, when applicable, provides the known height (in US feet) for select structure types. When heights were determined using FEMA FIS Flood Profiles, the scaled vertical distances from channel bed to indicated roadway bottom were used.
US_Invert	The Upstream Invert field, when applicable, provides the known upstream invert elevation (in US feet) for select structure types.
DS_Invert	The Downstream Invert field, when applicable, provides the known downstream invert elevation (in US feet) for select structure types.

Attribute	Description
RD_EL_NAVD	The Roadway Elevation (NAVD) field, when applicable, provides the known roadway elevation (in US feet, NAVD) for select structure types. When roadway elevations were determined using FEMA FIS Flood Profiles, the horizontal projection onto the vertical grid scales were used.
Loc_Descr	The Location Description field, when applicable, provides information for structures crossing a known roadway. In nearly all cases, Google Earth imagery was used to determine the roadway name.
Other	The Other field is used to convey any information not present within the preceding fields. Typically, "other" information includes jurisdictional, plan, and supplemental dimensions for a given structure.

Example Structure Identification

The following example demonstrates the structure identification process for a discrete structure (ID 907029) along the San Diego River. The San Diego River is located in the San Diego River watershed (WMA 907). Scanning the river from lower to higher reached, a new point feature was placed at the road crossing over the San Diego River as indicated in Figure A.5.1. Select attributes of this particular structure were available from the FEMA NFHL as displayed in the highlighted boxes in Figure A.5.1. Additional attributes such as the culvert height, length, roadway elevation, and name were also determined from the FIS Flood Profile as indicated in Figure A.5.2. Satellite imagery (e.g., Google) was used to verify the existence of structure. In this case, the most current Google Map data indicated that the culvert still exists and that the roadway name has been changed to Qualcomm Way. When structures could not be verified with satellite imagery, the structure identification was based solely upon the information provided or readily available and was not physically verified in the field. Figure A.5.3 displays an example of imagery used to identify structures.

Figure A.5.1: Typical ArcMap Window

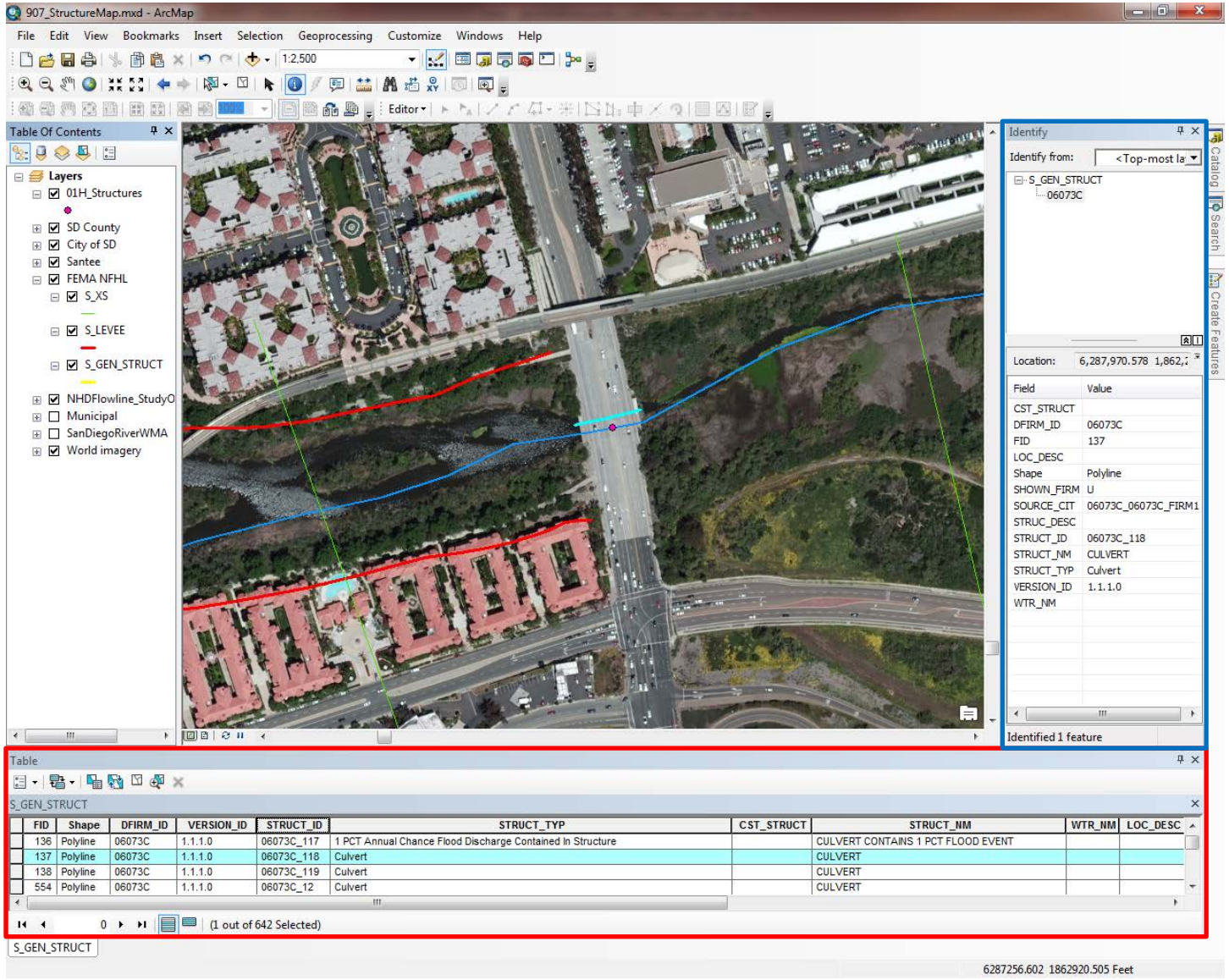
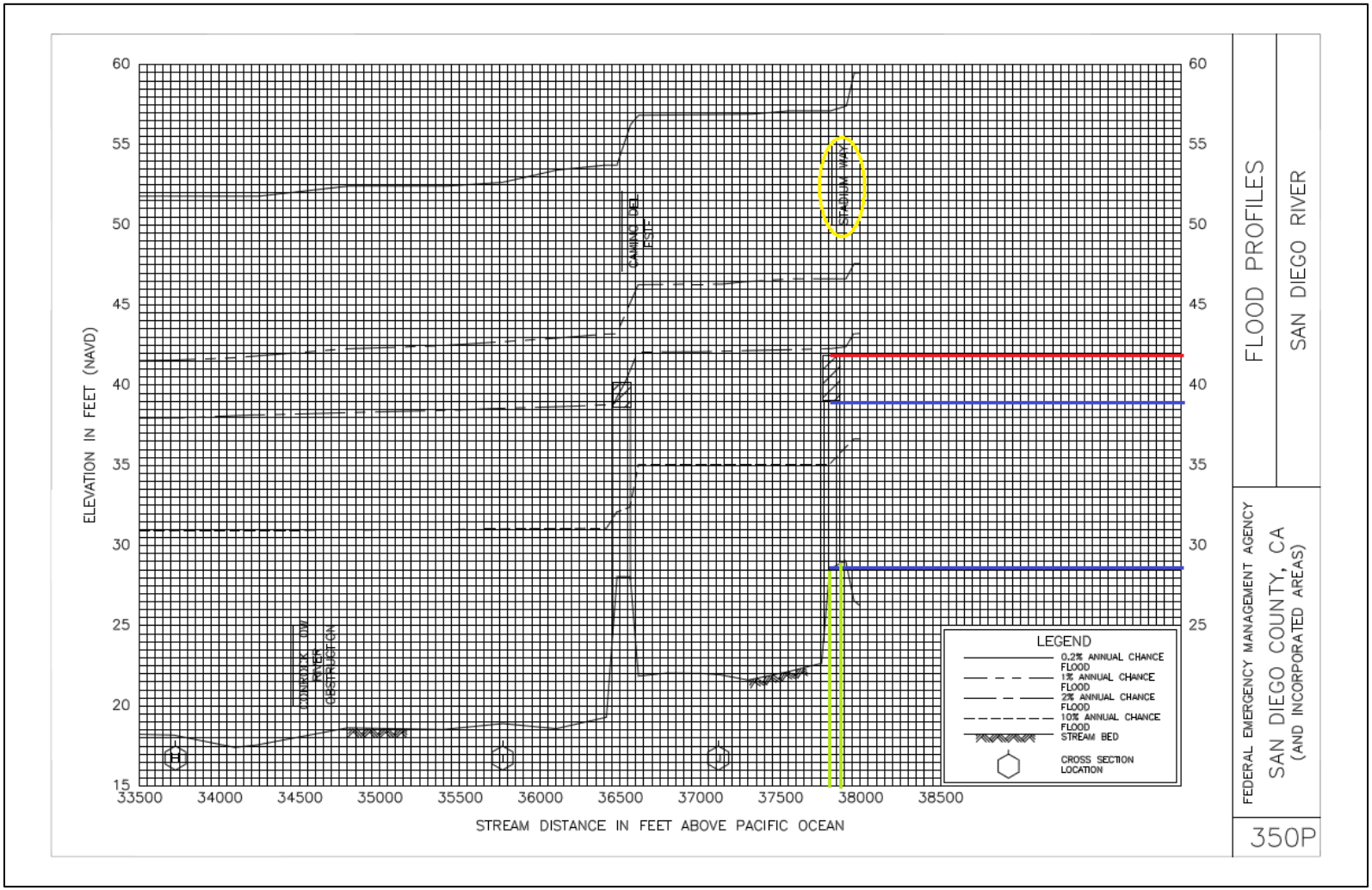


Figure A.5.2: Typical FEMA FIS Flood Profile



Legend: roadway elevation (red), roadway name (yellow), culvert height (blue), culvert width (green)

Figure A.5.3: Google Map Imagery for Structure Identification



The following bridge structure dimensional attributes were included in the point feature attributes:

- length 110 feet
- height 10 feet
- roadway elevation 41.9 feet

The attribute table associated with the identified structure included in the GIS shapefile is indicated in Table A.5.2.

Table A.5.2: Structure 907029 Attribute Table

Attribute	Description
Struct_ID	907029
WMA	San Diego
Channel_ID	San Diego River
Struct_Typ	Culvert
Struct_Dtl	
Struct_Mtl	
Struct_Shp	
Jurisd_ID	06073C_118
Plan_ID	06073C_06073C_FIRM1
Diameter	0
Length	110
Width	0
Height	10
US_Invert	0
DS_Invert	0
RD_EL_NAVD	41.9
Loc_Descr	Qualcomm Way
Other	Info from FEMA NFHL shapefile data/FIS FP V.9-350P

REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
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11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
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17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams

Channel Structure Type

- Bridge
- Culvert
- Dam
- Energy Dissipator
- Pipeline
- Unknown

Aerial Imagery Source: DigitalGlobe, 06/2012

Miles 0 5 10 15

NORTH

Watershed Management Area Streams with Channel Structures

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

RICK Engineering Company

ATTACHMENT B
HYDROMODIFICATION MANAGEMENT APPLICABILITY/EXEMPTIONS

ATTACHMENT B.1

ADDITIONAL ANALYSIS FOR HYDROMODIFICATION MANAGEMENT EXEMPTIONS

ATTACHMENT B.1.1
EXEMPT RIVER REACHES

B.1.1 Exempt River Reaches

B.1.1.1 Approach for Exempt River Reach Analysis

The approach selected in this cumulative hydromodification impacts study accounts for: (1) hydrology, (2) channel geometry, (3) bed and bank material, and (4) sediment supply. The selected approach compares long-term changes in sediment transport capacity, or in-stream work, and sediment supply for the existing and future development conditions. The ratio of future/existing condition transport capacity, or work, is termed Erosion Potential (Ep). The ratio of future/existing condition bed sediment supply is termed Sediment Supply Potential (Sp). To calculate Ep, the hydrology, channel geometry, and bed/bank materials are characterized for the existing and future conditions. To calculate Sp, the sediment supply factor is characterized for the existing and future conditions.

The findings in this study propose exemption for a given river reach if the analysis satisfies the following criteria:

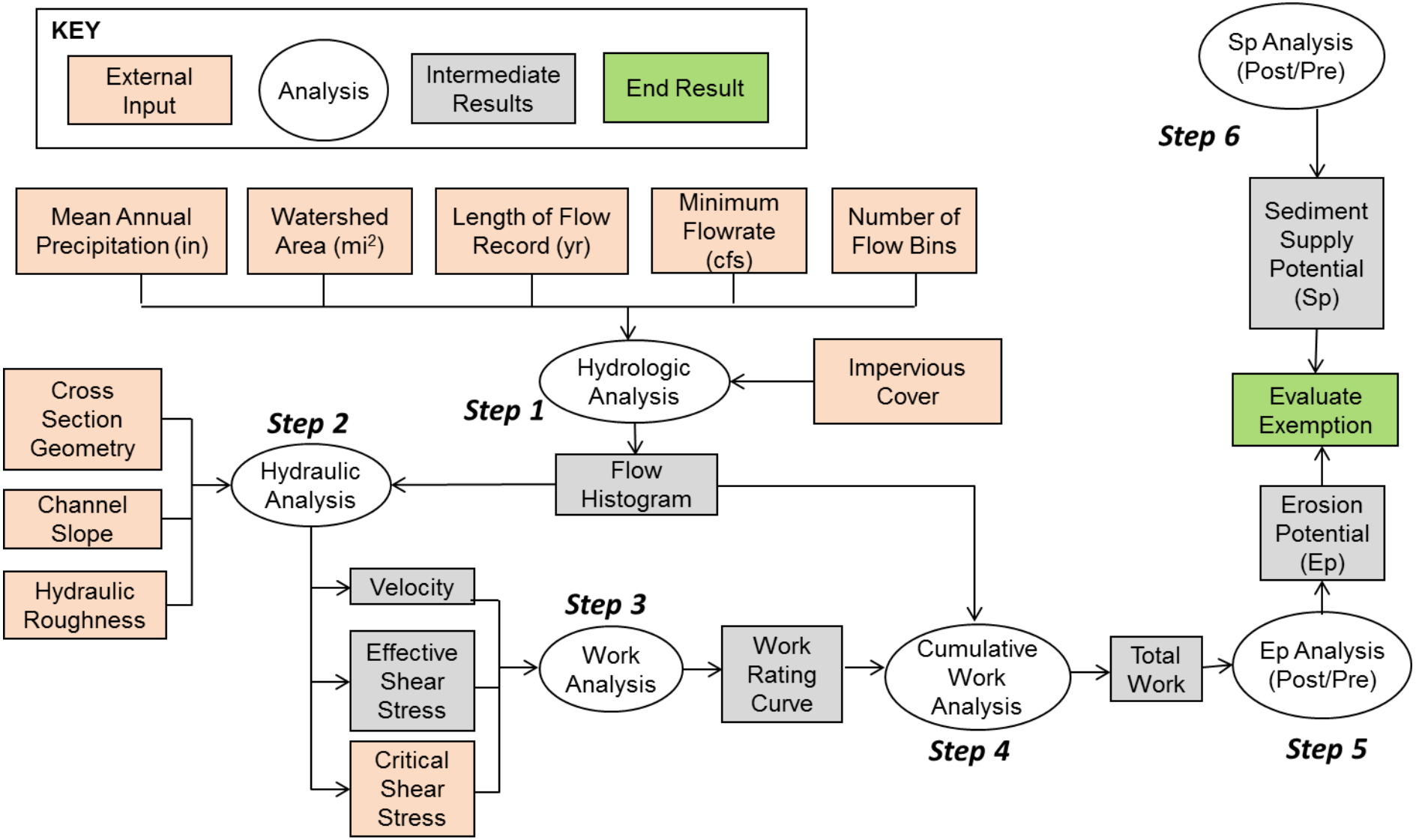
- Ep < 1.05 when d50 < 16 mm or Ep < 1.20 when d50 > 16 mm, and;
- Sp > 0.90

The following bullet points provide basis for the criteria listed above:

- For Ep
    - According to the Journal of Hydrology article titled Channel Enlargement in Semiarid Suburbanizing Watersheds: A Southern California Case Study (Hawley and Bledsoe, 2013): "*The threshold corresponding to the presence/absence of headcutting varied based on substrate type, and was roughly quantified as a sediment-transport ratio greater than ~1.20 in systems with a median grain size > 16mm, and [Ep] ~ 1.05 when* $d_{50} < 16$ *mm"*
- For Sp
    - Soar and Thorne (2001) indicate that a greater than 10% reduction in sediment supply can have potentially significant effects on stream stability.
    - SCCWRP Technical Report 605, 2010 states that changes of less than 10% in either driver (Water delivery and sediment are the drivers in this report) are unlikely to instigate, on their own, significant channel changes.

The flow chart summarizing the analysis procedure is presented below.

Flowchart for Exempt River Reach Analysis



B.1.1.2 Selection of Inputs for Exempt River Reach Analysis

The following steps were implemented for each river reach:

- Step 1 – Hydrologic Analysis:
  - Due to limited flow data, a flow duration equation developed for Southern California (Hawley and Bledsoe, 2011) was used to estimate existing and future flow histograms for each watershed.
  - The change in impervious cover between existing and future development conditions was estimated using the developable land use layer from Section 2.3.
  - A desktop-level GIS exercise was performed to manually assign land use classifications if the parcel in the developable land use layer directly discharges into the analyzed reach. Results are summarized in Section B.1.13.
  - Assumptions for percent imperviousness for each land use type were based on the information provided in the San Diego County Imperviousness Study (County of San Diego, 2010).
  - The table below presents the input parameters used to construct flow histograms, as well as the estimated channel slope at the critical cross section.

Exempt River Reach	Area (sq. miles)	Mean Annual Precipitation (in)	Length of Daily Flow Record (Years)	Channel Slope (ft/ft)
San Diego River	173	14.5	30	0.0012
Otay River – West of Interstate 805	46	12	30	0.0026
San Dieguito River	45	14	30	0.0012
San Luis Rey River	353	20	30	0.0019
Sweetwater River	72	12	30	0.0033

- Step 2 – Hydraulic Analysis: The reach type classification from Section 2.2 was used to identify the critical cross section along the reach for Ep analysis. A critical flow rate of $0.5Q_2$ was assigned to estimate the critical shear stress for the analyzed cross section. Flow rates below $0.5Q_2$ were assumed to perform no work on the reach.
- Step 3 – Work Analysis: The simplified effective work equation shown below is used to calculate the work done for each flow bin.

$$W = (\tau - \tau_c)^{1.5} V$$

Where

W = Work (dimensionless)
τ = effective Shear Stress [lb/ft^2]
τ_c = Critical Shear Stress [lb/ft^2]
V = Flow Velocity [ft/s]

- Step 4 – Cumulative Work Analysis: Cumulative work is a measure of the long-term total work or sediment transport capacity performed at a given stream location. Cumulative work incorporates both discharge magnitude and flow duration distributions for the full range of simulated flow rates. Cumulative work is calculated by multiplying work and

duration for each bin. Total work is calculated through summation of work from all flow bins.

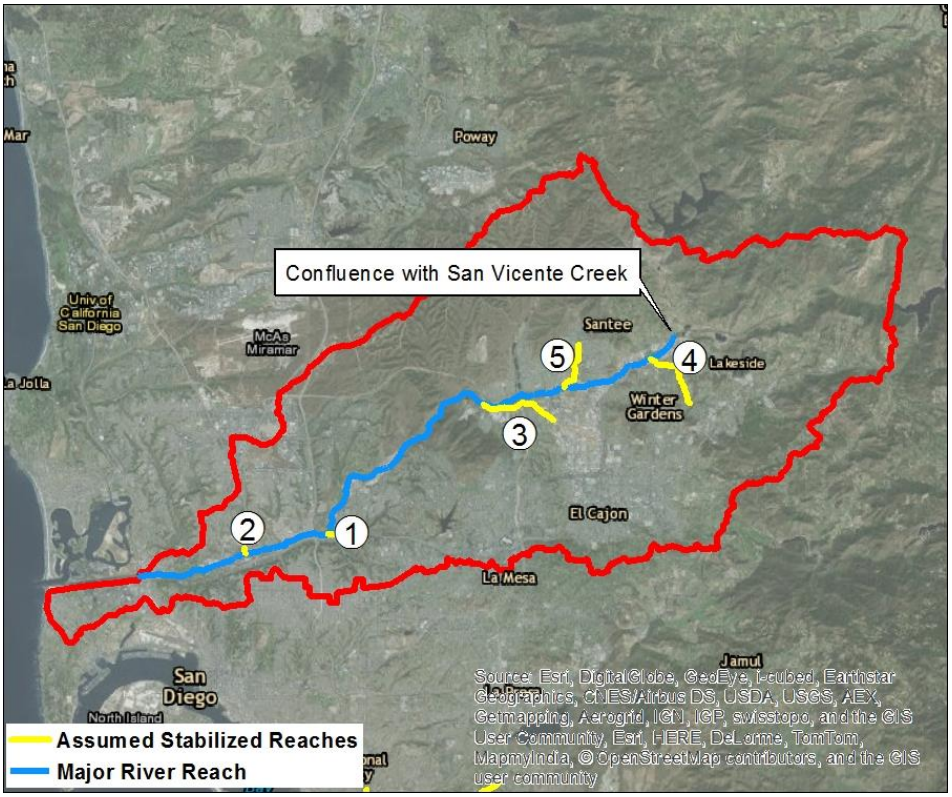
- Step 5 – Ep Analysis: Ep is calculated by dividing the total work of the future condition by that of the existing condition. The existing river reaches analyzed appear relatively stable and have not experienced excessive geomorphic instability due to the alteration of the drainage areas. Given the stable condition of the existing channels, the existing condition was used as the baseline condition instead of natural. Results from the Ep analysis are presented in Section B.1.1.3.
- Step 6 – Sp Analysis: Coarse Sediment Supply Potential for each watershed was estimated using the quantitative results from Section 2.4. First, the watershed coarse sediment soil loss was estimated for all GLUs producing coarse sediment. Then, the future-condition coarse sediment soil loss was estimated by subtracting the approximate exempt parcel soil loss from the existing soil loss. Sp is ultimately calculated by dividing the future coarse sediment soil loss by the existing coarse sediment soil loss. Results from Sp analysis are presented in Section B.1.1.3.

Steps 1 to 5 were performed in Excel and Steps 1 and 6 were executed in GIS. Ep estimates for the exempt river reaches are included in this attachment.

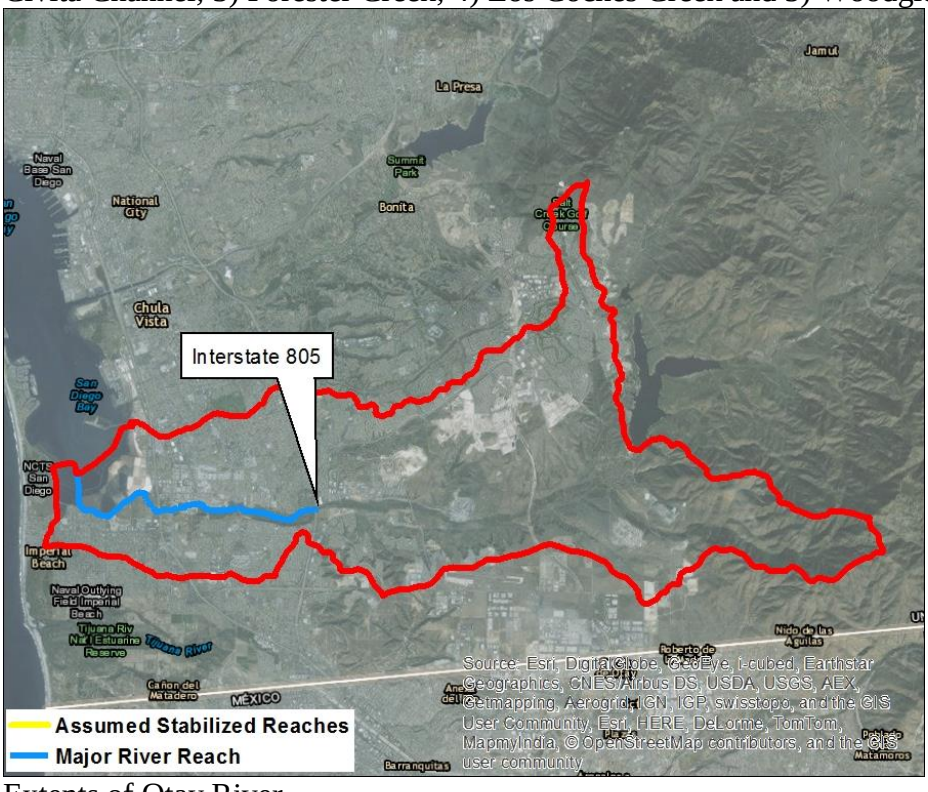
Exempt river reach extents are shown in the figures below. Figures also indicate the tributaries assumed to be stable for performing the erosion potential analysis as a conservative approach to approximate potential HMP exempt flows that may enter the river reach being analyzed.

For a PDP draining to one of the assumed stable tributaries shown in the following exempt reach figures, the PDP applicant shall verify and document that the assumed stable tributary is a stabilized conveyance system by using the methodology presented in section 4.1.2 prior to claiming exemption from hydromodification management requirements.

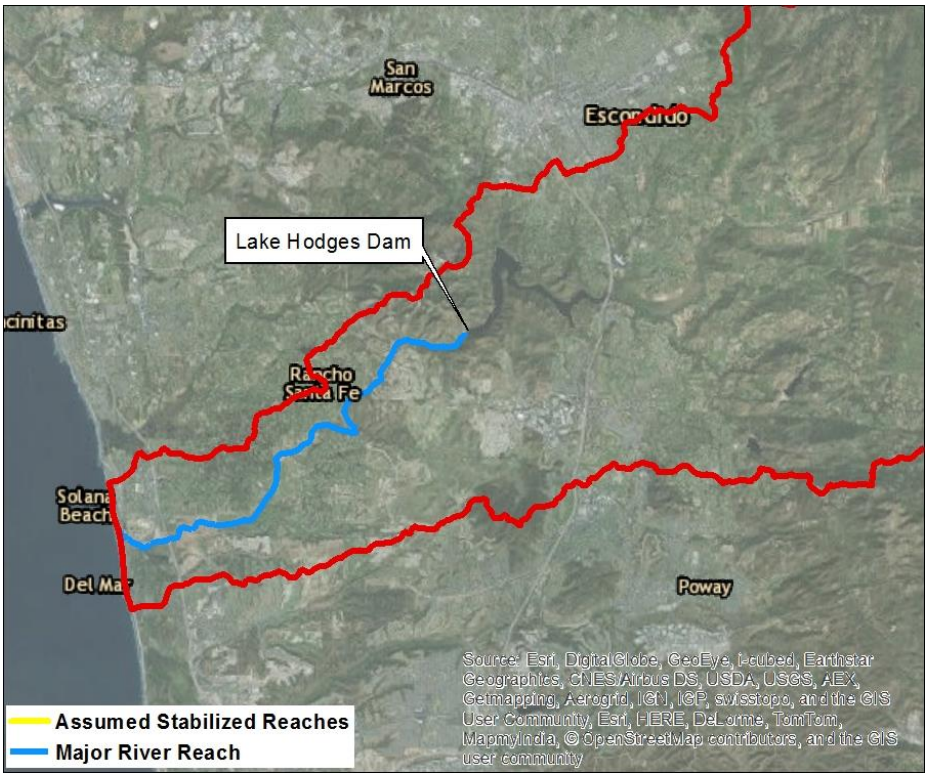
For a PDP draining to a tributary not shown in the figures below to be considered for exemption, a stability analysis using the section 4.1.2 methodology is to be conducted for the given tributary. If the stability analysis determines the tributary is stable, then the exempt river reach analysis indicated in section 4.1.1 shall be performed by adding the additional stabilized tributary to the current list of tributaries shown in the figures below to confirm that the reach satisfies the Ep and Sp criteria.



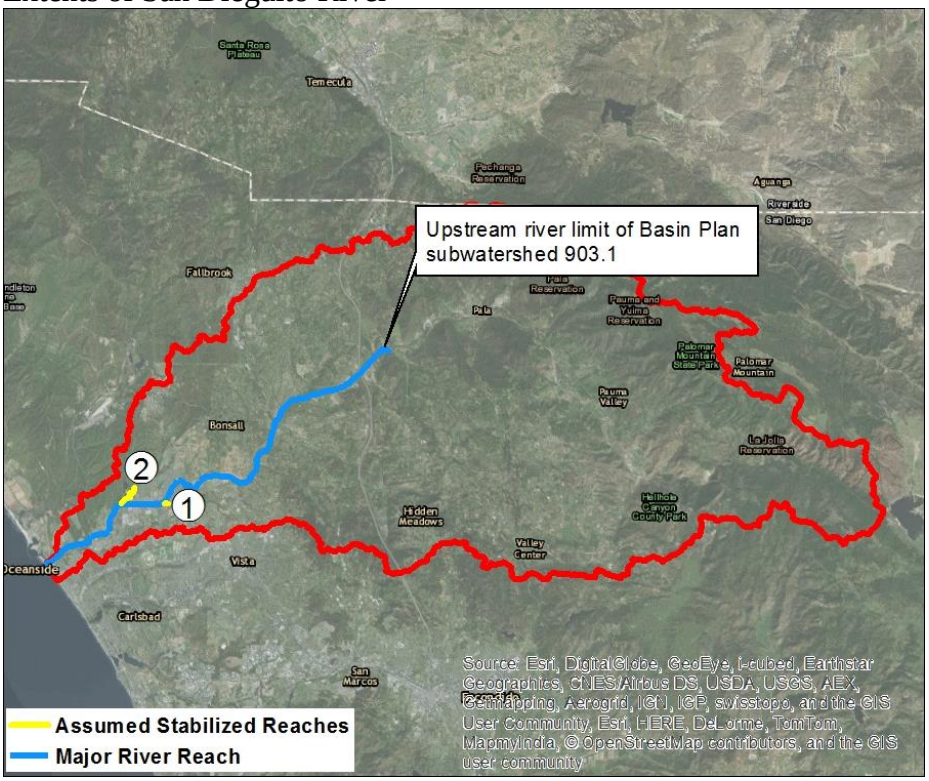
Extents of San Diego River and extents of assumed Stabilized Reaches: 1) Alvarado Creek; 2) Civita Channel; 3) Forester Creek; 4) Los Coches Creek and 5) Woodglen Vista Creek



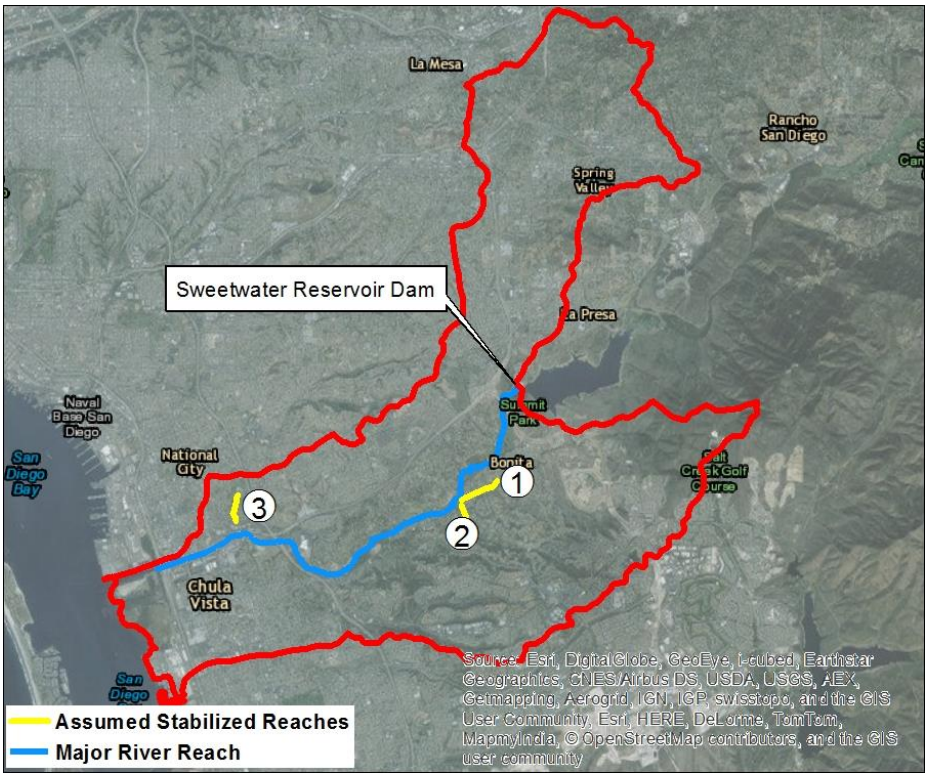
Extents of Otay River



Extents of San Dieguito River



Extents of San Luis Rey River and extents of assumed Stabilized Reaches: 1) Frazee Road Channel and 2) Pilgrim Creek



Extents of Sweetwater River and extents of assumed Stabilized Reaches: 1) Sunnyside Channel; 2) Long Canyon Channel; and 3) National City Gold Course Channel

The table below presents the summary of the developable land in each of the five watersheds with the exempt river reach and the estimated developable area that will be exempted from hydromodification management area requirements if the exempt river reach exemption is reinstated. This area will still be subject to the pollutant control requirements from the regional MS4 permit.

Exempt River Reach	Developable Land		
	Total (acres)	Area exempt (acres)	Exempt (%)
Otay River – West of Interstate 805	4,310	68	2%
San Diego River	13,667	1,196	9%
San Dieguito River	4,653	1,054	23%
San Luis Rey River	77,418	4,223	5%
Sweetwater River	1,332	255	19%

B.1.1.3 Results from Exempt River Reach Analysis

Results from Erosion potential analysis are presented below:

Exempt River Reach	Area (acres)	Impervious Area (acres) [%]			Ep (Post/Pre) [Criteria<1.05]
		Pre	Post	Increase	
Otay River – West of Interstate 805	29,571	9,428[31.8]	9,473[32.0]	45[0.2]	1.01
San Diego River	111,006	32,106[28.9]	32,777[29.5]	671 [0.6]	1.03
San Dieguito River	28,701	6,008[20.9]	6,042[21.0]	34[0.1]	1.01
San Luis Rey River	225,768	26,216[11.6]	26,803[11.9]	587[0.3]	1.01
Sweetwater River	26,596	10,566[39.7]	10,663[40.1]	97[0.4]	1.03

Results from coarse sediment supply potential analysis are presented below:

Exempt River Reach	Soil Loss (tons/yr.)			Sp (Post/Pre) [Criteria>0.90]
	Pre	Exempt Parcels	Post [Pre – Exempt Parcels]	
Otay River – West of Interstate 805	24,402	38	24,364	1.00
San Diego River	354,619	2,575	352,044	0.99
San Dieguito River	53,549	3,582	49,967	0.93
San Luis Rey River	1,503,964	27,072	1,476,892	0.98
Sweetwater River	16,672	601	16,071	0.96

Based on the results from the analysis it is recommended that exemption be reinstated for Otay River west of Interstate 805, San Diego River, San Dieguito River, San Luis Rey River and Sweetwater River.

Erosion Potential Analysis for Otay River - West of I805

Erosion Potential (Ep)	**1.01**

Channel Slope	0.0026	ft/ft
Estimated Q_2	133	cfs
$0.5Q_2$	66.5	cfs
Critical Shear	0.135	lb/sq. ft
γ	62.4	lb/ft^3

			Existing Condition	**Future Condition**
Tributary Area	*A*	sq mi	46	46
Mean Annual Precip	*MAP*	in/yr	12.0	12.0
Length of Daily Flow Record	*Yr*	yr	30	30
Imperviousness	*Impav*	mi^2/mi^2	0.3188	0.3203
Maximum Flow of Record	*Qmax*	cfs	1236.9	1236.9
Minimum Flow of Record	*Qmin*	cfs	0.01	0.01
10-year peak flow	*Q10*	cfs	3405.1	3405.1
Coefficient of DDF	*day1*	days & cfs	14796.19	15110.20
Exponent of DDF	*day2*	days & cfs	-0.91	-0.91
Number of Bins	N_B	--	25	25
Bin Size	$H_{B\text{-}log}$	--	0.489	0.489

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
B	$B_{lwr\text{-}log\ (cfs)}$	$B_{upr\text{-}log\ (cfs)}$	*Q (cfs)*	*R (ft)*	*v (ft/s)*	τ (psf)	*W*		*W*duration*		*W*duration*
1	0.006	0.010	0.01	0.03	0.18	0.005	0.000	1169806	0.00	1205056	0.00
2	0.010	0.016	0.01	0.03	0.18	0.005	0.000	751154	0.00	773107	0.00
3	0.016	0.027	0.02	0.04	0.22	0.006	0.000	482330	0.00	495989	0.00
4	0.027	0.043	0.03	0.05	0.24	0.008	0.000	309713	0.00	318204	0.00
5	0.043	0.071	0.06	0.06	0.29	0.010	0.000	198872	0.00	204144	0.00
6	0.071	0.115	0.09	0.07	0.32	0.011	0.000	127699	0.00	130970	0.00
7	0.115	0.188	0.15	0.08	0.36	0.013	0.000	81998	0.00	84024	0.00
8	0.188	0.306	0.25	0.10	0.41	0.016	0.000	52653	0.00	53906	0.00
9	0.306	0.498	0.40	0.12	0.46	0.019	0.000	33809	0.00	34583	0.00
10	0.498	0.812	0.66	0.14	0.52	0.023	0.000	21709	0.00	22187	0.00
11	0.812	1.324	1.07	0.17	0.59	0.028	0.000	13940	0.00	14234	0.00
12	1.324	2.158	1.74	0.21	0.66	0.034	0.000	8951	0.00	9132	0.00
13	2.158	3.517	2.84	0.25	0.75	0.041	0.000	5748	0.00	5859	0.00
14	3.517	5.733	4.62	0.30	0.85	0.049	0.000	3691	0.00	3759	0.00
15	5.733	9.344	7.54	0.36	0.96	0.058	0.000	2370	0.00	2411	0.00
16	9.344	15.230	12.29	0.43	1.08	0.070	0.000	1522	0.00	1547	0.00
17	15.230	24.825	20.03	0.52	1.22	0.084	0.000	977	0.00	992	0.00
18	24.825	40.465	32.64	0.62	1.38	0.101	0.000	627	0.00	637	0.00
19	40.465	65.956	53.21	0.75	1.56	0.122	0.000	403	0.00	409	0.00
20	65.956	107.507	86.73	0.94	1.82	0.153	0.004	259	1.12	262	1.14
21	107.507	175.233	141.37	1.18	2.11	0.191	0.029	166	4.74	168	4.80
22	175.233	285.626	230.43	1.46	2.44	0.237	0.080	107	8.50	108	8.60
23	285.626	465.563	375.59	1.80	2.81	0.292	0.175	68	12.02	69	12.14
24	465.563	758.856	612.21	2.15	3.16	0.349	0.313	44	13.77	44	13.90
25	758.856	1236.916	997.89	2.57	3.56	0.417	0.534	28	15.08	28	15.21

Erosion Potential Analysis for San Diego River

Erosion Potential (Ep)	**1.03**

Channel Slope	0.0012	ft/ft
Estimated Q_2	436	cfs
$0.5Q_2$	218	cfs
Critical Shear	0.109	lb/sq. ft
γ	62.4	lb/ft^3

			Existing Condition	**Future Condition**
Tributary Area	*A*	sq mi	173	173
Mean Annual Precip	*MAP*	in/yr	14.5	14.5
Length of Daily Flow Record	*Yr*	yr	30	30
Imperviousness	*Impav*	mi^2/mi^2	0.2892	0.2953
Maximum Flow of Record	*Qmax*	cfs	6336.8	6336.8
Minimum Flow of Record	*Qmin*	cfs	0.01	0.01
10-year peak flow	*Q10*	cfs	12411.4	12411.4
Coefficient of DDF	*day1*	days & cfs	48535.40	52754.33
Exponent of DDF	*day2*	days & cfs	-0.88	-0.88
Number of Bins	N_B	--	25	25
Bin Size	$H_{B\text{-}log}$	--	0.557	0.557

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
B	$B_{lwr\text{-}log\ (cfs)}$	$B_{upr\text{-}log\ (cfs)}$	*Q (cfs)*	*R (ft)*	*v (ft/s)*	τ (psf)	*W*		*W*duration*		*W*duration*
1	0.006	0.010	0.01	0.00	0.02	0.000	0.000	3404271	0.00	3830691	0.00
2	0.010	0.017	0.01	0.00	0.02	0.000	0.000	2089074	0.00	2341409	0.00
3	0.017	0.030	0.02	0.00	0.03	0.000	0.000	1281986	0.00	1431125	0.00
4	0.030	0.053	0.04	0.01	0.04	0.001	0.000	786707	0.00	874737	0.00
5	0.053	0.093	0.07	0.01	0.05	0.001	0.000	482773	0.00	534660	0.00
6	0.093	0.162	0.13	0.01	0.07	0.001	0.000	296259	0.00	326797	0.00
7	0.162	0.282	0.22	0.02	0.08	0.001	0.000	181803	0.00	199746	0.00
8	0.282	0.492	0.39	0.02	0.10	0.001	0.000	111566	0.00	122090	0.00
9	0.492	0.859	0.68	0.03	0.13	0.002	0.000	68464	0.00	74624	0.00
10	0.859	1.499	1.18	0.04	0.16	0.003	0.000	42014	0.00	45612	0.00
11	1.499	2.615	2.06	0.06	0.20	0.004	0.000	25782	0.00	27879	0.00
12	2.615	4.562	3.59	0.09	0.25	0.007	0.000	15822	0.00	17040	0.00
13	4.562	7.960	6.26	0.12	0.31	0.009	0.000	9709	0.00	10415	0.00
14	7.960	13.889	10.92	0.17	0.39	0.013	0.000	5958	0.00	6366	0.00
15	13.889	24.234	19.06	0.23	0.49	0.017	0.000	3656	0.00	3891	0.00
16	24.234	42.283	33.26	0.33	0.61	0.025	0.000	2244	0.00	2378	0.00
17	42.283	73.776	58.03	0.45	0.76	0.034	0.000	1377	0.00	1454	0.00
18	73.776	128.724	101.25	0.63	0.94	0.047	0.000	845	0.00	889	0.00
19	128.724	224.597	176.66	0.87	1.17	0.065	0.000	519	0.00	543	0.00
20	224.597	391.875	308.24	1.20	1.45	0.090	0.000	318	0.00	332	0.00
21	391.875	683.742	537.81	1.65	1.80	0.124	0.003	195	0.60	203	0.62
22	683.742	1192.991	938.37	2.25	2.21	0.168	0.032	120	3.81	124	3.94
23	1192.991	2081.525	1637.26	3.00	2.68	0.225	0.105	74	7.72	76	7.96
24	2081.525	3631.836	2856.68	3.80	3.13	0.285	0.230	45	10.36	46	10.64
25	3631.836	6336.812	4984.32	4.06	3.28	0.304	0.282	28	7.80	28	7.98

Erosion Potential Analysis for San Dieguito River

Erosion Potential (Ep)	**1.01**

Channel Slope	0.0012	ft/ft
Estimated Q_2	156	cfs
$0.5Q_2$	78	cfs
Critical Shear	0.044	lb/sq. ft
γ	62.4	lb/ft^3

			Existing Condition	**Future Condition**
Tributary Area	*A*	sq mi	45	45
Mean Annual Precip	*MAP*	in/yr	14.0	14.0
Length of Daily Flow Record	*Yr*	yr	30	30
Imperviousness	*Impav*	mi^2/mi^2	0.209	0.211
Maximum Flow of Record	*Qmax*	cfs	1583.0	1583.0
Minimum Flow of Record	*Qmin*	cfs	0.01	0.01
10-year peak flow	*Q10*	cfs	3734.4	3734.4
Coefficient of DDF	*day1*	days & cfs	5669.51	5762.95
Exponent of DDF	*day2*	days & cfs	-0.84	-0.84
Number of Bins	N_B	--	25	25
Bin Size	$H_{B\text{-}log}$	--	0.499	0.499

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
B	$B_{lwr\text{-}log\ (cfs)}$	$B_{upr\text{-}log\ (cfs)}$	*Q (cfs)*	*R (ft)*	*v (ft/s)*	τ (psf)	*W*		*W*duration*		*W*duration*
1	0.006	0.010	0.01	0.01	0.07	0.001	0.000	322675	0.00	330221	0.00
2	0.010	0.016	0.01	0.01	0.07	0.001	0.000	212448	0.00	217264	0.00
3	0.016	0.027	0.02	0.02	0.09	0.001	0.000	139875	0.00	142946	0.00
4	0.027	0.045	0.04	0.01	0.10	0.001	0.000	92093	0.00	94049	0.00
5	0.045	0.074	0.06	0.03	0.11	0.002	0.000	60634	0.00	61878	0.00
6	0.074	0.121	0.10	0.03	0.13	0.002	0.000	39921	0.00	40712	0.00
7	0.121	0.199	0.16	0.04	0.14	0.003	0.000	26284	0.00	26786	0.00
8	0.199	0.328	0.26	0.05	0.16	0.004	0.000	17305	0.00	17623	0.00
9	0.328	0.541	0.43	0.05	0.19	0.004	0.000	11394	0.00	11595	0.00
10	0.541	0.891	0.72	0.07	0.21	0.005	0.000	7502	0.00	7629	0.00
11	0.891	1.467	1.18	0.08	0.25	0.006	0.000	4939	0.00	5019	0.00
12	1.467	2.416	1.94	0.11	0.29	0.008	0.000	3252	0.00	3302	0.00
13	2.416	3.979	3.20	0.13	0.34	0.010	0.000	2141	0.00	2173	0.00
14	3.979	6.552	5.27	0.17	0.40	0.013	0.000	1410	0.00	1430	0.00
15	6.552	10.790	8.67	0.21	0.46	0.016	0.000	928	0.00	941	0.00
16	10.790	17.769	14.28	0.26	0.53	0.019	0.000	611	0.00	619	0.00
17	17.769	29.263	23.52	0.34	0.62	0.025	0.000	402	0.00	407	0.00
18	29.263	48.191	38.73	0.43	0.73	0.032	0.000	265	0.00	268	0.00
19	48.191	79.361	63.78	0.54	0.85	0.040	0.000	174	0.00	176	0.00
20	79.361	130.694	105.03	0.68	1.00	0.051	0.001	115	0.06	116	0.06
21	130.694	215.228	172.96	0.86	1.16	0.064	0.003	76	0.25	76	0.25
22	215.228	354.441	284.83	1.08	1.35	0.081	0.009	50	0.47	50	0.48
23	354.441	583.699	469.07	1.34	1.57	0.100	0.021	33	0.68	33	0.69
24	583.699	961.245	772.47	1.65	1.80	0.124	0.040	22	0.87	22	0.87
25	961.245	1582.993	1272.12	1.98	2.03	0.148	0.068	14	0.97	14	0.97

Erosion Potential Analysis for San Luis Rey River

Erosion Potential (Ep)	**1.01**

Channel Slope	0.0019	ft/ft
Estimated Q_2	1225	cfs
$0.5Q_2$	612.5	cfs
Critical Shear	0.077	lb/sq. ft
γ	62.4	lb/ft^3

			Existing Condition	**Future Condition**
Tributary Area	*A*	sq mi	353	353
Mean Annual Precip	*MAP*	in/yr	20.0	20.0
Length of Daily Flow Record	*Yr*	yr	30	30
Imperviousness	*Impav*	mi^2/mi^2	0.1161	0.1187
Maximum Flow of Record	*Qmax*	cfs	22579.2	22579.2
Minimum Flow of Record	*Qmin*	cfs	0.01	0.01
10-year peak flow	*Q10*	cfs	29414.3	29414.3
Coefficient of DDF	*day1*	days & cfs	23720.72	24587.28
Exponent of DDF	*day2*	days & cfs	-0.76	-0.76
Number of Bins	N_B	--	25	25
Bin Size	$H_{B\text{-}log}$	--	0.610	0.610

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
B	$B_{lwr\text{-}log\ (cfs)}$	$B_{upr\text{-}log\ (cfs)}$	*Q (cfs)*	*R (ft)*	*v (ft/s)*	τ (psf)	*W*		*W*duration*		*W*duration*
1	0.01	0.01	0.01	0.00	0.02	0.000	0.000	955692	0.00	1005555	0.00
2	0.01	0.02	0.01	0.00	0.02	0.000	0.000	601390	0.00	631581	0.00
3	0.02	0.03	0.03	0.00	0.03	0.000	0.000	378438	0.00	396691	0.00
4	0.03	0.06	0.05	0.00	0.03	0.000	0.000	238140	0.00	249158	0.00
5	0.06	0.11	0.09	0.00	0.04	0.000	0.000	149855	0.00	156494	0.00
6	0.11	0.21	0.16	0.01	0.05	0.001	0.000	94299	0.00	98293	0.00
7	0.21	0.39	0.30	0.01	0.07	0.001	0.000	59340	0.00	61737	0.00
8	0.39	0.71	0.55	0.01	0.08	0.001	0.000	37341	0.00	38776	0.00
9	0.71	1.31	1.0	0.02	0.11	0.002	0.000	23498	0.00	24355	0.00
10	1.3	2.4	1.9	0.02	0.14	0.002	0.000	14786	0.00	15297	0.00
11	2.4	4.4	3.4	0.03	0.17	0.004	0.000	9305	0.00	9608	0.00
12	4.4	8.2	6.3	0.05	0.22	0.006	0.000	5855	0.00	6035	0.00
13	8.2	15.0	11.6	0.07	0.27	0.008	0.000	3684	0.00	3790	0.00
14	15.0	27.6	21.3	0.10	0.35	0.012	0.000	2319	0.00	2381	0.00
15	27.6	50.9	39.2	0.14	0.44	0.017	0.000	1459	0.00	1495	0.00
16	50.9	93.6	72.2	0.20	0.55	0.024	0.000	918	0.00	939	0.00
17	93.6	172.1	132.8	0.28	0.70	0.033	0.000	578	0.00	590	0.00
18	172.1	316.6	244.4	0.40	0.87	0.047	0.000	364	0.00	371	0.00
19	316.6	582.5	449.6	0.55	1.09	0.065	0.000	229	0.00	233	0.00
20	582.5	1071.6	827.0	0.76	1.35	0.090	0.002	144	0.29	146	0.29
21	1071.6	1971.3	1521.4	1.07	1.69	0.127	0.019	91	1.70	92	1.72
22	1971.3	3626.6	2798.9	1.50	2.12	0.178	0.068	57	3.87	58	3.91
23	3626.6	6671.6	5149.1	2.09	2.65	0.248	0.187	36	6.71	36	6.77
24	6671.6	12273.5	9472.6	2.92	3.31	0.346	0.462	23	10.43	23	10.51
25	12273.5	22579.2	17426.3	4.06	4.12	0.481	1.059	14	15.04	14	15.13

Erosion Potential Analysis for Sweetwater River

Erosion Potential (Ep)	**1.025**

Channel Slope	0.0033	ft/ft
Estimated Q_2	110	cfs
$0.5Q_2$	55	cfs
Critical Shear	0.136	lb/sq. ft
γ	62.4	lb/ft^3

			Existing Condition	**Future Condition**
Tributary Area	*A*	sq mi	42	42
Mean Annual Precip	*MAP*	in/yr	12.0	12.0
Length of Daily Flow Record	*Yr*	yr	30	30
Imperviousness	*Impav*	mi^2/mi^2	0.397	0.401
Maximum Flow of Record	*Qmax*	cfs	1114.9	1114.9
Minimum Flow of Record	*Qmin*	cfs	0.01	0.01
10-year peak flow	*Q10*	cfs	3105.6	3105.6
Coefficient of DDF	*day1*	days & cfs	40664.46	42754.73
Exponent of DDF	*day2*	days & cfs	-1.01	-1.01
Number of Bins	N_B	--	25	25
Bin Size	$H_{B\text{-}log}$	--	0.484	0.484

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
B	$B_{lwr\text{-}log\ (cfs)}$	$B_{upr\text{-}log\ (cfs)}$	*Q (cfs)*	*R (ft)*	*v (ft/s)*	τ (psf)	*W*		*W*duration*		*W*duration*
1	0.006	0.010	0.01	0.03	0.18	0.006	0.000	5155264	0.00	5533785	0.00
2	0.010	0.016	0.01	0.03	0.18	0.006	0.000	3168799	0.00	3394387	0.00
3	0.016	0.026	0.02	0.03	0.22	0.006	0.000	1947774	0.00	2082094	0.00
4	0.026	0.043	0.03	0.04	0.24	0.008	0.000	1197243	0.00	1277143	0.00
5	0.043	0.069	0.06	0.05	0.29	0.010	0.000	735912	0.00	783391	0.00
6	0.069	0.113	0.09	0.06	0.32	0.012	0.000	452345	0.00	480527	0.00
7	0.113	0.183	0.15	0.07	0.36	0.014	0.000	278044	0.00	294752	0.00
8	0.183	0.297	0.24	0.08	0.40	0.016	0.000	170906	0.00	180799	0.00
9	0.297	0.481	0.39	0.10	0.46	0.021	0.000	105051	0.00	110901	0.00
10	0.481	0.781	0.63	0.12	0.51	0.025	0.000	64572	0.00	68026	0.00
11	0.781	1.268	1.02	0.14	0.58	0.029	0.000	39691	0.00	41727	0.00
12	1.268	2.057	1.66	0.17	0.66	0.035	0.000	24397	0.00	25595	0.00
13	2.057	3.339	2.70	0.20	0.74	0.041	0.000	14996	0.00	15700	0.00
14	3.339	5.419	4.38	0.24	0.83	0.049	0.000	9218	0.00	9630	0.00
15	5.419	8.795	7.11	0.29	0.94	0.060	0.000	5666	0.00	5907	0.00
16	8.795	14.273	11.53	0.35	1.06	0.072	0.000	3483	0.00	3623	0.00
17	14.273	23.165	18.72	0.42	1.20	0.086	0.000	2141	0.00	2223	0.00
18	23.165	37.595	30.38	0.51	1.36	0.105	0.000	1316	0.00	1363	0.00
19	37.595	61.014	49.30	0.63	1.57	0.130	0.000	809	0.00	836	0.00
20	61.014	99.022	80.02	0.78	1.81	0.161	0.007	497	3.50	513	3.61
21	99.022	160.707	129.86	0.70	1.67	0.144	0.001	306	0.38	315	0.39
22	160.707	260.818	210.76	0.71	1.69	0.146	0.002	188	0.33	193	0.34
23	260.818	423.291	342.05	0.81	1.85	0.167	0.010	115	1.16	118	1.19
24	423.291	686.974	555.13	1.04	2.19	0.214	0.048	71	3.40	73	3.48
25	686.974	1114.916	900.95	1.35	2.61	0.278	0.140	44	6.10	45	6.23

ATTACHMENT B.1.2

SUPPORT MATERIALS FOR ANALYSIS OF FORESTER CREEK AS A STABILIZED CONVEYANCE SYSTEM

Forester Creek Erosion Potential Analysis for Cross Section 1300 Located Downstream of Mission Gorge Road

			Existing Condition	Future Condition
Tributary Area	*A*	sq mi	23.36	23.36
Mean Annual Precip	*MAP*	in/yr	14	14
Length of Daily Flow Record	*Yr*	yr	30	30
Imperviousness	*Impav*	mi^2/mi^2	0.4634	0.4792
Maximum Flow of Record	*Qmax*	cfs	836.0	836.0
Minimum Flow of Record	*Qmin*	cfs	0.01	0.01
10-year peak flow	*Q10*	cfs	2120.2	2120.2
Coefficient of DDF	*day1*	days & cfs	121556.06	151171.59
Exponent of DDF	*day2*	days & cfs	-1.17	-1.19
Number of Bins	N_B	--	25	25
Bin Size	$H_{B\text{-}log}$	--	0.472	0.472

γ	62.4	lb/ft^3
Critical Shear	2.100	lb/sq. ft
Channel Slope	0.0060	ft/ft

Critical Shear Flow Rate	2150	cfs	Approximate flow rate that would achieve critical shear stress for this channel cross section
Critical Shear Flow Depth	6.3	ft	Approximate flow depth that would achieve critical shear stress for this channel cross section

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Flow Depth	Flow Area	Wetted Perimeter	Hydraulic Radius	Flow Velocity	Channel Slope	Shear Stress	Work	Existing Condition Duration	Existing Condition Duration	Existing Condition Cumulative Work	Future Condition Duration	Future Condition Duration	Future Condition Cumulative Work
B	$B_{lwr\text{-}log}$	$B_{upr\text{-}log}$	*Q*	*D*	*A*	*P*	*R*	*v*	*ft/ft*	τ	*W*	*days*	*years*	*W*days*	*days*	*years*	*W*days*
--	cfs	cfs	cfs	ft	sq ft	ft	ft	ft/s	ft/ft	psf	--	days	years	--	days	years	--
1	0.006	0.010	0.008	0.00	0.30	84.01	0.00	0.03	0.006	0.000	0.000	34249940.4	93771.2	0.00	46609552.7	127610.0	0.00
2	0.010	0.016	0.013	0.00	0.40	84.02	0.00	0.03	0.006	0.000	0.000	19693227.1	53917.1	0.00	26564034.2	72728.4	0.00
3	0.016	0.026	0.021	0.01	0.53	84.03	0.01	0.04	0.006	0.004	0.000	11323324.6	31001.6	0.00	15139555.5	41449.8	0.00
4	0.026	0.041	0.033	0.01	0.70	84.03	0.01	0.05	0.006	0.004	0.000	6510750.1	17825.5	0.00	8628438.7	23623.4	0.00
5	0.041	0.066	0.054	0.01	0.94	84.05	0.01	0.06	0.006	0.004	0.000	3743588.4	10249.4	0.00	4917578.7	13463.6	0.00
6	0.066	0.106	0.086	0.01	1.24	84.06	0.01	0.07	0.006	0.004	0.000	2152509.9	5893.3	0.00	2802660.0	7673.3	0.00
7	0.106	0.170	0.138	0.02	1.65	84.08	0.02	0.08	0.006	0.007	0.000	1237662.5	3388.5	0.00	1597311.1	4373.2	0.00
8	0.170	0.273	0.221	0.03	2.19	84.11	0.03	0.10	0.006	0.011	0.000	711638.3	1948.4	0.00	910350.4	2492.4	0.00
9	0.273	0.437	0.355	0.03	2.91	84.14	0.03	0.12	0.006	0.011	0.000	409181.9	1120.3	0.00	518833.1	1420.5	0.00
10	0.437	0.701	0.569	0.05	3.86	84.19	0.05	0.15	0.006	0.019	0.000	235273.7	644.1	0.00	295696.9	809.6	0.00
11	0.701	1.124	0.913	0.06	5.13	84.25	0.06	0.18	0.006	0.022	0.000	135279.0	370.4	0.00	168525.6	461.4	0.00
12	1.124	1.803	1.464	0.08	6.81	84.33	0.08	0.22	0.006	0.030	0.000	77783.5	213.0	0.00	96047.3	263.0	0.00
13	1.803	2.891	2.347	0.11	9.04	84.43	0.11	0.26	0.006	0.041	0.000	44724.4	122.4	0.00	54739.9	149.9	0.00
14	2.891	4.636	3.764	0.14	12.01	84.58	0.14	0.31	0.006	0.052	0.000	25715.9	70.4	0.00	31197.7	85.4	0.00
15	4.636	7.435	6.036	0.19	15.96	84.76	0.19	0.38	0.006	0.071	0.000	14786.3	40.5	0.00	17780.4	48.7	0.00
16	7.435	11.922	9.679	0.25	21.22	85.01	0.25	0.46	0.006	0.094	0.000	8501.9	23.3	0.00	10133.5	27.7	0.00
17	11.922	19.119	15.520	0.33	28.21	85.35	0.33	0.55	0.006	0.124	0.000	4888.5	13.4	0.00	5775.4	15.8	0.00
18	19.119	30.658	24.888	0.44	37.53	85.79	0.44	0.66	0.006	0.165	0.000	2810.8	7.7	0.00	3291.5	9.0	0.00
19	30.658	49.163	39.911	0.59	49.95	86.37	0.58	0.80	0.006	0.217	0.000	1616.2	4.4	0.00	1875.9	5.1	0.00
20	49.163	78.837	64.000	0.78	66.55	87.15	0.76	0.96	0.006	0.285	0.000	929.3	2.5	0.00	1069.1	2.9	0.00
21	78.837	126.421	102.629	1.03	88.77	88.18	1.01	1.16	0.006	0.378	0.000	534.3	1.5	0.00	609.3	1.7	0.00
22	126.421	202.726	164.574	1.37	118.57	89.54	1.32	1.39	0.006	0.494	0.000	307.2	0.8	0.00	347.3	1.0	0.00
23	202.726	325.088	263.907	1.82	158.67	91.35	1.74	1.66	0.006	0.651	0.000	176.7	0.5	0.00	197.9	0.5	0.00
24	325.088	521.305	423.196	2.41	212.84	93.74	2.27	1.99	0.006	0.850	0.000	101.6	0.3	0.00	112.8	0.3	0.00
25	521.305	835.955	678.630	3.20	286.33	96.91	2.95	2.37	0.006	1.104	0.000	58.4	0.2	0.00	64.3	0.2	0.00
														0.000000			0.000000

Ep #DIV/0!

(No work occurs in existing or future condition for the range of geomorphically significant flows)

Calculations shown below are for reference only - the flow rates are higher than the range of geomorphically significant flows:

Maximum Flow of Record			836.0	3.62	326.77	98.61	3.31	2.56	0.006	1.239	0.000
10-year peak flow			2120.2	6.27	595.18	109.31	5.44	3.56	0.006	2.037	0.000
Critical Shear Flow Rate			2150.0	6.32	600.64	109.52	5.48	3.58	0.006	2.052	0.000

Forester Creek Erosion Potential Analysis for Cross Section 2475 Located between Mission Gorge Road and State Route 52

			Existing Condition	Future Condition
Tributary Area	*A*	sq mi	23.36	23.36
Mean Annual Precip	*MAP*	in/yr	14	14
Length of Daily Flow Record	*Yr*	yr	30	30
Imperviousness	*Impav*	mi^2/mi^2	0.4634	0.4792
Maximum Flow of Record	*Qmax*	cfs	836.0	836.0
Minimum Flow of Record	*Qmin*	cfs	0.01	0.01
10-year peak flow	*Q10*	cfs	2120.2	2120.2
Coefficient of DDF	*day1*	days & cfs	121556.06	151171.59
Exponent of DDF	*day2*	days & cfs	-1.17	-1.19
Number of Bins	N_B	--	25	25
Bin Size	$H_{B\text{-}log}$	--	0.472	0.472

γ	62.4	lb/ft^3
Critical Shear	2.100	lb/sq. ft
Channel Slope	0.0030	ft/ft

Critical Shear Flow Rate	9400	cfs	Approximate flow rate that would achieve critical shear stress for this channel cross section
Critical Shear Flow Depth	12.92	ft	Approximate flow depth that would achieve critical shear stress for this channel cross section

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Flow Depth	Flow Area	Wetted Perimeter	Hydraulic Radius	Flow Velocity	Channel Slope	Shear Stress	Work	Existing Condition Duration	Existing Condition Duration	Existing Condition Cumulative Work	Future Condition Duration	Future Condition Duration	Future Condition Cumulative Work
B	$B_{lwr\text{-}log}$	$B_{upr\text{-}log}$	*Q*	*D*	*A*	*P*	*R*	*v*	*ft/ft*	τ	*W*	*days*	*years*	*W*days*	*days*	*years*	*W*days*
--	cfs	cfs	cfs	ft	sq ft	ft	ft	ft/s	ft/ft	psf	--	days	years	--	days	years	--
1	0.006	0.010	0.008	0.00	0.47	155.01	0.00	0.02	0.003	0.000	0.000	34249940.4	93771.2	0.00	46609552.7	127610.0	0.00
2	0.010	0.016	0.013	0.00	0.63	155.02	0.00	0.02	0.003	0.000	0.000	19693227.1	53917.1	0.00	26564034.2	72728.4	0.00
3	0.016	0.026	0.021	0.01	0.84	155.02	0.01	0.03	0.003	0.002	0.000	11323324.6	31001.6	0.00	15139555.5	41449.8	0.00
4	0.026	0.041	0.033	0.01	1.10	155.03	0.01	0.03	0.003	0.002	0.000	6510750.1	17825.5	0.00	8628438.7	23623.4	0.00
5	0.041	0.066	0.054	0.01	1.48	155.04	0.01	0.04	0.003	0.002	0.000	3743588.4	10249.4	0.00	4917578.7	13463.6	0.00
6	0.066	0.106	0.086	0.01	1.95	155.06	0.01	0.04	0.003	0.002	0.000	2152509.9	5893.3	0.00	2802660.0	7673.3	0.00
7	0.106	0.170	0.138	0.02	2.59	155.07	0.02	0.05	0.003	0.004	0.000	1237662.5	3388.5	0.00	1597311.1	4373.2	0.00
8	0.170	0.273	0.221	0.02	3.44	155.10	0.02	0.06	0.003	0.004	0.000	711638.3	1948.4	0.00	910350.4	2492.4	0.00
9	0.273	0.437	0.355	0.03	4.57	155.13	0.03	0.08	0.003	0.006	0.000	409181.9	1120.3	0.00	518833.1	1420.5	0.00
10	0.437	0.701	0.569	0.04	6.07	155.17	0.04	0.09	0.003	0.007	0.000	235273.7	644.1	0.00	295696.9	809.6	0.00
11	0.701	1.124	0.913	0.05	8.06	155.23	0.05	0.11	0.003	0.009	0.000	135279.0	370.4	0.00	168525.6	461.4	0.00
12	1.124	1.803	1.464	0.07	10.70	155.31	0.07	0.14	0.003	0.013	0.000	77783.5	213.0	0.00	96047.3	263.0	0.00
13	1.803	2.891	2.347	0.09	14.21	155.41	0.09	0.17	0.003	0.017	0.000	44724.4	122.4	0.00	54739.9	149.9	0.00
14	2.891	4.636	3.764	0.12	18.87	155.54	0.12	0.20	0.003	0.022	0.000	25715.9	70.4	0.00	31197.7	85.4	0.00
15	4.636	7.435	6.036	0.16	25.06	155.72	0.16	0.24	0.003	0.030	0.000	14786.3	40.5	0.00	17780.4	48.7	0.00
16	7.435	11.922	9.679	0.21	33.29	155.96	0.21	0.29	0.003	0.039	0.000	8501.9	23.3	0.00	10133.5	27.7	0.00
17	11.922	19.119	15.520	0.28	44.23	156.27	0.28	0.35	0.003	0.052	0.000	4888.5	13.4	0.00	5775.4	15.8	0.00
18	19.119	30.658	24.888	0.38	58.79	156.69	0.38	0.42	0.003	0.071	0.000	2810.8	7.7	0.00	3291.5	9.0	0.00
19	30.658	49.163	39.911	0.50	78.15	157.24	0.50	0.51	0.003	0.094	0.000	1616.2	4.4	0.00	1875.9	5.1	0.00
20	49.163	78.837	64.000	0.66	103.94	157.97	0.66	0.62	0.003	0.124	0.000	929.3	2.5	0.00	1069.1	2.9	0.00
21	78.837	126.421	102.629	0.88	138.32	158.95	0.87	0.74	0.003	0.163	0.000	534.3	1.5	0.00	609.3	1.7	0.00
22	126.421	202.726	164.574	1.17	184.24	160.24	1.15	0.89	0.003	0.215	0.000	307.2	0.8	0.00	347.3	1.0	0.00
23	202.726	325.088	263.907	1.55	245.63	161.95	1.52	1.07	0.003	0.285	0.000	176.7	0.5	0.00	197.9	0.5	0.00
24	325.088	521.305	423.196	2.06	327.91	164.22	2.00	1.29	0.003	0.374	0.000	101.6	0.3	0.00	112.8	0.3	0.00
25	521.305	835.955	678.630	2.73	438.50	167.22	2.62	1.55	0.003	0.490	0.000	58.4	0.2	0.00	64.3	0.2	0.00
														0.000000			0.000000

Ep #DIV/0!

(No work occurs in existing or future condition for the range of geomorphically significant flows)

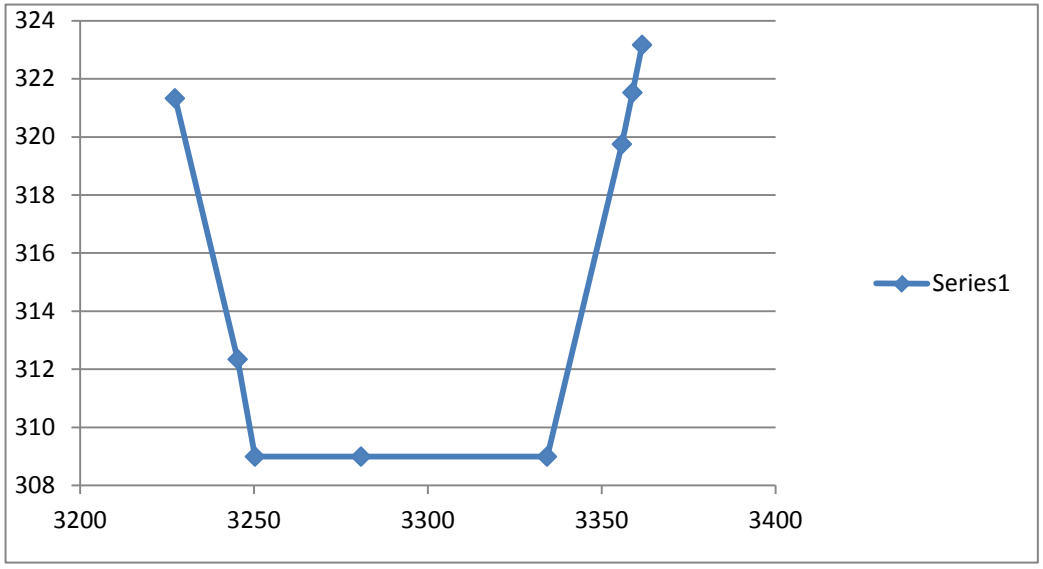
Calculations shown below are for reference only - the flow rates are higher than the range of geomorphically significant flows:

Maximum Flow of Record			836.0	3.09	498.85	168.84	2.95	1.68	0.003	0.552	0.000
10-year peak flow			2120.2	5.39	892.72	179.08	4.98	2.37	0.003	0.932	0.000
Critical Shear Flow Rate			9400.0	12.92	2337.34	212.80	10.98	4.02	0.003	2.055	0.000

CHANNEL GEOMETRY FOR FORESTER CREEK SECTION 1300
DOWNSTREAM OF MISSION GORGE ROAD

RS = 1300

STATION (FT)	ELEVATION (FT)
3227.329	321.325
3245.341	312.336
3250.328	308.99
3280.84	308.99
3334.35	308.99
3355.84	319.751
3358.858	321.522
3361.621	323.163



DEPTH = 321.325 - 308.99
12.335 (12 FEET)

TOP = 3358.858 - 3227.329
131.529 (132 FEET)

BOTTOM = 3334.35 - 3250.328
84.022 (84 FEET)

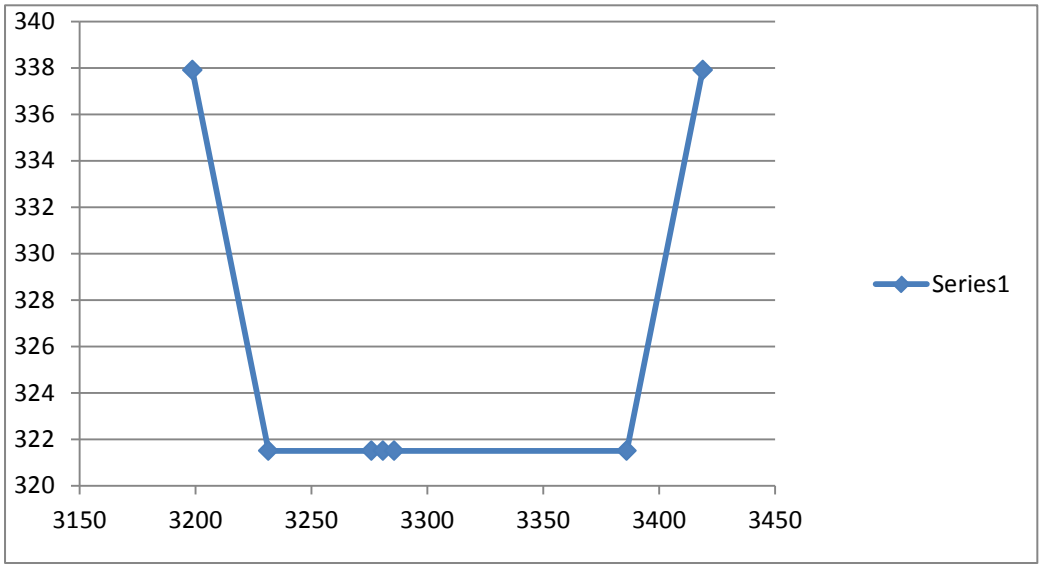
Z1 = (3250.328 - 3245.321) / (312.336 - 308.99)
1.5

Z2 = (3355.84 - 3334.35) / (319.751 - 308.99)
2.0

CHANNEL GEOMETRY FOR FORESTER CREEK SECTION 2475
BETWEEN MISSION GORGE ROAD AND STATE ROUTE 52

RS = 2475

STATION (FT)	ELEVATION (FT)
3198.688	337.913
3231.463	321.509
3275.919	321.509
3280.84	321.509
3285.761	321.509
3385.991	321.509
3418.799	337.913



DEPTH = 337.913 - 321.509
16.404 (16 FEET)

TOP = 3418.799 - 3198.688
220.111 (220 FEET)

BOTTOM = 3385.991 - 3231.463
154.528 (155 FEET)

Z1 = (3418.799 - 3385.991) / (337.913 - 321.509)
2.0

Z2 = (3231.463 - 3198.688) / (337.913 - 321.509)
2.0

Impervious Area Calculations for Forester Creek Watershed

Existing Condition

Existing Land Use

FREQUENCY	lu	landuse	Acres	% Impervious	A_Imp
81	1000	Spaced Rural Residential	754.48	0.10	75.45
	1100	Single Family Residential	0	0.42	0.00
1039	1110	Single Family Detached	5821.90	0.42	2445.20
353	1120	Single Family Multiple-Units	227.58	0.42	95.58
149	1190	Single Family Residential Without Units	45.72	0.42	19.20
297	1200	Multi-Family Residential	844.76	0.74	625.13
12	1290	Multi-Family Residential Without Units	1.44	0.74	1.06
40	1300	Mobile Home Park	399.85	0.74	295.89
25	1409	Other Group Quarters Facility	42.06	0.47	19.77
20	1501	Hotel/Motel (Low-Rise)	27.71	0.50	13.86
1	2001	Heavy Industry	20.29	0.80	16.23
52	2101	Industrial Park	587.62	0.82	481.85
15	2103	Light Industry - General	108.35	0.84	91.02
8	2104	Warehousing	16.18	0.84	13.59
15	2105	Public Storage	26.97	0.84	22.65
1	2301	Junkyard/Dump/Landfill	0.83	0.62	0.51
1	4103	General Aviation Airport	390.90	0.45	175.90
5	4111	Rail Station/Transit Center	6.62	0.77	5.10
8	4112	Freeway	365.74	0.58	212.13
44	4113	Communications and Utilities	38.39	0.40	15.35
11	4114	Parking Lot - Surface	3.28	0.75	2.46
1	4115	Parking Lot - Structure	1.30	0.61	0.79
1	4116	Park and Ride Lot	0.88	0.87	0.77
18	4117	Railroad Right of Way	25.88	0.52	13.46
58	4118	Road Right of Way	1907.10	0.60	1144.26
5	4119	Other Transportation	33.72	0.55	18.54
1	5002	Regional Shopping Center	73.97	0.94	69.53
4	5003	Community Shopping Center	37.14	0.83	30.83
17	5004	Neighborhood Shopping Center	110.81	0.85	94.19
21	5006	Automobile Dealership	58.88	0.89	52.40
193	5007	Arterial Commercial	260.86	0.83	216.52
37	5008	Service Station	18.68	0.94	17.56
42	5009	Other Retail Trade and Strip Commercial	74.30	0.80	59.44
	6001	Office (High-Rise)	0	0.61	0.00
38	6002	Office (Low-Rise)	44.03	0.65	28.62
2	6003	Government Office/Civic Center	16.31	0.80	13.05
2	6101	Cemetery	12.41	0.44	5.46
49	6102	Religious Facility	105.29	0.48	50.54
1	6103	Library	1.44	0.57	0.82
2	6104	Post Office	4.70	0.78	3.66
11	6105	Fire/Police Station	30.20	0.63	19.02
11	6109	Other Public Services	18.60	0.56	10.42
1	6502	Hospital - General	12.28	0.74	9.09
24	6509	Other Health Care	44.38	0.68	30.18
1	6701	Military Use	4.70	0.62	2.92
2	6802	Other University or College	34.53	0.54	18.64
4	6804	Senior High School	130.06	0.56	72.83
4	6805	Junior High School or Middle School	62.55	0.55	34.40
18	6806	Elementary School	163.06	0.56	91.31
1	6807	School District Office	13.59	0.72	9.78
5	6809	Other School	7.39	0.51	3.77
3	7210	Other Recreation - High	14.52	0.34	4.94
13	7601	Park - Active	83.80	0.14	11.73
42	7603	Open Space Park or Preserve	894.01	0.06	53.64
90	7606	Landscape Open Space	49.08	0.42	20.61
9	7607	Residential Recreation	10.06	0.42	4.22
	7609	Undevelopable Natural Area	0	0.06	0.00
	9700	Mixed Use	0	0.74	0.00
3	8001	Orchard or Vineyard	7.72	0.03	0.23
1	8002	Intensive Agriculture	2.09	0.12	0.25
1	8003	Field Crops	2.12	0.09	0.19
323	9101	Vacant and Undeveloped Land	806.75	0.08	64.54
23	9501	Residential Under Construction	37.51	0.42	15.76
1	9506	Road Under Construction	0.31	0.60	0.18
1	9507	Freeway Under Construction	0.79	0.58	0.46
			14948.47		6927.50
		square miles:	23.36		10.82
					46.34%

Impervious Area Calculations for Forester Creek Watershed

Future Condition

Planned Land Use

FREQUENCY	plu	plannedlu	Acres	% Impervious	A_Imp
45	1000	Spaced Rural Residential	1139.00	0.10	113.90
237	1100	Single Family Residential	391.50	0.42	164.43
996	1110	Single Family Detached	5691.47	0.42	2390.42
272	1120	Single Family Multiple-Units	200.38	0.42	84.16
161	1190	Single Family Residential Without Units	28.38	0.42	11.92
320	1200	Multi-Family Residential	975.71	0.74	722.02
15	1290	Multi-Family Residential Without Units	6.62	0.74	4.90
33	1300	Mobile Home Park	370.34	0.74	274.05
26	1409	Other Group Quarters Facility	42.48	0.47	19.97
12	1501	Hotel/Motel (Low-Rise)	20.38	0.50	10.19
1	2001	Heavy Industry	20.29	0.80	16.23
52	2101	Industrial Park	613.06	0.82	502.71
20	2103	Light Industry - General	143.05	0.84	120.16
8	2104	Warehousing	18.92	0.84	15.89
13	2105	Public Storage	24.52	0.84	20.59
	2301	Junkyard/Dump/Landfill	0	0.62	0.00
2	4103	General Aviation Airport	331.86	0.45	149.34
4	4111	Rail Station/Transit Center	6.91	0.77	5.32
11	4112	Freeway	366.71	0.58	212.69
46	4113	Communications and Utilities	38.92	0.40	15.57
	4114	Parking Lot - Surface	0	0.75	0.00
	4115	Parking Lot - Structure	0	0.61	0.00
1	4116	Park and Ride Lot	0.88	0.87	0.77
17	4117	Railroad Right of Way	34.97	0.52	18.19
58	4118	Road Right of Way	1919.19	0.60	1151.52
6	4119	Other Transportation	32.96	0.55	18.13
1	5002	Regional Shopping Center	73.97	0.94	69.53
4	5003	Community Shopping Center	38.33	0.83	31.82
21	5004	Neighborhood Shopping Center	110.59	0.85	94.00
12	5006	Automobile Dealership	39.76	0.89	35.39
134	5007	Arterial Commercial	202.24	0.83	167.86
34	5008	Service Station	17.73	0.94	16.67
74	5009	Other Retail Trade and Strip Commercial	95.29	0.80	76.23
11	6001	Office (High-Rise)	37.42	0.61	22.83
35	6002	Office (Low-Rise)	52.57	0.65	34.17
2	6003	Government Office/Civic Center	16.31	0.80	13.05
2	6101	Cemetery	12.42	0.44	5.46
42	6102	Religious Facility	97.91	0.48	47.00
1	6103	Library	1.44	0.57	0.82
2	6104	Post Office	4.70	0.78	3.66
11	6105	Fire/Police Station	28.83	0.63	18.16
12	6109	Other Public Services	20.95	0.56	11.73
1	6502	Hospital - General	12.28	0.74	9.09
22	6509	Other Health Care	45.84	0.68	31.17
1	6701	Military Use	4.70	0.62	2.92
2	6802	Other University or College	34.53	0.54	18.64
4	6804	Senior High School	130.09	0.56	72.85
4	6805	Junior High School or Middle School	62.60	0.55	34.43
19	6806	Elementary School	171.68	0.56	96.14
1	6807	School District Office	4.98	0.72	3.59
6	6809	Other School	11.02	0.51	5.62
2	7210	Other Recreation - High	11.59	0.34	3.94
23	7601	Park - Active	89.56	0.14	12.54
41	7603	Open Space Park or Preserve	866.19	0.06	51.97
90	7606	Landscape Open Space	55.58	0.42	23.34
10	7607	Residential Recreation	9.77	0.42	4.10
21	7609	Undevelopable Natural Area	34.38	0.06	2.06
77	9700	Mixed Use	134.73	0.74	99.70
	8001	Orchard or Vineyard	0	0.03	0.00
	8002	Intensive Agriculture	0	0.12	0.00
	8003	Field Crops	0	0.09	0.00
	9101	Vacant and Undeveloped Land	0	0.08	0.00
	9501	Residential Under Construction	0	0.42	0.00
	9506	Road Under Construction	0	0.60	0.00
	9507	Freeway Under Construction	0	0.58	0.00
			14948.47		7163.55
		square miles:	23.36		11.19

47.92%

ATTACHMENT B.1.3

EXCERPT OF VENTURA COUNTY HCP (FINAL DRAFT DATED SEPTEMBER 2013): APPENDIX D, BASIS FOR DESIGNATING NEGLIGIBLE RISK BASED ON CUMULATIVE FUTURE BUILDOUT

APPENDIX D

Basis for Designating Negligible Risk Based on Cumulative Future Buildout

APPENDIX D

BASIS FOR DESIGNATING NEGLIGIBLE RISK BASED ON CUMULATIVE FUTURE BUILDOUT

1. BACKGROUND

Hydromodification impacts are typically most severe just downstream of development and tend to decrease if more undeveloped watershed area contributes to the channel in the downstream direction. Analyses were performed to evaluate thresholds for additional impervious cover, from existing conditions (at the time of the HCP effective date) to buildout conditions, for the area tributary to a susceptible receiving water below which the risk of hydromodification impacts is considered negligible for that channel.

The following results are provided as a function of a susceptible channel's tributary area (A) and median grain size (D_{50}):

- If $A \geq 1$ square mile and $D_{50} \leq 16$ mm, then the threshold of additional imperviousness is evaluated using the nomograph in Figure 3-12.

  Figure 3-12 is based on empirical flow duration equations (Hawley and Bledsoe, 2011), empirical channel geometry relationships (Coleman et al, 2005 and County of San Diego, 2009), and Erosion Potential analyses (see HCP Section 6.3 for a discussion on the Erosion Potential analysis method). The results range from 0.46% to 1.00% additional imperviousness, depending on watershed size and mean annual precipitation (MAP).

- If $A < 1$ square mile and $D_{50} \leq 16$ mm, then the threshold of additional imperviousness is 0.44%. (See Section 6.2 below.)

- If $D_{50} \geq 16$ mm, then the threshold of additional imperviousness is 1.65%. (See Section 6.2 below.)

The analyses used to establish these thresholds are described below.

2. HYDROLOGIC ANALYSIS

2.1 Identify the Typical Range of Rainfall Conditions

For the purposes of this analysis, the typical range of mean annual precipitation (MAP) is assumed to be 14 inches to 18 inches per year because most of the developed regions within Ventura County fall within this range on the isohyetal map (Figure 2-5) and this range is consistent with Ventura County's long-term precipitation gage records

(VCWPD 2007). It is anticipated that future development will impact the most miles of susceptible channel in the Calleguas Watershed within and downstream of the Cities of Thousand Oaks, Simi Valley, and Moorpark. The long-term precipitation records in these areas are all within the 14 inch to 18 inch range and thus these two MAPs were used in this analysis.

Table D-1. Long-Term Precipitation Gage Records in Ventura County

Precipitation Gage ID	Period of Record	Mean Annual Precipitation (inches)
Camarillo #219	1965-2006	13.45
Port Hueneme #17	1891-2006	13.62
Moorpark #141	1949-2006	14.45
Ventura #66	1873-2006	14.71
Simi Valley #154	1948-2006	14.89
Thousand Oaks #128	1943 -2006	15.6
Santa Paula #245	1961-2006	17.35
Piru #36	1927-2006	17.39
Fillmore #199	1959-2006	18.44
Ojai #30	1906-2006	21.32

2.2 Identify the Range of Watershed Areas

The range of typical watershed areas used in the sensitivity analysis were established based on an inventory of a subset of natural drainage channels that have significant urban development in their tributary areas. While there are a few susceptible drainage channels with watershed areas over 100 square miles or less than 1 square mile, most of the susceptible channels downstream of development are lower order with watershed areas ranging from about 2 to 10 square miles. Seven categories of watershed area (1-, 2-, 5-, 10-, 20-, 50-, and 100-square miles) were used in this analysis.

2.3 Identify Length of Daily Flow Record

A 30-year length of daily flow record was assumed in this analysis. During preliminary runs it was found that the threshold of additional impervious cover was not sensitive to changes in the assumed length of daily flow record.

2.4 Calculate Necessary Peak Flow Inputs (Q_2, Q_5, Q_{10})

Empirical peak flow equations used to estimate the 2-, 5-, and 10-year recurrence interval flows (Hawley and Bledsoe, 2011). The general form of the equation is:

$$Q_i = e^{(Incpt)} * A^a * P^p * e^{(impmax * Impmax)}$$

Where:

Q_i	=	the instantaneous peak flow at return interval i years (cfs)
Incpt	=	the vertical axis intercept of the log-transformed linear regression model
A	=	total drainage area (mi^2)
P	=	average annual precipitation (in)
Impmax	=	the maximum spatial extent of the total impervious area during the gage record as a fraction of the total drainage area (mi^2/mi^2)

a, p, and impmax = regression parameters specific to each return period

Table D-2 provides the regression parameters for each return period of interest.

Table D-2. Regression parameters for the 2-, 5-, and 10-year peak flows

Return Period (yrs)	Incpt (-)	a (mi^2)	p (in)	Impmax (-)
2	-0.644	0.667	1.29	8.61
5	2.137	0.838	0.773	3.23
10	2.90	0.868	0.767	0

Table D-3 presents the resulting flowrates for each combination of tributary area and mean annual precipitation analyzed (14 total) assuming no imperviousness.

Table D-3. Peak Flow (Q_2, Q_5, Q_{10}) Results

Tributary Area	Mean Annual Precipitation	Q2	Q5	Q10
A	MAP			
sq mi	in/yr	cfs	cfs	cfs
1	14	15.8	65.2	138
2	14	25.1	116	251
5	14	46.2	251	556
10	14	73.4	449	1015
20	14	117	802	1853
50	14	215	1729	4104
100	14	341	3091	7491
1	18	21.9	79.1	167
2	18	34.7	141	304
5	18	63.9	305	674
10	18	102	545	1231
20	18	161	974	2247
50	18	297	2100	4977
100	18	472	3753	9083

2.5 Calculate Inputs for Long-Term Cumulative Durations (Q_{max}, Q_{min}, day1, day2, N_B, $H_{B\text{-}log}$)

In order to represent the mean daily flows with cumulative duration curves, logarithmic histogram bins were created to represent flow frequencies without any discontinuities

following the Hawley and Bledsoe (2011) methodology. The bin size of the logarithmically-spaced histogram bins ($H_{B\text{-}log}$) is represented as follows:

$$H_{B\text{-}log} = \{\ln(Q_{max})\text{-}\ln(Q_{min})\}/(N_B\text{-}1)$$

Where:

Q_{max}	=	the maximum flow of record (cfs)
Q_{min}	=	the minimum flow of record (cfs)
N_B	=	the number of bins

The minimum flow (Q_{min}) was set equal to 0.01 cfs, which represents the lowest non-zero mean daily flow reported at any gage used in the Hawley and Bledsoe (2011) analysis. The number of bins (N_B) was set at 25 to provide a balance between using small enough bin sizes for adequate resolution and ensuring that the flow-record data would be capable of populating each of the bins. The maximum flow of record (Q_{max}) is equivalent to the maximum mean 24-hour flow and is estimated using the following equation:

$$Q_{max}=e^{(-2.24)}*A^{0.979}*P^{1.79}*Yr^{0.341}$$

Where:

A	=	total drainage area (mi^2)
P	=	average annual precipitation (in)
Yr	=	the length of the mean daily flow record (30 years)

Q_{max} is also the scaling factor for the duration density function (DDF), or conditional probability density function, used to predict the cumulative durations of the binned geomorphically-effective flows. A power function is used to represent the duration in days, with the following form:

$$days = day1*Q^{day2}$$

The parameter 'day1' represents the magnitude of the power function calibrated in 'days' and 'cfs' and is estimated using the following relationship:

$$day1 = e^{(-12.9)}*A^{0.676}*P^{3.71}*Yr^{1.85}*e^{(13.8*Impav)}$$

Where:

A	=	total drainage area (mi^2)

P	=	average annual precipitation (in)
Yr	=	the length of the mean daily flow record (30 years)
Impav	=	the average spatial extent of the total impervious area expressed as a fraction of the total drainage area (mi^2/mi^2)

The parameter 'day2' represents the shape of the power function and is calibrated in 'days' and 'cfs' through the following relationship:

$$day2 = -1.60+0.166*\ln(Q_{10})-0.138*\ln(day1)+0.129*\ln(Yr)+0.720*Impav$$

Where:

Q_{10}	=	the instantaneous 10-year peak flow
Yr	=	the length of the mean daily flow record (30 years)
Impav	=	the average spatial extent of the total impervious area expressed as a fraction of the total drainage area (mi^2/mi^2)

2.6 Calculate Long-Term Cumulative Durations for Each Flow Bin (B, $B_{lwr-log}$, $B_{upr-log}$, Q, days)

Using the bin size estimated above (H_{B-log}), the lower and upper bounds of each logarithmically-spaced bin (B) can be calculated as follows:

$$B_{lwr-log} = e^{\{\ln(Qmin)+(B-2)*HB-log\}}$$

$$B_{upr-log} = e^{\{\ln(Qmin)+(B-1)*HB-log\}}$$

The average flow within each of the bins was used in the power function to calculate the cumulative duration for the histogram.

$$Q = (B_{lwr-log}+B_{upr-log})/2$$

$$days = day1*Q^{day2}$$

3. HYDRAULIC ANALYSIS

3.1 Identify a Range of Typical Receiving Channel Geometry Dimensions

An empirical relationship developed by Coleman et al (2005), modified by Stein (County of San Diego, 2009) was used to express channel dimensions (width, depth,

and, to a lesser extent, gradient) as a function of dominant discharge (Q_{bf}, in cfs). The Stein and Coleman relationship was used because it: (1) produced more consistent and conservative results than the Hey-Thorne (1986) relationship; (2) resulted in Qcrit results within the range of values suggested for implementation in the San Diego HMP (0.1Q2, 0.3Q2, 0.5Q2); (3) was general in that it did not require an assumption of D50; and (4) is applicable to the most sensitive sand bedded channels, which the Parker (2007) relationship is not. The geometry relationships are as follows:

$$\text{Width (ft)} = 0.6012 * Q_{bf}^{0.6875}$$

$$\text{Depth (ft)} = 0.3854 * Q_{bf}^{0.3652}$$

Q_{bf}, assumed to be approximately the 5-year peak discharge (Q_5), was estimated using the empirical equation from Hawley and Bledsoe (2011) provided in Section 2.4 of this Appendix. This equation calculates Q_5 (cfs) as a function of watershed area (sq. mi.), mean annual precipitation (MAP, in/yr), and percent impervious cover (%) based on empirical observations of USGS gages.

Manning's equation was used to iteratively find the slope for each channel dimension, such that the wetted cross sectional area at bankfull conveys the Q_5. Manning's equation is expressed as:

$$Q = \frac{1.49 A R^{0.67} S^{0.5}}{n}$$

Where:

Q	=	Flowrate (cfs)
A	=	Cross Section Flow Area (ft^2)
R	=	Hydraulic Radius (ft) = A / P
P	=	Wetted Perimeter (ft)
S	=	Energy Gradient Assumed Equal to Longitudinal Slope (ft/ft)
n	=	Manning Roughness (unitless)

The hydraulic analysis assumed a Manning Roughness value (n) of 0.035 for the main channel, corresponding to a non-vegetated, straight channel with no riffles and pools. This reflects the small, ephemeral receiving channels which are prevalent in Southern California. A relatively low 'n' value was used at the request of the San Diego Regional Water Board in the development of the San Diego HMP. A Manning's roughness of

0.07 was used for the over bank floodplain with an assumed side slope of 10 to 1 (Horizontal:Vertical). The overbank parameters were not as sensitive of parameters as longitudinal slope and channel geometry for the purpose of this analysis, therefore a range was not evaluated.

The receiving channel geometry dimensions used for hydraulic analysis of each model scenario are presented in Table D-4.

Table D-4. Receiving Channel Geometry Dimensions

Tributary Area	Mean Annual Precipitation	Longitudinal Slope	Bankfull Width	Bankfull Depth
A	***MAP***	***S***	***W***	***D***
sq mi	**in/yr**	**%**	**ft**	**ft**
1	14	0.45	10.6	1.8
2	14	0.30	15.8	2.2
5	14	0.18	26.8	2.9
10	14	0.12	40.0	3.6
20	14	0.08	59.7	4.4
50	14	0.05	101.2	5.9
100	14	0.04	150.8	7.3
1	18	0.40	12.1	1.9
2	18	0.27	18.1	2.4
5	18	0.16	30.7	3.1
10	18	0.11	45.7	3.8
20	18	0.07	68.2	4.8
50	18	0.05	115.6	6.3
100	18	0.03	172.4	7.8

3.2 Calculate Effective Shear Stress and Velocity for Each Flow Bin

The flow velocity was calculated after iterating for the slope to achieve $Q=Q_5$ as:

$$V = Q/A$$

Where:

V = Flow Velocity (ft/s)

Q = Flowrate (cfs)

A	=	Cross Section Flow Area (ft^2)

Average boundary shear stress was calculated as:

$$\tau = \gamma R S$$

Where:

τ	=	Effective Shear Stress (lb/ft^2)
γ	=	Unit Weight of Water (lb/ft^3)
R	=	Hydraulic Radius (ft)
S	=	Longitudinal slope (ft/ft)

4. WORK ANALYSIS

4.1 Identify Critical Flowrate (10%Q_2)

The regional default critical flowrate of 10% Q_2, per Appendix E, was used for this analysis. Flow rates below this value were assumed to perform no work on the channel.

4.2 Calculate Work for Each Flow Bin

The simplified effective work equation used is specified in the Ventura County MS4 Permit (LARWQCB, 2010) and is expressed as:

$$W = (\tau - \tau_c)^{1.5} V$$

Where:

W	=	Work [dimensionless];
τ	=	Effective Shear Stress [lb/ft^2];
τ_c	=	Critical Shear Stress [lb/ft^2];
V	=	Flow Velocity [ft/s]

If the effective shear stress for a given flow bin is less than the critical shear stress, then the effective work is equal to zero.

5. CUMULATIVE WORK ANALYSIS

Cumulative work is a measure of the long-term total work or sediment transport capacity performed at a creek location. It incorporates the distribution of both discharge magnitude and duration for the full range of flowrates simulated. To calculate cumulative work, first the work and duration associated with each flow bin is multiplied. Then the cumulative work for all flow bins is summed to obtain total work. This analysis can be expressed as:

$$W_t = \sum_{i=1}^{n} W_i \, \Delta t_i$$

Where:

W_t	=	Total Work [unitless]
W_i	=	Work per flow bin [unitless]
Δt	=	Duration per flow bin [days]
n	=	number of flow bins

6. EROSION POTENTIAL ANALYSIS

Ep is calculated by simply dividing the total work of the post-project condition by that of the pre-project condition. Ep is expressed as:

$$E_p = W_{t,post} / W_{t,pre}$$

Where:

E_p	=	Erosion Potential [unitless]
$W_{t,post}$	=	Total Work associated with the post-project condition [unitless]
$W_{t,pre}$	=	Total Work associated with the pre-project condition [unitless]

6.1 Iterate % Impervious Cover to Meet the Hydromodification Management Standard (Ep < 1.05)

Considering that the Hydromodification Management Standard for Ventura County aims to "maintain the Ep in-stream at a value of 1.0", it is assumed that an Ep value less than 5% of the target value meets the Management Standard (i.e., an Ep value of 1.04 rounds to 1.0). Additional basis for the use of a +/- 5% allowance on Ep is supported in Section 6.3.7 in the HCP. An iterative process was used to determine the percentage of

impervious cover that meets the hydromodification management standard (Ep < 1.05). The percent imperviousness is an input for the DDF power function coefficient and exponent (day1 and day2, respectively) and modifies the duration of flows within each of the logarithmically-spaced flow bin. The new durations (days) for each flow bin are multiplied by the work per flow bin (W_i) and summed across all bins to arrive at a new value for total work associated with the post-project condition ($W_{t,post}$) and Erosion Potential (Ep). Percent impervious cover is subsequently adjusted until an E_p of 1.05 is converged upon.

In preliminary runs it was evaluated that the threshold additional impervious cover associated with Ep equal to 1.05 was not highly sensitive to the baseline pre-development (or existing condition) imperviousness. For example, an increase in imperviousness from 0% to 1% resulted in the same Ep as an increase from 10% to 11%. The resulting thresholds of additional imperviousness from existing (at the time of the HCP effective date) to buildout conditions are provided below in Table D-5 and in Figure 3-12. The results provided used an existing imperviousness of 0%.

Table D-5: Threshold Additional Imperviousness Results

Tributary Area	**Mean Annual Precipitation**	**Threshold Additional Imperviousness**	**Pre-Project Total Cumulative Work**	**Post-Project Total Cumulative Work**	**Erosion Potential**
A	***MAP***	***Impav***	***Wt, pre***	***Wt, post***	***Ep***
sq mi	**in/yr**	**%**	--	--	--
1	14	0.46	1.67	1.75	1.05
2	14	0.50	1.52	1.59	1.05
5	14	0.56	1.45	1.52	1.05
10	14	0.61	1.48	1.55	1.05
20	14	0.68	1.59	1.67	1.05
50	14	0.80	1.89	1.98	1.05
100	14	0.92	2.27	2.39	1.05
1	18	0.48	2.69	2.82	1.05
2	18	0.52	2.44	2.57	1.05
5	18	0.59	2.12	2.23	1.05
10	18	0.65	2.07	2.17	1.05
20	18	0.72	2.12	2.23	1.05
50	18	0.85	2.25	2.36	1.05
100	18	1.00	2.54	2.67	1.05

6.2 Thresholds of Additional Imperviousness Based on Hawley and Bledsoe (2013)

For susceptible channels with a tributary area less than one square mile, the threshold of additional imperviousness below which the risk of hydromodification impacts is considered negligible for that channel is 0.44%. This result is based on equating two of the channel enlargement equations listed in Hawley and Bledsoe (2013) and solving for an Ep of 1.05. The two enlargement functions are:

$$Ar = 1.18*Ep^{0.998}$$

and

$$Ar = 1.18*e^{(11.0*Imp)}$$

Where:

Ar = Enlargement expressed as the relative magnitude

Ep = Sediment-transport capacity load ratio between 25-yr post-developed and pre-developed DDF simulations

Imp = Total impervious area as a fraction of total drainage area

The following equation expresses Imp as a function of Ep:

$$Imp = (0.998/11) * \ln(Ep)$$

Assuming Ep is equal to 1.05, the resulting Imp is 0.44%.

For susceptible channels with a median grain size (D_{50}) greater than 16 mm, a +/- 20% allowance on Ep is supported in Section 6.3.7 in the HCP. Assuming an Ep of 1.20 and using the equation above, the threshold additional imperviousness, below which the risk of hydromodification impacts is considered negligible for that channel, is 1.65%.

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ATTACHMENT B.1.4

TEXT AND HMP EXEMPTION EXHIBITS EXCERPTED FROM: "HYDROMODIFICATION EXEMPTION ANALYSES FOR SELECT CARLSBAD WATERSHEDS," PREPARED BY CHANG CONSULTANTS, DATED SEPTEMBER 17, 2015

HYDROMODIFICATION EXEMPTION ANALYSES FOR SELECT CARLSBAD WATERSHEDS

September 17, 2015



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APPENDICES (on CD in map pocket)

A. Dokken Engineering's HEC-RAS Analyses

B. 10-Year Rational Method Analyses

MAP POCKET

Study Area Exhibit
HMP Exemption Exhibit
CD Containing As-Built Plans

City of Carlsbad
Report accepted by:

_____

Jason Geldert, City Engineer Date
PE# 63912 Exp 9/30/16

EXECUTIVE SUMMARY

In accordance with Order No. R9-2013-0001, issued by the California Regional Water Quality Control Board (Municipal Permit), projects that are subject to Priority Development Project requirements must incorporate: 1) Treatment control best management practices, and 2) Flow-control requirements to address potential hydromodification impacts to downstream natural (non-hardened) channels.

However, certain improved/hardened drainage systems are not impacted by channel erosion. For these cases, the Municipal Permit includes provisions where a local agency may provide exemptions from hydromodification:

> *Each Copermittee has the discretion to exempt a Priority Development Project from hydromodification management BMP performance requirements of Provisions E.3.c.(2) where the project discharges water runoff to:*
>
> *(i) Existing underground storm drains discharging directly to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean.*
>
> *ii) Conveyance channels whose bed and bank are concrete lined all the way from the point of discharge to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean;*

Having development/redevelopment projects explore HMP exemption criteria could require an individual project proponent to undertake significant engineering analyses and evaluation of downstream drainage facilities and conditions within a watershed area. Consequently, the City of Carlsbad's Land Development Engineering Division commissioned this hydromodification exemption study.

This report focuses on certain watershed areas tributary to the Agua Hedionda Lagoon, Batiquitos Lagoon, and Buena Vista Lagoon. All three Lagoons are located within the Carlsbad Watershed area and are considered enclosed embayments per the Municipal Permit.

The study limits focus on select areas draining to the lagoons that are highly-developed and are served by improved existing paved streets that collect and convey runoff via reinforced concrete pipes (hardened systems) that are not subject to erosion potential. For each storm drain network discharging to the lagoon, the discharge locations were evaluated to ensure they qualify as a 'direct discharge'. To qualify as a direct discharge, field visits were performed at each outlet location to verify properly sized energy dissipation and, by a review of record drawings, that the discharge locations are below the 100-year flood elevation of the lagoon (consistent with Watershed Management Area Analysis (WMAA) for the San Diego River). Pictures of the outlet locations are at the end of this study.

The HMP Exemption Exhibit in the map pocket at the back of this report includes the limits of the study areas. For those projects located within a hatched area, they are considered exempt from hydromodification requirements either under current conditions or with some future

improvements. In accordance with the Municipal Permit, projects that are exempt from hydromodification must still satisfy all other applicable storm water standards (i.e.: site design, source control measures, treatment control best management practices, low impact development, etc.).

Although several watershed areas were evaluated, not all drainage areas qualified for exemption from hydromodifcation requirements. These reasons why they did not qualify will be explained further in the study and are, therefore, not included as exempt areas in the HMP Exemption Exhibit.

INTRODUCTION

In accordance with the Municipal Permit, development and redevelopment projects are subject to either: 1) Standard Stormwater or 2) Priority Development Project (PDP) requirements, which are more rigorous. The City's "Storm Water Standards Questionnaire E-34" (see Figure 11) is used to determine whether a project must meet Standard Stormwater or PDP requirements. The questionnaire, using criteria from the Municipal Permit, provides specific thresholds under which these new development/redevelopment projects trigger PDP requirements.

Among other things, projects subject to PDP requirements must include treatment control best management practices (BMPs) and are required to incorporate hydromodification BMPs. Hydromodification provides requirements to control post-development storm water runoff rates, velocities, and durations in order to maintain or reduce pre-development downstream erosion, sediment pollutant generation, and protect beneficial uses and stream habitat.

For this study, a focus was made to look at the three lagoons within the city (Buena Vista, Agua Hedionda, and Batiquitos Lagoon) and explore applicable HMP exemptions. This study assesses the lagoons and seven (7) major drainage areas contributing to the lagoons to determine whether they meet hydromodification exemption criteria. The seven major drainage areas are tributary to one of the seven following storm drain outlets into Buena Vista, Agua Hedionda, or Batiquitos Lagoon (see the Study Area Exhibits and HMP Exemption Exhibit in the map pocket):

Buena Vista Lagoon

- 48" and 66" outlets on the east side of Carlsbad Boulevard into the south side of the lagoon
- 48" outlet on the west side of Interstate 5 into the south side of the lagoon
- 66" outlet on the west side of Jefferson Street into the south side of the lagoon

Agua Hedionda Lagoon

- 18" outlet on the west end of Date Avenue into the north side of the lagoon
- 84" outlet on the east side of the railroad tracks into the north side of the lagoon
- 60" outlet near the south end of Marina Drive into the north side of the lagoon

Batiquitos Lagoon

- 84" outlet on the east side of Carlsbad Boulevard into the north side of the lagoon

With the exception of one area, the studied tributary areas do not include natural (non-hardened) channels directly to a lagoon. Each of these major drainage areas is served by a network of improved (hardened) public drainage facilities that outlet into a lagoon. The majority of the public facilities are underground storm drain systems or paved streets. Some facilities are also lined (concrete, gunite, etc.) drainage ditches or swales. Provided runoff from the study area discharges into a non-erodible drainage network that is continuous with a direct discharge to a lagoon, it is potentially eligible for a hydromodification exemption. Based on record drawing research and field reconnaissance, the Study Area Exhibits identify the improved (hardened) drainage networks. The exhibits demonstrate that each major drainage area, except the 48" outlet

towards Buena Vista Lagoon on the west side of Interstate 5, contains a continuously improved non-erodible network that serves the drainage area; therefore MS4's draining directly into the lagoons are not subject to potential impacts from hydromodification. The discharge points must be below the 100-year water surface elevations in the lagoon (consistent with Watershed Management Area Analysis (WMAA) for the San Diego River).

Areas Draining to Buena Vista Lagoon

Using rational method analyses from the 2003 County *Hydrology Manual* and as-built (record drawing) research, the existing storm drain network collecting run-off for all of the Buena Vista Lagoon drainage areas (Major Drainage Basins 100, 200, and 300 as shown on the Study Area Exhibits) analyzed in this report have been shown to be adequate to convey the Q_{10} runoff, which is the upper range for hydromodification as described the Municipal Permit. Each outlet structure was observed to ensure they include adequate energy dissipation to address erosion potential. For details of how these each of these criteria where satisfied, refer to the Appendices of this study. The select areas draining to the Buena Vista Lagoon from Major Drainage Basins 100 and 300, which are determined to be exempt from HMP are shown in the HMP Exemption Exhibit.

Although Major Drainage Basin 200 includes an improved non-erosive (hardened) storm drain system, the existing 48" outlet is not directly adjacent to the waters edge of Buena Vista Lagoon; therefore, does not qualify as a direct discharge to an exempt water body. In order for Major Drainage Basin 200 to qualify for an exemption a non-erodible drainage facility capable of conveying at least the 10-year flow will need to be constructed from the existing 48" outlet to the 100-year floodplain in the receiving lagoon.

Areas Draining to Agua Hedionda Lagoon and Batiquitos Lagoon

Certain drainage areas that drain to these lagoons were selected (Major Drainage Basin 400, 500, 600, and 700 as shown on the Study Area Exhibits). The existing storm drain network for each drainage area was also evaluated against their ability to carry the Q10. As provided in the Technical Appendices, the storm drain system for each drainage areas has the capacity to carry the Q10. The outlet for each storm drain system was also observed to ensure they include adequate energy dissipation to address erosion potential. For details of how these each of these criteria where satisfied, refer to the Appendices of this study. Based on these findings, the select areas draining to Agua Hedionda Lagoon and Batiquitos Lagoon are shall be considered exempt from HMP. These exempt areas are shown in the HMP Exemption Exhibit.

There are two isolated areas within Major Drainage Basin 600 that direct storm runoff over the natural ground surface west of the railroad tracks. Without further analysis using erosion potential (or equivalent), the naturally-lined swales are not considered exempt from hydromodification. Therefore, these areas were excluded from the exemption area in HMP Exemption Exhibit and from further analysis.

OUTLET CONDITIONS

Since the storm drain networks considered in this report are continuously non-erodible to one of the three lagoons (except from Major Drainage Basin 200 and a portion of 600), the energy dissipation to be studied are at the lagoon outlets. As-built drawings were reviewed and a site visit was performed to determine the conditions at each outlet. The following describes the findings for each outlet. In addition, the Lagoon Assessment section contained next in this report confirms that each outlet is below the 100-year water surface elevation. This effort confirms the storm drain network (MS4's) qualifies as a 'direct discharge' to an exempt water body.

Buena Vista Lagoon 48" and 66" Outlets

These are adjacent reinforced concrete pipe outlets that discharge into the south edge of Buena Vista Lagoon immediately east of the merge of State Street and Carlsbad Boulevard. During the site visit, the lagoon water level was at the invert of the 48" outlet and just above the invert of the 66" outlet (see Figure 1 after this report text). Riprap energy dissipation was not observed below the outlets nor was there evidence of erosion below the outlets (see Figure 2).

Drawing No. 215-9 shows that the invert elevation of the 66" reinforced concrete pipe outlet is at 6.0 feet NGVD 29 (the reference drawings are included on the compact disc in the map pocket). The 48" outlet is shown on Drawing 153-9, but the plan does not identify the vertical datum. Based on the site visit, the 48" outlet invert is approximately 6 inches higher than the 66" outlet invert. Buena Vista Lagoon contains a weir structure near the Pacific Ocean that controls the water surface in the lagoon. A field survey by Algert Engineering revealed that the top of the weir structure is at 7.6 feet NAVD 88 or 5.5 feet NGVD 29. Therefore, the water level in the lagoon will be within at least 6 to 12 inches of the outlets. During most periods, the water level should be higher than 5.5 feet due to natural sand build-up above the weir crest caused by littoral processes as well as backwater in the lagoon. Since ponded water is an effective energy dissipater, the 48" and 66" outlets contain proper energy dissipation. This is further evidenced by the absence of erosion below the outlets even though they have been in place since at least the mid-1980's.

Buena Vista Lagoon 48" Outlet

This 48" reinforced concrete pipe is a Caltrans facility whose outlet discharges towards, but not directly into, the south edge of Buena Vista Lagoon immediately west of Interstate 5. The as-built plans (Document No. 40002483) show that the outlet is at elevation 22.0 feet and was designed with "rock slope protection." During the site visit, riprap was observed below the 48" outlet (see Figure 3). The typical riprap diameter was over 12 inches, which is consistent with the sizing proposed on the design plans. Tall grasses obscured some of the riprap, but the grass indicates that the energy dissipation is effective. However, since this outlet is not a 'direct' discharge to the lagoon (see Lagoon Assessment section), no further analysis is provided.

Buena Vista Lagoon 66" Outlet

This 66" reinforced concrete pipe discharges into the south edge of Buena Vista Lagoon immediately west of Jefferson Street. The as-built plans (Drawing No. 182-10) show that the outlet invert is at elevation 5.3 feet NGVD 29 and contains ¼-ton riprap. The outlet invert was just below the lagoon water level (see Figure 4) during the site visit, which is consistent with the

weir-controlled lagoon water level. Riprap was not observed at the outlet during the site visit due to the difficulty in accessing the outlet through the dense vegetation. However, the fact that the water level will be at or above the outlet invert indicates that this outlet has appropriate energy dissipation.

Agua Hedionda Lagoon 18" Outlet

This 18" corrugated metal pipe discharges onto a riprap-lined revetment protecting the northeast bank of Agua Hedionda Lagoon immediately west of the intersection of Date Avenue with Garfield Street (see Figure 5). Storm runoff flows a short distance down the revetment and into the lagoon. As-built plans (Drawing No. 133-3) show that the outlet invert is at elevation 5.36 feet and that energy dissipation has been designed below the outlet. In addition, the tributary drainage area covers approximately 5.2 acres, so the pipe flows will be relatively small.

Agua Hedionda Lagoon 84" Outlet

This 84" reinforced concrete pipe discharges into the north edge of Agua Hedionda Lagoon just east of the railroad tracks. The engineering plans (Drawing No. 360-5) were as-built in 2006, so this is a relatively recent system. The plans show that the storm drain system and its grouted riprap energy dissipater were designed for the 100-year storm flow in accordance with current engineering criteria. A site visit confirmed that the grouted riprap energy dissipater exists and is in substantial conformance with the plans (see Figure 6).

Agua Hedionda Lagoon 60" Outlet

This 60" reinforced concrete pipe discharges directly into the north edge of Agua Hedionda Lagoon just west of Marina Drive. The as-built plans (Drawing No. 152-3) show that the outlet invert elevation is -1.75 feet NGVD 29. This elevation is lower than mean sea level, so the lagoon water level will serve as appropriate energy dissipation for the outflow. A site visit confirmed that the invert is lower than the lagoon water level (see Figure 8).

Batiquitos Lagoon 84" Outlet

This 84" reinforced concrete pipe discharges into the north edge of Batiquitos Lagoon just east of Carlsbad Boulevard and west of the railroad tracks. The as-built drawings (Drawing No. 337-9) show that the storm drain system and its energy dissipater (1-ton riprap and concrete sill) were designed for the 100-year storm flow in accordance with current engineering criteria. A site visit confirmed that the energy dissipater exists in substantial conformance with the plans (see Figure 9).

Summary

For those outlets that qualify as direct discharges, the above information confirms that proper energy dissipation currently exists at each of the storm drain outlet locations for the drainage areas. The dissipation is provided by either riprap or the water level in a lagoon.

DISCHARGE TO LAGOONS

The October 3, 2014, *San Diego River Watershed Management Area Analysis,* states that "to qualify for the potential [hydromodification] exemption, the outlet elevation must be between the river bottom elevation and the 100-year floodplain elevation and properly designed energy dissipation must be provided." Proper energy dissipation was verified in the prior section. This section discusses the 100-year floodplain elevations. Research was performed to determine the 100-year water surface elevations in each of the three lagoons. FEMA provides 100-year floodplain information for many waterbodies. FEMA defines a 100-year floodplain for the lagoons, but does not provide the necessary water surface elevations. However, Dokken Engineering (Dokken) performed detailed HEC-RAS hydraulic analyses of each lagoon as part of their December 2008, *Interstate 5 North Coast Floodplain Studies,* for Caltrans. Relevant excerpts from the Dokken studies are included in the Appendices. Table 1 summarizes the outlet elevations of each discharge point from the as-built drawings (discussed in the prior section) and the associated 100-year floodplain elevation from the Dokken studies. The as-built drawings are either identified as being on NGVD 29 datum or were prepared prior to 1988, so by default should be on NGVD 29. On the other hand, the Dokken studies are on NAVD 88 datum. Corpscon is provided by the US Army Corps of Engineers for coordinate conversions, and shows that 2.2 feet is added to the NGVD 29 elevations to convert to NAVD 88 elevations.

Major Drainage Basin	Description	Outlet Elevation, feet[1]	Lagoon 100-Year Water Surface Elevation, feet[2]
100	Buena Vista Lagoon 48" and 66" Outlets	6.00	13.93
200	Buena Vista Lagoon 48" Outlet	22.00	13.89
300	Buena Vista Lagoon 66" Outlet	5.30	15.75
400	Agua Hedionda Lagoon 60" Outlet	-1.75	12.33
500	Agua Hedionda Lagoon 18" Outlet	5.36	11.68
600	Agua Hedionda Lagoon 84" Outlet	7.95	12.21
700	Batiquitos Lagoon 84" Outlet	6.27	8.90

[1]Elevations are on NGVD 29 (add 2.2 feet to convert to NAVD 88)
[2]Elevations are on NAVD 88

Table 1. Summary of Storm Drain Outlet Elevations and Lagoon Elevations

Table 1 shows that all of the storm drain outlets (with the conversion applied) except at Major Drainage Basin 200 are below the 100-year water surface elevation in the associated lagoon. Therefore, the hydromodification exemption requirement to have the outlet elevation below the 100-year floodplain elevation is met except at Major Drainage Basin 200.

Summary
The four drainage areas (Major Drainage Basins 400, 500, 600, 700) tributary to the Agua Hedionda Lagoon and Batiquitos Lagoon are served by an improved (non-erosive) street and underground storm drains system and have capacity to convey the 10-year rain event condition. The storm drain outlets for these drainage areas to the lagoon are considered direct discharges. Therefore, these areas are considered exempt from hydromodification.

The easterly and westerly drainage areas (Major Dainage Basins 100 and 300) tributary to and outletting directly into Buena Vista Lagoon are served by an improved (non-erosive) street and underground storm drains system and have capacity to convey the 10-year rain event condition. The storm drain outlets for these drainage areas to the lagoon are considered direct discharges. Therefore, these areas are also considered exempt from hydromodification.

The westerly drainage areas (Major Drainage Basin 200) tributary to and outletting adjacent to the Buena Vista Lagoon west of Interstate 15 is served by an improved (non-erosive) street and underground storm drains system and have capacity to convey the 10-year rain event condition. However, this outlet is not considered a direct discharge. In order to create a direct discharge, drainage improvements will need to be constructed that are capable of conveying the 10-year flow to the lagoon. The new outlet must have proper energy dissipation and extend below the 100-year water surface elevation. If such improvements are constructed in the future, this area can be considered as exempt from hydromodification.

HYDROLOGIC AND HYDRAULIC ANALYSES

As mentioned in the Introduction, hydromodification applies to flows up to the 10-year event. Consequently, the drainage network (storm drain pipes, streets, etc.) within each major drainage area are required to convey the 10-year flow in order to qualify for an exemption. All of the available as-built plans for the public storm drain systems in the seven major drainage areas were obtained and reviewed. Several of the more recent as-built plans list 10- or 100-year flow rates in the pipes and/or hydraulic grade lines on the storm drain profiles. These systems have been identified on the Study Area Exhibits and further analyses were not required since the systems have been designed to convey the 10-year or greater flow rates. Therefore, development within these areas is exempt from HMP.

Hydrologic and hydraulic analyses have been performed for the remaining systems whose plans do not contain the flow or hydraulic grade line data. The hydrologic analyses were performed to determine the ultimate condition 10-year flow rates. The County of San Diego's 2003 *Hydrology Manual* rational method procedure was used for the 10-year hydrologic analyses. The rational method input parameters are summarized below and the supporting data is included in Appendix B:

- Precipitation: The 10-year, 6- and 24-hour precipitation values are 1.7 and 3.1 inches, respectively, for the drainage areas tributary to Buena Vista and Agua Hedionda Lagoon. The 10-year, 6- and 24-hour precipitation values are 1.7 and 2.9 inches, respectively, for the drainage areas tributary to Batiquitos Lagoon.

- Drainage subbasin: The drainage subbasins were delineated from the City's 2005 2-foot contour interval topographic mapping, the City's GIS storm drain network, available as-built plans, and a site investigation. See the Study Area Exhibits in the map pocket for the major and subbasin boundaries, rational method node numbers, and subbasin areas.

- Hydrologic soil groups: The hydrologic soil groups were determined from the *San Diego County Soils Interpretation Study* maps for Encinitas and Rancho Santa Fe. The soil group in the study area is primarily A with some pockets of C and D.

- Runoff coefficients: The runoff coefficients were assigned based on the underlying land uses and soil groups. The land uses range from undisturbed areas to commercial/industrial development. The land uses were determined from a 2009 aerial photograph from the City and 2010 Google Earth aerials as well as a site investigation. For undeveloped areas that could be subject to development, a developed condition was assumed. Therefore, the hydrologic analyses essentially model a fully built-out condition. This approach is similar to what would be done for a storm water master plan.

- Flow lengths and elevations: The flow lengths and elevations were obtained from the topographic mapping and engineering plans.

The 10-year rational method analyses were performed using CivilDesign's San Diego County Rational Hydrology Program and the results are included in Appendix B. Separate analyses were performed for the major drainage areas and are labeled as follows:

Buena Vista Lagoon

- Major Basin 100 is tributary to the 48" and 66" outlet on the east side of Carlsbad Boulevard
- Major Basin 200 is tributary to the 48" outlet on the west side of Interstate 5
- Major Basin 300 is tributary to the 66" outlet on the west side of Jefferson Street

Agua Hedionda Lagoon

- Major Basin 400 is tributary to the 60" outlet at the south end of Marina Drive
- Major Basin 500 is tributary to the 18" outlet at the west end of Date Avenue
- Analyses were not performed for the 84" outlet on the east side of the railroad tracks because flow rates and hydraulic grade lines were provided on the majority of the as-built plans.

Batiquitos Lagoon

- Analyses were not performed for the 84" outlet on the east side of Carlsbad Boulevard because flow rates and hydraulic grade lines were provided on the majority of the as-built plans.

The CivilDesign rational method analyses include pipeflow routines for modeling flow in circular pipes. The upstream and downstream invert elevations and pipe length are entered in the model for each storm drain segment. The program then determines the required normal depth pipe size based on the calculated 10-year flow rate, longitudinal slope, and roughness coefficient. The pipeflow routines were used to assess the adequacy of the existing pipes. Invert elevations were selected so that the longitudinal slope from the as-built plans was accurately modeled in the analyses. The longitudinal slope of each storm drain segment was determined from a review of all relevant as-built plans. Some storm drain segments contain varying or multiple slopes. In this case, the flattest slope was used because it will result in the most conservative sizing. A few segments were missing elevations on the as-built plans. For these segments, the average street slope was used. The pipe size from the hydraulic analyses were then compared to the size from the as-built plans to identify pipes with adequate capacity and those with deficiencies.

Since the rational method program determines the minimum required pipe size to convey the 10-year flow in each specific segment, it is possible that program will show the required size increasing or decreasing in adjacent segments of the overall storm drain system. For instance, if the same flow rate is conveyed in two adjacent segments, but the downstream segment has a steeper longitudinal slope, the results can show that the downstream pipe is smaller. Engineering design criteria typically does not allow subsequent segments in a storm drain system to be smaller. However, since the rational method results are merely used as a comparison with the sizes from the as-built plans, any usual telescoping effects are not relevant.

The pipes have been categorized based on their capacity and identified on the Study Area Exhibits per their category. The first category represents pipes in which the as-built plans contain flow rate or hydraulic grade line information indicating that the pipes can convey the 10-year runoff. As mentioned above, analyses were not specifically performed for these systems since detailed information is contained on the as-built plans. The second category represents pipes in which the rational method analyses show that the existing size can convey the 10-year flow rate. The third category represents pipes in which the rational method analyses show that the existing pipes need to be upsized by at most one pipe size (6 inches) to convey the 10-year flow. The fourth category represents pipes in which the rational method analyses show that the existing pipes need to be upsized by more than one pipe size to convey the 10-year flow.

The first and second categories represent no major deficiencies in capacity. The third category indicates that the existing pipe is slightly undersized. However, if pressure flow and street capacity are considered, these systems will be capable of conveying the 10-year flows since the additional flow associated with an at most 6 inch increase in pipe size can be conveyed under pressure or within the adjacent street. This was confirmed by comparing the 10-year flow rates with a street flow capacity chart. For a given pipe segment, the street flow capacity chart indicated that the associated street can convey the required flow. Therefore, the drainage systems within the first three categories have capacity for the 10-year flow.

Existing pipes under the fourth category require additional review to determine whether the 10-year flow can be conveyed. Additional review resulted in the following assessment of the storm drain systems within the fourth category.

Major Basin 100

There are four storm drain segments in Major Basin 100 that fall within the fourth category. The segments are between rational method nodes 105 to 109, 135 to 136, 137 to 138, and 138 to 141. The following assesses the pipe and street capacity of each of these four segments.

The existing pipe from nodes 105 to 109 has an 18” diameter with a normal depth capacity of approximately 10 cubic feet per second (cfs). However, the rational method results show that the 10-year flow rate is 37 cfs, and the pipe size needed to convey 37 cfs varies from 30” to 33”. The corridor along the street between these nodes has capacity for the additional 27 cfs (37 – 10 = 27 cfs) needed beyond the pipe capacity. Therefore, the combined pipe and street in this area can convey the 10-year flow.

A similar assessment is made for the other three segments. The existing pipe from nodes 135 to 136 is a 24” reinforced concrete pipe (RCP), while the analyses show that a 33” RCP is needed. The existing pipe from nodes 137 to 138 is a 36” RCP while the analyses show that a 45” RCP is needed. The existing pipe from nodes 138 to 141 is a 12” RCP while the analyses show that a 30” RCP is needed. For each of these deficient segments, the associated streets can handle the additional capacity needs. In addition, the adjacent upstream and downstream pipe segments are not deficient. Therefore, the overall drainage systems along these nodes can convey the 10-year flow.

Major Basin 300

There are two storm drain segments in Major Basin 300 that fall within the fourth category. The segments are between rational method nodes 309 to 316 and nodes 340 to 343. The existing pipes from nodes 309 to 316 are 24" RCPs, while the required pipe varies from 36" to 39". The existing pipes from nodes 340 to 343 are 66" RCPs, while the required size varies from 78" to 81". For both of these areas, the associated streets can handle the additional capacity needs, so these areas can convey the 10-year flow.

Major Basin 400

There are two storm drain segments in Major Basin 400 that fall within the fourth category. The segments are between rational method nodes 408 to 409 and 418 to 420. The existing pipe between nodes 408 and 409 is an 18" RCP, while a 30" RCP is needed. This pipe crosses a sump in the street. The excess stormwater will pond in the street until it drains through the 18" RCP. Therefore, the 10-year flow will be detained in this area. In addition, there are no natural streams in the vicinity that would be subject to HMP requirements.

The existing pipe between nodes 418 and 420 is a 60" RCP that outlets into Agua Hedionda Lagoon, while the analyses show that a 72" RCP is required. However, a 60" bypass structure near the upper end of this segment can divert a portion of the runoff to a second outlet that discharges to a cove connecting to Agua Hedionda Lagoon. The as-built plans (Drawing No. 152-3) show that the bypass is controlled by stop logs. If the bypass is open, then the pipe capacity below the bypass will be sufficient for the 10-year flow. The City of Carlsbad's Utilities Operations staff has a "Weir Wall Removal Procedure," so the stop logs will be removed during high flow events to ensure 10-year flow capacity. Therefore, this area conveys the 10-year runoff to Agua Hedionda Lagoon.

CONCLUSION

The City of Carlsbad's final HMP outlines conditions under which a Priority Development Project can be exempt from hydromodification requirements. The purpose of this study is to explore HMP exemptions based on the January 2011 Carlsbad SUSMP and Order No. R9-2013-0001 adopted by the Regional Water Quality Control Board. In particular, this study examines the criteria necessary for HMP exemptions for 1) enclosed embayments (lagoons) and 2) stabilized conveyances to exempt systems.

These analyses have been performed for seven major drainage areas selected by the City of Carlsbad and are summarized below based on the two primary criteria that were investigated. Additional criteria must be met in addition to the primary criteria to achieve an exemption. The additional criteria is also summarized below.

Stabilized Conveyances with Energy Dissipation

The hydrologic and hydraulic analyses show that the 10-year flow is conveyed by the underground storm drain alone in most areas, and the combination of the underground storm drain and improved public streets in the remaining areas. In addition, each storm drain outlet into

a lagoon has proper energy dissipation. Therefore, each study area contains an underground storm drain or conveyance channel that discharges directly to an enclosed conveyance.

Lagoon Floodplains

A comparison of as-built drawings with a recent detailed HEC-RAS analysis of each lagoon confirmed that each outlet is below the 100-year floodplain except in Major Drainage Basin 200. Each outlet is also at or above the associated lagoon floor. Therefore, each outlet except in Major Drainage Basin 200 meets the floodplain criteria for a hydromodification exemption. Major Drainage Basin 200 can meet the criteria if its non-erodible drainage system is extended to the lagoon.

Future Projects

Based on the findings in this report, future projects within one of the studied drainage areas (except Major Drainage Basin 200) qualify for an exemption if their storm runoff is directed to a public drainage facility included in this report without being conveyed over a natural drainage course.

However, future projects in certain locations within the study area will be required to perform additional analyses prior to receiving a hydromodification exemption. These exceptions are outlined below.

The major drainage area tributary to the 84” outlet into Agua Hedionda Lagoon is bisected along its westerly side by the existing railroad tracks. Storm runoff from two areas west of the tracks will be directed to naturally-lined swales near the tracks. Since naturally-lined swales prevent a hydromodification exemption, development west of the tracks may need to replace a natural swale with a non-erodible conveyance. It will be the responsibility for a future development project west of the tracks to assess this situation in detail and propose a solution, as needed. The HMP Exemption Exhibit delineates the two non-exempt areas for reference. Hydrologic analyses have not been performed for these two areas.



PIPE SEGMENT	AS-BUILT DRAWING NO.	EXISTING FACILITY AND MINIMUM SLOPE	10-YEAR FLOW, CFS	10-YEAR FLOW CONTAINED IN PIPE UNDER PRESSURE	EXCESS 10-YEAR FLOW CONTAINED IN STREET	EXCESS 10-YEAR FLOW ENTERS ADJACENT LAGOON
A	287-2	18" RCP AT 0.5%	13	Y		
B	220-8	18" RCP (UNKNOWN SLOPE)	37		Y	
C	462-6	18" RCP AT 0.5%	13	Y		
D	137-3A	12" RCP AT 0.24%	18		Y	
E	133-9	36" RCP AT 0.76%	91		Y	
F	146-8	24" RCP AT 0.43%	57		Y	
G	CALTRANS CONTRACT 11-039724	30" RCP (UNKNOWN SLOPE)	32	Y		
H	182-10, 304-2	66" RCP AT 0.28%	293		Y	
I	166-8, 189-6, 206-2	36" RCP AT 1.60% TO 48" RCP AT 2.27%	116 TO 265	Y		
J	141-3	24" RCP AT 1.03% TO 27" RCP AT 2.30%	56 TO 104		Y	
K	146-3	18" RCP AT 1.52%	19	Y		
L	125-4	18" RCP AT 1.23%	16	Y		
M	158-6	18" RCP AT 1.00%	34		Y	
N	158-6	24" RCP AT 1.00%	39	Y		
O	167-4	24" RCP AT 2.00%	39	Y		
P	167-4	21" RCP AT 10.00% TO 24" RCP AT 2.00%	36	Y		
Q	167-5	42" RCP AT 1.00%	117	Y		
R	152-3	60" RCP AT 0.4%	263			Y

NOTE:
THE STORM DRAIN SEGMENTS IN THIS TABLE ARE ONES IN WHICH THE HYDRAULIC ANALYSES SHOW INSUFFICIENT NORMAL DEPTH CAPACITY TO CONVEY THE 10-YEAR FLOW (YELLOW AND RED LINES ON THE LEGEND). THIS TABLE INDICATES IF THE SEGMENTS HAVE CAPACITY TO CONVEY THE 10-YEAR FLOW UNDER PRESSURE. FOR SYSTEMS THAT CANNOT CONVEY THE 10-YEAR FLOW UNDER PRESSURE, THE TABLE INDICATES IF THE EXCESS FLOW CAN BE CONVEYED IN THE STREET OR WILL DIRECTLY ENTER AN ADJACENT LAGOON. ALL OF THE SEGMENTS MEET ONE OF THESE CRITERIA AND, HENCE, SATISFIES THE HYDROMODIFICATION EXEMPTION REQUIREMENT FOR CONVEYING THE 10-YEAR FLOW.

THE DRAINAGE AREAS ENCOMPASSING SEGMENTS A THROUGH L ARE ON STUDY AREA EXHIBIT SHEET 2. THE DRAINAGE AREAS ENCOMPASSING SEGMENTS M THORUGH R ARE ON STUDY AREA EXHIBIT SHEET 1.

STUDY AREA EXHIBIT
HYDROMODIFICATION EXEMPTION

AGUA HEDIONDA CREEK
DRAINAGE AREAS

SHEET 1 OF 2



DETAIL

GRAPHIC SCALE
300 0 300 600
1 INCH = 300 FEET

MAJOR DRAINAGE BASIN 300

MAJOR DRAINAGE BASIN 200

MAJOR DRAINAGE BASIN 100

MAJOR DRAINAGE BASIN 700

BUENA VISTA LAGOON

MATCHLINE - SEE DETAIL ABOVE

SEE SHEET 1

SEE SHEET 1

SEE SHEET 1

BATIQUITOS LAGOON

BUENA VISTA CREEK DRAINAGE AREAS

PIPE SEGMENT	AS-BUILT DRAWING NO.	EXISTING FACILITY AND MINIMUM SLOPE	10-YEAR FLOW, CFS	10-YEAR FLOW CONTAINED IN PIPE UNDER PRESSURE	EXCESS 10-YEAR FLOW CONTAINED IN STREET	EXCESS 10-YEAR FLOW ENTERS ADJACENT LAGOON
A	287-2	18" RCP AT 0.5%	13	Y		
B	220-8	18" RCP (UNKNOWN SLOPE)	37		Y	
C	462-6	18" RCP AT 0.5%	13	Y		
D	137-3A	12" RCP AT 0.24%	18		Y	
E	133-9	36" RCP AT 0.76%	91		Y	
F	146-8	24" RCP AT 0.43%	57		Y	
G	CALTRANS CONTRACT 11-039724	30" RCP (UNKNOWN SLOPE)	32	Y		
H	182-10, 304-2	66" RCP AT 0.28%	293		Y	
I	166-8, 189-6, 206-2	36" RCP AT 1.60% TO 48" RCP AT 2.27%	116 TO 265	Y		
J	141-3	24" RCP AT 1.03% TO 27" RCP AT 2.30%	56 TO 104		Y	
K	146-3	18" RCP AT 1.52%	19	Y		
L	125-4	18" RCP AT 1.23%	16	Y		
M	158-6	18" RCP AT 1.00%	34		Y	
N	158-6	24" RCP AT 1.00%	39	Y		
O	167-4	24" RCP AT 2.00%	39	Y		
P	167-4	21" RCP AT 10.00% TO 24" RCP AT 2.00%	36	Y		
Q	167-5	42" RCP AT 1.00%	117	Y		
R	152-3	60" RCP AT 0.4%	263			Y

NOTE:
THE STORM DRAIN SEGMENTS IN THIS TABLE ARE ONES IN WHICH THE HYDRAULIC ANALYSES SHOW INSUFFICIENT NORMAL DEPTH CAPACITY TO CONVEY THE 10-YEAR FLOW (YELLOW AND RED LINES ON THE LEGEND). THIS TABLE INDICATES IF THE SEGMENTS HAVE CAPACITY TO CONVEY THE 10-YEAR FLOW UNDER PRESSURE. FOR SYSTEMS THAT CANNOT CONVEY THE 10-YEAR FLOW UNDER PRESSURE, THE TABLE INDICATES IF THE EXCESS FLOW CAN BE CONVEYED IN THE STREET OR WILL DIRECTLY ENTER AN ADJACENT LAGOON. ALL OF THE SEGMENTS MEET ONE OF THESE CRITERIA AND, HENCE, SATISFIES THE HYDROMODIFICATION EXEMPTION REQUIREMENT FOR CONVEYING THE 10-YEAR FLOW.

THE DRAINAGE AREAS ENCOMPASSING SEGMENTS A THROUGH L ARE ON STUDY AREA EXHIBIT SHEET 2. THE DRAINAGE AREAS ENCOMPASSING SEGMENTS M THORUGH R ARE ON STUDY AREA EXHIBIT SHEET 1.

LEGEND:

- MAJOR DRAINAGE BASIN BOUNDARY
- MINOR DRAINAGE BASIN BOUNDARY (SUBBASIN)
- OVERLAND FLOW PATH
- 3.62 AC DRAINAGE BASIN AREA
- [10] RATIONAL METHOD NODE NUMBER
- EXISTING CATCH BASIN OR INLET
- EXISTING DRAINAGE DITCH OR SWALE
- MINOR EXISTING STORM DRAIN PIPE OR LATERAL
- AS-BUILT PLANS SHOWING 10-YEAR OR HIGHER FLOW CONTAINED IN EXISTING PIPE
- NORMAL DEPTH ANALYSIS SHOWING 10-YEAR FLOW CONTAINED IN EXISTING PIPE
- NORMAL DEPTH ANALYSIS SHOWING EXISTING PIPE INCREASED BY ONE PIPE SIZE (6") TO CONTAIN 10-YEAR FLOW (SEE TABLE FOR DETAILS)
- NORMAL DEPTH ANALYSIS SHOWING EXISTING PIPE INCREASED BY MORE THAN ONE PIPE SIZE TO CONTAIN 10-YEAR FLOW (SEE TABLE FOR DETAILS)
- OUTLET INTO LAGOON
- (A) PIPE SEGMENT (SEE TABLE FOR DETAILS)

BATIQUITOS CREEK DRAINAGE AREAS

STUDY AREA EXHIBIT
HYDROMODIFICATION EXEMPTION

GRAPHIC SCALE

1000 0 500 1000

1 INCH = 500 FEET

LEGEND:

- MAJOR DRAINAGE BASIN BOUNDARY
- NATURAL FLOW PATH
- HYDROMODIFICATION EXEMPT AREA
- HYDROMODIFICATION EXEMPT AREA IF FUTURE DRAINAGE IMPROVEMENTS ARE CONSTRUCTED

HMP EXEMPTION EXHIBIT

ATTACHMENT B.2

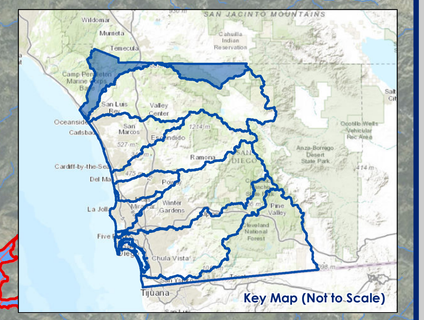
HYDROMODIFICATION MANAGEMENT EXEMPTION MAPS

Santa Margarita Watershed Management Area
HU 902.00, 198 mi2

Legend

- Watershed Boundaries
- Municipal Boundaries
- Regional WMAA Streams
- **Exempt Bodies:** Water Storage Reservoirs, Lakes, Enclosed Embayments, Pacific Ocean, Buena Vista Lagoon
- **Exempt River Reaches:** Reaches of San Luis Rey River, San Dieguito River, San Diego River, Forester Creek, Sweetwater River, Otay River
- **Exempt Conveyance Systems:** Existing underground storm drains or conveyance channels whose bed and bank are concrete-lined, discharging directly to exempt water bodies, exempt rivers, or localized areas of Agua Hedionda Lagoon and Batiquitos Lagoon

Santa Margarita River
San Luis Rey River
S.D. COUNTY
San Luis Rey River
OCEANSIDE
Buena Vista Creek
VISTA
Agua Hedionda Creek
SAN MARCOS
CARLSBAD
San Marcos Creek
Escondido Creek
S.D. COUNTY
ESCONDIDO
S.D. COUNTY
SAN DIEGO



Aerial Imagery Source: DigitalGlobe, 06/2012

0 4 8 16 Miles

NORTH

Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014

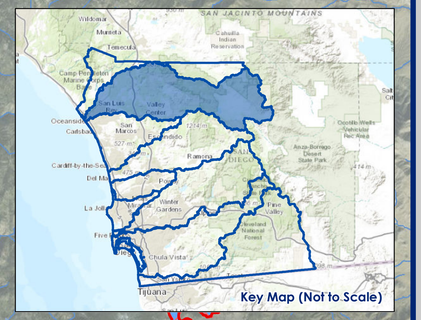
Geosyntec consultants | RICK Engineering Company

San Luis Rey Watershed Management Area
HU 903.00, 559 mi2

Legend

- Watershed Boundaries
- Municipal Boundaries
- Regional WMAA Streams
- **Exempt Bodies:** Water Storage Reservoirs, Lakes, Enclosed Embayments, Pacific Ocean, Buena Vista Lagoon
- **Exempt River Reaches:** Reaches of San Luis Rey River, San Dieguito River, San Diego River, Forester Creek, Sweetwater River, Otay River
- **Exempt Conveyance Systems:** Existing underground storm drains or conveyance channels whose bed and bank are concrete-lined, discharging directly to exempt water bodies, exempt rivers, or localized areas of Agua Hedionda Lagoon and Batiquitos Lagoon

Santa Margarita River
San Luis Rey River
San Luis Rey River
S.D. COUNTY
OCEANSIDE
Buena Vista Creek
VISTA
Agua Hedionda Creek
SAN MARCOS
CARLSBAD
San Marcos Creek
Escondido Creek
Santa Ysabel Creek
S.D. COUNTY
ENCINITAS
San Dieguito River
SAN DIEGO
San Dieguito Lusardi Creek
POWAY



Aerial Imagery Source: DigitalGlobe, 06/2012

0 4.5 9 18 Miles

NORTH

Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

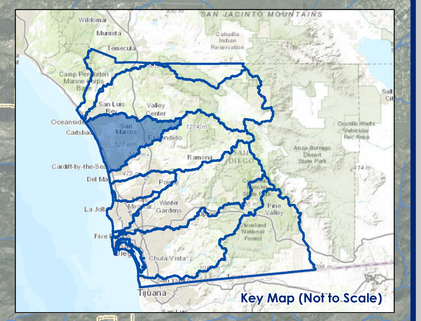
RICK ENGINEERING COMPANY

Carlsbad Watershed Management Area
HU 904.00, 211 mi2

Legend

- Watershed Boundaries
- Municipal Boundaries
- Regional WMAA Streams
- **Exempt Bodies:** Water Storage Reservoirs, Lakes, Enclosed Embayments, Pacific Ocean, Buena Vista Lagoon
- **Exempt River Reaches:** Reaches of San Luis Rey River, San Dieguito River, San Diego River, Forester Creek, Sweetwater River, Otay River
- **Exempt Conveyance Systems:** Existing underground storm drains or conveyance channels whose bed and bank are concrete-lined, discharging directly to exempt water bodies, exempt rivers, or localized areas of Agua Hedionda Lagoon and Batiquitos Lagoon

a Margarita River
San Luis Rey River
OCEANSIDE
VISTA
Buena Vista Creek
Agua Hedionda Creek
CARLSBAD
San Marcos Creek
SAN MARCOS
San Marcos Creek
Encinitas Creek
ENCINITAS
DEL MAR
ESCONDIDO
Escondido Creek
S.D. COUNTY
S.D. COUNTY
Santa Ysabel Creek
S.D. COUNTY
San Dieguito River
San Dieguito River
Lusardi Creek
SAN DIEGO
POWAY
Rattlesnake Creek



Aerial Imagery Source: DigitalGlobe, 06/2012

0 2.5 5 10 Miles

NORTH

Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

RICK ENGINEERING COMPANY

San Dieguito Watershed Management Area
HU 905.00, 346 mi2

Legend

- Watershed Boundaries
- Municipal Boundaries
- Regional WMAA Streams
- **Exempt Bodies:** Water Storage Reservoirs, Lakes, Enclosed Embayments, Pacific Ocean, Buena Vista Lagoon
- **Exempt River Reaches:** Reaches of San Luis Rey River, San Dieguito River, San Diego River, Forester Creek, Sweetwater River, Otay River
- **Exempt Conveyance Systems:** Existing underground storm drains or conveyance channels whose bed and bank are concrete-lined, discharging directly to exempt water bodies, exempt rivers, or localized areas of Agua Hedionda Lagoon and Batiquitos Lagoon

San Luis Rey River
Buena Vista Creek
VISTA
Agua Hedionda Creek
CARLSBAD
San Marcos Creek
San Marcos
Encinitas Creek
ENCINITAS
SAN MARCOS
ESCONDIDO
Escondido Creek
S.D. COUNTY
Santa Ysabel Creek
San Dieguito River
Lusardi Creek
POWAY
Los Penasquitos Creek
SAN DIEGO
Carroll Canyon Creek
Rose Creek
SANTEE
San Diego River
MIRAMAR RESERVOIR

Aerial Imagery Source: DigitalGlobe, 06/2012

Key Map (Not to Scale)

0 3.75 7.5 15 Miles

NORTH

Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

RICK ENGINEERING COMPANY

Los Penasquitos Watershed Management Area
HU 906.00, 94 mi2

Legend

- Watershed Boundaries
- Municipal Boundaries
- Regional WMAA Streams
- **Exempt Bodies:** Water Storage Reservoirs, Lakes, Enclosed Embayments, Pacific Ocean, Buena Vista Lagoon
- **Exempt River Reaches:** Reaches of San Luis Rey River, San Dieguito River, San Diego River, Forester Creek, Sweetwater River, Otay River
- **Exempt Conveyance Systems:** Existing underground storm drains or conveyance channels whose bed and bank are concrete-lined, discharging directly to exempt water bodies, exempt rivers, or localized areas of Agua Hedionda Lagoon and Batiquitos Lagoon

S.D. COUNTY
Lusardi Creek
San Dieguito River
DEL MAR
POWAY
Rattlesnake Creek
S.D. COUNTY
Poway Creek
Los Penasquitos Creek
SAN DIEGO
Carroll Canyon Creek
Rose Creek
Rose Creek
Sycamore Creek
SAN JACINTO MOUNTAINS
Key Map (Not to Scale)

Aerial Imagery Source: DigitalGlobe, 06/2012

0 1.5 3 6 Miles

NORTH

Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

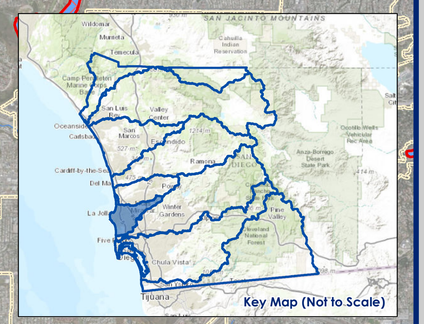
RICK ENGINEERING COMPANY

Mission Bay/La Jolla Watershed Management Area
HU 906.00, 68 mi2

Legend

- Watershed Boundaries
- Municipal Boundaries
- Regional WMAA Streams
- **Exempt Bodies:** Water Storage Reservoirs, Lakes, Enclosed Embayments, Pacific Ocean, Buena Vista Lagoon
- **Exempt River Reaches:** Reaches of San Luis Rey River, San Dieguito River, San Diego River, Forester Creek, Sweetwater River, Otay River
- **Exempt Conveyance Systems:** Existing underground storm drains or conveyance channels whose bed and bank are concrete-lined, discharging directly to exempt water bodies, exempt rivers, or localized areas of Agua Hedionda Lagoon and Batiquitos Lagoon

Carroll Canyon Creek
Rose Creek
Rose Creek
Sycamore Creek
Forester Creek
San Diego River
San Diego River
POWAY
SAN DIEGO
SANTEE
EL CAJON



Aerial Imagery Source: DigitalGlobe, 06/2012

0 1.5 3 6 Miles

NORTH

Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014

Geosyntec consultants | RICK Engineering Company

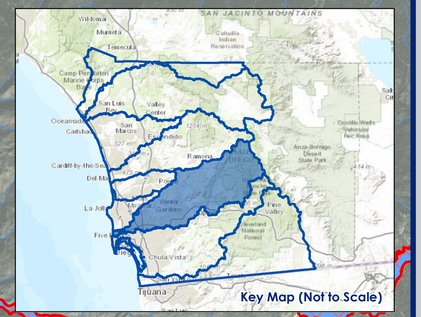
San Diego River Watershed Management Area
HU 907.00, 436 mi2

Legend

- Watershed Boundaries
- Municipal Boundaries
- Regional WMAA Streams
- **Exempt Bodies:** Water Storage Reservoirs, Lakes, Enclosed Embayments, Pacific Ocean, Buena Vista Lagoon
- **Exempt River Reaches:** Reaches of San Luis Rey River, San Dieguito River, San Diego River, Forester Creek, Sweetwater River, Otay River
- **Exempt Conveyance Systems:** Existing underground storm drains or conveyance channels whose bed and bank are concrete-lined, discharging directly to exempt water bodies, exempt rivers, or localized areas of Agua Hedionda Lagoon and Batiquitos Lagoon

CARLSBAD
SAN MARCOS
Marcos Creek
Escondido Creek
ENCINITAS
S.D. COUNTY
San Dieguito River
Santa Ysabel Creek
Lusardi Creek
POWAY
Rattlesnake Creek
Los Penasquitos Creek
Carroll Canyon Creek
Rose Creek
SAN DIEGO
SANTEE
San Diego River
Forester Creek
LAKE MIRAMAR RESERVOIR
LAKE MURRAY
EL CAJON
LA MESA
LEMON GROVE
Chollas Creek
Sweetwater River
CORONADO
S.D. COUNTY

Aerial Imagery Source: DigitalGlobe, 06/2012



0 3.75 7.5 15 Miles

NORTH

Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

RICK ENGINEERING COMPANY

San Diego Bay Watershed Management Area
HU 908.00, 909.00, & 910.00, 441 mi2

Legend

- Watershed Boundaries
- Municipal Boundaries
- Regional WMAA Streams
- **Exempt Bodies:** Water Storage Reservoirs, Lakes, Enclosed Embayments, Pacific Ocean, Buena Vista Lagoon
- **Exempt River Reaches:** Reaches of San Luis Rey River, San Dieguito River, San Diego River, Forester Creek, Sweetwater River, Otay River
- **Exempt Conveyance Systems:** Existing underground storm drains or conveyance channels whose bed and bank are concrete-lined, discharging directly to exempt water bodies, exempt rivers, or localized areas of Agua Hedionda Lagoon and Batiquitos Lagoon

S.D. COUNTY
Los Penasquitos Creek
Carroll Canyon Creek
Rose Creek
SANTEE
San Diego River
Forester Creek
EL CAJON
SAN DIEGO
LA MESA
S.D. COUNTY
San Diego River
Chollas Creek
LEMON GROVE
Sweetwater River
NATIONAL CITY
Sweetwater River
Dulzura Creek
CHULA VISTA
Jamul Creek
Otay River
Otay River
Cottonwood Creek
Tijuana River



Aerial Imagery Source: DigitalGlobe, 06/2012

0 4 8 16 Miles

NORTH

Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014

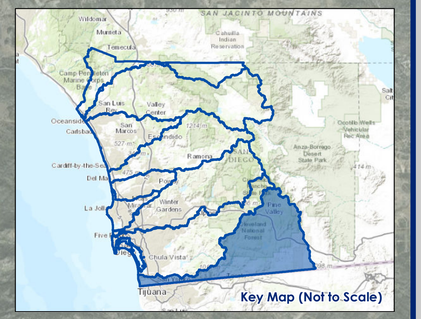
Geosyntec consultants | RICK ENGINEERING COMPANY

Tijuana Watershed Management Area
HU 911.00, 467 mi2

Legend

- Watershed Boundaries
- Municipal Boundaries
- Regional WMAA Streams
- **Exempt Bodies:** Water Storage Reservoirs, Lakes, Enclosed Embayments, Pacific Ocean, Buena Vista Lagoon
- **Exempt River Reaches:** Reaches of San Luis Rey River, San Dieguito River, San Diego River, Forester Creek, Sweetwater River, Otay River
- **Exempt Conveyance Systems:** Existing underground storm drains or conveyance channels whose bed and bank are concrete-lined, discharging directly to exempt water bodies, exempt rivers, or localized areas of Agua Hedionda Lagoon and Batiquitos Lagoon

POWAY
SANTEE
EL CAJON
LA MESA
LEMON GROVE
SAN DIEGO
NATIONAL CITY
CHULA VISTA
S.D. COUNTY
Batiquitos Creek
Carroll Canyon Creek
Rose Creek
San Diego River
Forester Creek
Chollas Creek
Sweetwater River
Dulzura Creek
Jamul Creek
Otay River
Otay River
Cottonwood Creek
Tijuana River



Aerial Imagery Source: DigitalGlobe, 06/2012

0 4.5 9 18 Miles

NORTH

Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014

Geosyntec consultants

RICK ENGINEERING COMPANY

ATTACHMENT C
ELECTRONIC FILES

Electronic Folder titled "Attachment _C_ElectronicData_Regional.zip" Contents:

1. ArcMap 10.0 and 10.1 map files created for purpose of viewing Regional WMAA data
   - Regional_WMAA_Data_2014_0908_v10.mxd (
   - Regional_WMAA_Data_2014_0908_v101.mxd (
2. ESRI Geodatabase titled "Regional_WMAA_Data_2014_0908_v10.gdb" containing the following data:
   - WatershedBoundaries
     - Watershed_Boundaries
   - HydrologicProcesses
     - HRUAnalysis
   - Streams – description of existing streams in the watershed
     - SD_Regional_WMAA_Streams (streams selected for detailed analysis)
     - SD_NHD_Streams (portion of NHD dataset included for reference)
   - LandUsePlanning
     - SanGIS_ExistingLandUse
     - SanGIS_PlannedLandUse
     - SanGIS_DevelopableLands
     - SanGIS_RedevelopmentandInfill
     - SanGIS_MunicipalBoundaries
     - Federal_State_Indian_Lands
     - SanGIS_MHPA_SD
     - SanGIS_MSCP_CN
     - SanGIS_MSCP_EAST_DRAFT_CN
     - SanGIS_Draft_North_County_MSCP_Version_8_Categories
   - PotentialCoarseSedimentYield
     - GLUAnalysis
     - PotentialCoarseSedimentYieldAreas
     - MacroLevelPotentialCriticalAreas
     - PotentialCriticalCoarseSedimentYieldAreas
   - ChannelStructures
     - ChannelStructures
   - HydromodExemptions
     - Exempt_Systems
     - Exempt_Bodies
   - Floodplains: included for reference
     - FEMA_NFHL
   - Baselayers: included for reference
     - SanGIS_Lakes
     - link to ESRI World Imagery (internet connection is required to access ESRI World Imagery basemap)

3. Regional_WMAA_Data_2014_0908.kmz**,** KMZ file containing the following data:
    - WatershedBoundaries
    - Streams
        - SD Regional WMAA Streams (streams selected for detailed analysis)
        - SD NHD Streams (portion of NHD dataset included for reference)
    - LandUsePlanning
        - Municipal Boundaries
        - Federal/State/Indian Lands
    - ChannelStructures
    - HydromodExemptions
        - Exempt_Systems
        - Exempt_Bodies
    - Floodplains: included for reference
        - FEMA Floodplain

Notes:

- Open a map file (with extension .mxd) using ArcMap to view the data.
- All data contained in the geodatabase is loaded into the map.
- Some data such as Hydrologic Processes and Coarse Sediment are best viewed at a large scale. Zoom the map to an area of interest to review this data.

ATTACHMENT D
REGIONAL MS4 PERMIT CROSSWALK

Table below provides a linkage between the Regional MS4 Permit requirements for WMAA and this report.

Regional MS4 Permit Provision	Regional WMAA Report
B.3.b.(4)(a)	Chapter 2; Section 5.1; Attachment A and Attachment C
B.3.b.(4)(a)(i)	Section 2.1; Attachment A.1 and Attachment C
B.3.b.(4)(a)(ii)	Section 2.2; Attachment A.2 and Attachment C
B.3.b.(4)(a)(iii)	Section 2.3; Attachment A.3 and Attachment C
B.3.b.(4)(a)(iv)	Section 2.4; Attachment A.4 and Attachment C
B.3.b.(4)(a)(v)	Section 2.5; Attachment A.5 and Attachment C
B.3.b.(4)(b)	Chapter 3 and Section 5.2
B.3.b.(4)(c)	Chapter 4; Section 5.3; Attachment B and Attachment C

Attachment J. Candidate Projects for the Upper SMR Subwatershed

Candidate Projects for the Upper SMR Subwatershed

Perris
Hemet
Lake Elsinore
Canyon Lake
Menifee
County of Riverside Integrated Mitigation Project
Wildomar
Wildomar MDP Lateral C Basin
Murrieta
Santa Gertrudis Valley Browning Street Water Quality Basin
Meadowview Stream Restoration Pilot Project
Riverside County
Temecula
Temecula Creek Streambed Stabilization
San Diego County
Aguanga

0 2 4 6 Miles

County Boundary
Incorporated Area
Candidate Projects
Santa Margarita River Watershed Boundary

Attachment K. Riverside County Flood Control Interim Criteria

INTERIM CRITERIA FOR SIZING INCREASED RUNOFF DETENTION FACILITIES

* The entire area of proposed development will be routed through a detention facility(s) to mitigate increased runoff. All basins must have positive drainage; dead storage basins shall not be acceptable.

* Storms to be studied will include the 1-hour, 3-hour, 6-hour and 24-hour duration events for the 2-year, 5-year and 10-year return frequencies. Detention basin(s) and outlet(s) sizing will ensure that none of these storm events have a higher peak discharge in the "after" condition than in the "before" condition.

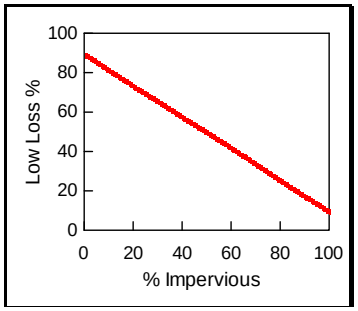
* For the 2-year and 5-year events the loss rate will be determined using an AMC I condition. For the 10-year event AMC II will be used. Constant loss rates shall be used for the 1-hour, 3-hour and 6-hour events. A variable loss rate shall be used for the 24-hour events.

* Low Loss rates will be determined using the following:

  - Undeveloped Condition --> *Low Loss = 90%*

  - Developed Condition --> *Low Loss = .9 - (.8 x % impervious)*

  - Basin Site --> *Low Loss = 10%*



* Where possible and feasible the on-site flows should be mitigated before combining with off-site flows to minimize the size of the detention facility required. If it is necessary to combine off-site and on-site flows into a detention facility two separate conditions should be evaluated for each duration/return period/before-after development combination studied; the first for the total tributary area (off-site plus on-site), and the second for the area to be developed alone (on-site). It must be clearly demonstrated that there is no increase in peak flow rates under either condition (total tributary area or on-site alone), for each of the return period/duration combinations required to be evaluated. A single plot showing the pre-developed, post-developed and routed hydrograghs for each storm considered, shall be included with the submittal of the hydrology study.

* No outlet pipe(s) will be less than 18" in diameter. Where necessary an orifice plate may be used to restrict outflow rates. Appropriate trash racks shall be provided for all outlets less than 48 inches in diameter.

* The basin(s) and outlet structure(s) must be capable of passing the 100-year storm without damage to the facility.

* Mitigation basins should be designed for joint use and be incorporated into open space or park areas. Side slopes should be no steeper than 4:1 and depths should be minimized where public access is uncontrolled.

* A viable maintenance mechanism, acceptable to both the County and the District, should be provided for detention facilities. Generally, this would mean a CSA, landscape district, parks agency or commercial property owners association. Residential homeowners associations would generally not be acceptable.

pcdoc/59946
DW:FJP 5-30-95

Attachment L. Santa Margarita Watershed Impervious Area Summary Table

Copermittee Impervious Area Summary Tables

Current

	County		Hemet		Menifee		Murrieta		Temecula		Wildomar	
SCAG code	ISC	Area	ISC	Area	ISC	Area	ISC	Area	ISC	Area	ISC	Area
1100	0.10	5324085.59		0		0	0.15	554047		0	0.42	9755.55
1110	0.18	155266002.3		0	0.3	2343782.049	0.41	32982102.71	0.36	279916827.2	0.33	92945883.25
1111	0.42	62904902.69		0		0	0.46	181518865.5	0.51	4565845.088		0
1112	0.17	1370932.95		0		0	0.4	30023817.89	0.19	8061398.63		0
1120	0.08	1852031.703		0		0	0.69	4238424.102	0.65	3310519.854	0.43	2290459.7
1122	0.19	1724856		0		0	0.46	1878455.17	0.61	2291268.681	0.37	445834.36
1123	0.69	1124374.58		0		0	0.71	6457666.531	0.67	14769752.76	0.69	836826
1124		0		0		0	0.71	1125317.93		0		0
1130	0.14	19295044.93		0	0.17	12243305.62	0.5	1322824.49		0	0.34	49068065.69
1131	0.42	8035540.83		0		0	0.45	7846292.992	0.02	1707278.4		0
1132	0.07	1046248.56		0		0	0.47	217805.17		0		0
1150	0.13	764248756		0		0	0.32	44347787.12	0.11	5592924	0.07	950480
1200	0.51	0	0.51	0	0.51	0	0.51	5775114.342	0.51	1240698.26	0.51	0
1210	0.29	7887880.7	0.29	0	0.29	444850	0.29	4499984.491	0.29	4925423.375	0.29	564512.232
1211	0.57	348212.41	0.57	0	0.57	0	0.57	1351678.017	0.57	2779638.85	0.57	0
1220	0.47	2954216.788	0.47	0	0.47	0	0.47	999453.45	0.47	8611803.54	0.47	546178.14
1221	0.72	0	0.72	0	0.72	0	0.72	0	0.72	2323360.8	0.72	0
1222	0.68	1182013.507	0.68	0	0.68	0	0.68	10190385.36	0.68	27021737.2	0.68	2199114.37
1223	0.50	1363605.25	0.50	0	0.50	0	0.50	9086816.83	0.50	991857.7	0.50	0
1230	0.10	8501.82	0.10	0	0.10	0	0.10	0	0.10	607345.2	0.10	0
1231	0.44	528134.27	0.44	0	0.44	0	0.44	2082729.6	0.44	2214019.5	0.44	0
1232	0.25	201710.38	0.25	0	0.25	0	0.25	1340415.5	0.25	0	0.25	0
1233	0.31	935703	0.31	0	0.31	0	0.31	82775.5	0.31	1516937	0.31	0
1240	0.22	0	0.22	315866	0.22	0	0.22	1500470.17	0.22	276486.2	0.22	2583217.3
1241	0.46	2248238	0.46	0	0.46	0	0.46	938480.3	0.46	1082359	0.46	0
1242	0.43	230777	0.43	0	0.43	0	0.43	389063	0.43	59539.9	0.43	0
1243	0.38	121932.4	0.38	0	0.38	0	0.38	290473.6	0.38	343914.3	0.38	0
1244	0.29	232407.36	0.29	0	0.29	0	0.29	756904	0.29	1156618.99	0.29	1080517.4
1245	0.31	564684	0.31	0	0.31	0	0.31	1857536.6	0.31	4362402.7	0.31	1195953
1246	0.27	887018.92	0.27	0	0.27	0	0.27	791607.99	0.27	1678293.2	0.27	0
1247	0.52	0	0.52	0	0.52	0	0.52	0	0.52	223807.3	0.52	0
1252	0.37	277529.21	0.37	0	0.37	0	0.37	669696.6	0.37	0	0.37	0
1253	0.16	1192381.8	0.16	0	0.16	0	0.16	93637.9	0.16	0	0.16	0
1260	0.27	580447.6	0.27	0	0.27	0	0.27	222160.4	0.27	5113989.2	0.27	2702718.2
1261	0.42	0	0.42	0	0.42	0	0.42	281658.5	0.42	241750.01	0.42	0
1262	0.41	2569393.475	0.41	0	0.41	0	0.41	5229471.79	0.41	4948552.58	0.41	0
1263	0.39	905954	0.39	0	0.39	0	0.39	1660395	0.39	5138099	0.39	340297
1264	0.41	1997955	0.41	0	0.41	0	0.41	6651659.98	0.41	7266500	0.41	0
1265	0.40	0	0.40	0	0.40	0	0.40	1800586.038	0.40	551728	0.40	0

Copermittee Impervious Area Summary Tables

Current

	County		Hemet		Menifee		Murrieta		Temecula		Wildomar	
1271	0.20	0	0.20	0	0.20	0	0.20	0	0.20	0	0.20	334961
1310	0.53	826661.36	0.53	0	0.53	0	0.53	94192.1	0.53	2293449.89	0.53	127376
1311	0.44	13110750.09	0.44	0	0.44	0	0.44	5902111.12	0.44	17394732.52	0.44	1032227.6
1320	0.06	1595986.08	0.06	0	0.06	0	0.06	221668.2	0.06	0	0.06	0
1321	0.01	863813	0.01	0	0.01	0	0.01	0	0.01	0	0.01	0
1323	0.11	2202592.78	0.11	0	0.11	0	0.11	1083122.9	0.11	0	0.11	0
1331	0.02	4971748.6	0.02	0	0.02	0	0.02	201034.5	0.02	0	0.02	0
1340	0.47	361053.5	0.47	0	0.47	0	0.47	0	0.47	2582769.7	0.47	685021
1400	0.64	0	0.64	0	0.64	0	0.64	0	0.64	232665.6	0.64	0
1410	0.52	0	0.52	0	0.52	0	0.52	0	0.52	3708674.911	0.52	0
1411	0.22	9697112	0.22	0	0.22	113902	0.22	3258724.3	0.22	0	0.22	60420.4
1413	0.46	0	0.46	0	0.46	0	0.46	46845.261	0.46	0	0.46	0
1415	0.07	209544	0.07	0	0.07	0	0.07	115379.5	0.07	0	0.07	0
1416	0.05	403420	0.05	0	0.05	0	0.05	12106.25	0.05	0	0.05	0
1420	0.14	55592.2	0.14	0	0.14	0	0.14	199754	0.14	94059.3	0.14	0
1430	0.63	0	0.63	0	0.63	0	0.63	0	0.63	502976	0.63	0
1431	0.42	513956.86	0.42	0	0.42	0	0.42	270625.9	0.42	405413.92	0.42	933962.151
1432	0.00	1375949	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
1433	0.37	0	0.37	0	0.37	0	0.37	2601277	0.37	3852531	0.37	0
1434	0.11	18547209.7	0.11	265393.6	0.11	0	0.11	2316777	0.11	400336.1	0.11	75419.8
1435	0.09	254225	0.09	0	0.09	0	0.09	0	0.09	0	0.09	0
1436	0.10	5666122	0.10	0	0.10	0	0.10	90737.6	0.10	2688789.98	0.10	0
1437	0.11	9977400.2	0.11	0	0.11	0	0.11	8930927.32	0.11	24514968.72	0.11	67750.4
1440	0.32	349517.2	0.32	0	0.32	0	0.32	598872.6	0.32	0	0.32	0
1500	0.67	310135.498	0.67	0	0.67	0	0.67	4852115.51	0.67	8671358.23	0.67	0
1600	0.21	0	0.21	0	0.21	0	0.21	0	0.21	97076.5	0.21	0
1700	0.23	54874025.34	0.23	0	0.23	98438.75	0.23	11230696.68	0.23	200034.48	0.23	338973.31
1800	0.16	0	0.16	0	0.16	0	0.16	4280901.49	0.16	45494839.51	0.16	0
1810	0.07	10812633.89	0.07	0	0.07	0	0.07	21947173.34	0.07	31892516.63	0.07	0
1820	0.18	2422076.669	0.18	0	0.18	0	0.18	7114176.99	0.18	13741915.82	0.18	85333.3
1830	0.00	1600590652	0.00	0	0.00	0	0.00	157539.2	0.00	4315720	0.00	2062800
1840	0.09	112192	0.09	0	0.09	0	0.09	428666	0.09	278718.7	0.09	0
1850	0.00	0	0.00	0	0.00	0	0.00	0	0.00	201798742.2	0.00	0
1880	0.03	27636808.29	0.03	0	0.03	0	0.03	1165767.1	0.03	3580.92	0.03	0
2000	0.03	4833575.98	0.03	0	0.03	10278648.4	0.03	0	0.03	0	0.03	7551491.868
2100	0.04	84193.4	0.04	0	0.04	0	0.04	0	0.04	1138871.8	0.04	0
2110	0.01	148602240.7	0.01	0	0.01	0	0.01	6816384.97	0.01	0	0.01	0
2120	0.03	414470503.7	0.03	0	0.03	0	0.03	24679753.95	0.03	0	0.03	0
2200	0.01	580541862.5	0.01	0	0.01	0	0.01	7892189.146	0.01	0	0.01	10958432

Copermittee Impervious Area Summary Tables

Current

		County		Hemet		Menifee		Murrieta		Temecula		Wildomar	
2300	0.02	27879310.15	0.02	0	0.02	0	0.02	4200642.7	0.02	0	0.02	0
2400	0.02	4719608.9	0.02	0	0.02	0	0.02	1276898	0.02	0	0.02	1787546.9
2500	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	477684.1
2600	0.02	38503359.54	0.02	0	0.02	0	0.02	3776665.3	0.02	0	0.02	39219231
2700	0.03	119504503.6	0.03	0	0.03	0	0.03	17155897.64	0.03	0	0.03	0
3000	0.02	14830.8	0.02	17331334.64	0.02	4389933	0.02	18750337.62	0.02	27814738.78	0.02	123785423.1
3100	0.01	7032468978	0.01	0	0.01	0	0.01	248934900.3	0.01	73002509.6	0.01	53667862.16
3200	0.01	2957047.1	0.01	0	0.01	0	0.01	0	0.01	0	0.01	0
3300	0.03	26061215	0.03	0	0.03	0	0.03	30785.55	0.03	26684210.46	0.03	0
4000	0.26	0	0.26	0	0.26	0	0.26	0	0.26	623656.6	0.26	0
4100	0.01	283526671	0.01	0	0.01	0	0.01	6811655	0.01	0	0.01	0
5555	0.00	895485516.2	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0
9999	0.11	207753.73	0.11	0	0.11	0	0.11	330894.13	0.11	0	0.11	432831
11111	0.26	350715504	0.26	191026	0.26	2909890	0.26	129396200	0.26	137162000	0.26	37989900
1300	0.24											
ISC: Weighted Avg	3%	12,747,729,324	3%	18,103,620	12%	32,822,750	24%	918,230,958	22%	1,036,484,534	16%	439,434,459

Area: Total

Global Avg Imperviousness: Existing 6%

Total area (ft2) 15192805645.882

Total (mi2) 544.936

348778.8257

Copermittee Impervious Area Summary Tables

Future

SCAG code	County ISC	County Area	Hemet ISC	Hemet Area	Menifee ISC	Menifee Area	Murrieta ISC	Murrieta Area	Temecula ISC	Temecula Area	Wildomar ISC	Wildomar Area
1110	0.20	24483476			0.44	3333584.493	0.47	270186186.7	0.07	17614058.02	0.20	1016040
1110	0.20	2219294							0.31	21521320.52	0.69	4177322
1110	0.27	8938925.5							0.46	215461920.4	0.27	23037297
1110	0.42	302391583.1									0.35	57222142.6
1110	0.42	59438476.1									0.42	107094508.8
1110	0.61	505685									0.52	9225942.3
1110	0.69	4648768									0.73	910167
1110											0.61	504692
1120							0.71	26971348.85	0.69	15170200		
1130									0.59	28454400.02		
1140												
1150	0.07	2719550392			0.20	15604445.8	0.15	134479713.5	0.16	109336013.9	0.07	106605175.8
1150	0.12	3098201381			0.07	550388.41					0.12	8621340
1150	0.20	544597636.2			0.35	35854.1					0.27	2803090
1150	0.27	11881689			0.12	10373860.3					0.20	48485550
1150	0.35	2549321.8										
1210	0.29	19832301.4	0.29		0.29		0.29	57771764.38	0.29	14770100	0.29	13879757
1200	0.51	0	0.51		0.51		0.51	53565995.86	0.51	0	0.51	0
1220	0.47	34819590.93	0.47		0.47		0.47	0	0.47	37434879.62	0.47	23851906
1221	0.72	0	0.72		0.72		0.72	0	0.72	3807510	0.72	0
1230	0.10	27341778	0.10		0.10		0.10	31203188.91	0.10	7407065.978	0.10	0
1233	0.31	0	0.31		0.31		0.31	0	0.31	0	0.31	0
1240	0.22	86117403.36	0.22		0.22		0.22	46177119.57	0.22	65600569.89	0.22	3098969
1250	0.00	0	0.00		0.00		0.00	0	0.00	0	0.00	0
1260	0.27	0	0.27		0.27		0.27	0	0.27	0	0.27	0
1265	0.40	0	0.40		0.40		0.40	0	0.40	0	0.40	0
1270	0.00	0	0.00		0.00		0.00	0	0.00	0	0.00	0
1300	0.24	0	0.24		0.24		0.24	8110904.88	0.24	46827323.1	0.24	0
1310	0.53	27629786.6	0.53		0.53		0.53	0	0.53	0	0.53	5102242.6
1311	0.44	0	0.44		0.44		0.44	0	0.44	0	0.44	0
1320	0.06	0	0.06		0.06		0.06	0	0.06	0	0.06	0
1321	0.01	0	0.01		0.01		0.01	0	0.01	0	0.01	0
1340	0.47	0	0.47		0.47		0.47	0	0.47	0	0.47	0
1410	0.52	6677010	0.52		0.52		0.52	22157774.8	0.52	11090277.28	0.52	7351550
1420	0.14	0	0.14		0.14		0.14	0	0.14	0	0.14	0
1430	0.63	0	0.63		0.63		0.63	0	0.63	0	0.63	0
1500	0.67	12846522	0.67		0.67		0.67	1860187.439	0.67	0	0.67	4860273
1600	0.21	0	0.21		0.21		0.21	0	0.21	0	0.21	0
1810	0.07	0	0.07		0.07		0.07	0	0.07	0	0.07	0

Copermittee Impervious Area Summary Tables

Future

SCAG code	County ISC	County Area	Hemet ISC	Hemet Area	Menifee ISC	Menifee Area	Murrieta ISC	Murrieta Area	Temecula ISC	Temecula Area	Wildomar ISC	Wildomar Area
1820	0.18	107668279.4	0.18		0.18		0.18	146017713.8	0.18	304263064.4	0.18	11186880.3
1830	0.00	0	0.00		0.00		0.00	0	0.00	0	0.00	0
1840	0.09	0	0.09		0.09		0.09	0	0.09	0	0.09	0
1850	0.00	2572489960	0.00		0.00		0.00	0	0.00	0	0.00	527110
1860	0.00	0	0.00		0.00		0.00	0	0.00	0	0.00	0
1870	0.00	0	0.00		0.00		0.00	0	0.00	0	0.00	0
1880	0.03	1329889911	0.03	18041200	0.03		0.03	0	0.03	0	0.03	0
1900	0.00	0	0.00		0.00		0.00	0	0.00	0	0.00	0
3000	0.02	0	0.02		0.02		0.02	0	0.02	0	0.02	0
2000	0.03	564200528	0.03		0.03		0.03	0	0.03	0	0.03	0
4000	0.26	279987483.6	0.26		0.26		0.26	0	0.26	0	0.26	0
7777	0.00	0	0.00		0.00		0.00	0	0.00	0	0.00	0
8888	0.00	0	0.00		0.00		0.00	0	0.00	0	0.00	0
9999	0.11	0	0.11		0.11		0.11	0	0.11	0	0.11	0
5555	0.00	898384576	0.00		0.00		0.00	0	0.00	6431870	0.00	0
11111	0.26	0	0.26		0.26	2919360	0.26	119832000	0.26	131293000	0.26	0
ISC: Weighted Avg	8%		3%		20%		32%		29%		29%	
Area: Total		12,747,291,758		18,041,200		32,817,493		918,333,899		1,036,483,573		439,561,955
Difference to existing (ft2)		-437566		-62420		-5257		102941		-961		127496

Global Avg Imperviousness: Future	12%
Total area (ft2)	1.5E+10
Total (mi2)	544.926

Appendix 5A – Santa Margarita Watershed Monitoring Plan

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OCTOBER 2018, REVISED JANUARY 2019

RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT AND COUNTY OF SAN DIEGO

Appendix 5A: Santa Margarita River Monitoring Plan

Santa Margarita River Watershed Management Area

Submitted by:

COUNTY OF RIVERSIDE, RIVERSIDE COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT, CITIES OF MENIFEE, MURRIETA, TEMECULA, WILDOMAR, AND COUNTY OF SAN DIEGO

Prepared by:

LARRY WALKER ASSOCIATES, INC.

WESTON SOLUTIONS

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ABBREVIATIONS AND ACRONYMS

303(d) list	Clean Water Act Section 303(d) List of Impaired Waterbodies
ADCP	Acoustic Doppler Current Profiler
AFDM	Ash-free dry mass
ASTM	American Society for Testing and Materials
Bight	Southern California Bight Regional Monitoring Program
BMI	Benthic macroinvertebrate
BMP	Best management practice
BOD	Biochemical oxygen demand
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CEDEN	California Environmental Data Exchange Network
cfs	Cubic feet per second
COC	Chain of custody
cm^2	Square centimeter
CRAM	California Rapid Assessment Method
CSCI	California Stream Condition Index
CWA	Clean Water Act
DO	Dissolved oxygen
EDDs	Electronic Data Deliverables
ELAP	Environmental Laboratory Accreditation Program
EPT taxa	Ephemeroptera, Plecoptera and Trichoptera taxa
GIS	Geographic information system
GPS	Global positioning system
GS/MS NCI-SIM	Gas chromatography/mass spectrometry negative-ion chemical ionization-selected ion monitoring
HMP	Hydromodification Monitoring Program
HPWQCs	Highest priority water quality conditions
IBI	Index of Biotic Integrity
IC/ID	Illicit connection and/or illicit discharge
IDDE	Illicit Discharge Detection and Elimination
JRMP	Jurisdictional Runoff Management Program
L	Liter
m	Meter
µg	Microgram
µS/cm	Micro Siemens per centimeter
mg/L	Milligrams per liter
mL	Milliliter
MAP	Monitoring and Assessment Program
MEP	Maximum extent practicable
MLS	Mass Loading Station
mm	Millimeter
MPN/100mL	Most probable number per 100 milliliters
MS/MSDs	Matrix spike/matrix spike duplicates
MS4	Municipal separate storm sewer system

ng/L	Nanograms per liter
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric turbidity units
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
Permit	RWQCB Order No. R9-2013-0001, as amended by Order Nos. R9-2015-0001 and R9-2015-0100
pH	Log of hydrogen ion concentration
PVC	Polyvinyl chloride
O/E	Observed to expected
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
QPS	Quantitative Precipitation Statement
RCFCWCD	Riverside County Flood Control and Water Conservation District
RL	Reporting Limit(s)
RWQCB	Regional Water Quality Control Board
SAFIT	Southwest Association of Freshwater Invertebrate Taxonomists
SCAMIT	Southern California Association of Marine Invertebrate Taxonomists
SCCWRP	Southern California's Coastal Water Research Project
SM	Standard Methods
SMC	Stormwater Monitoring Coalition
SMC Workgroup	SMC Bioassessment Technical Workgroup
SMR	Santa Margarita River
SOP	Standard operating procedure
SQO	Sediment quality objectives
SWAMP	Surface Water Ambient Monitoring Program
TAC	Technical Advisory Committee
TIE	Toxicity identification evaluation
TKN	Total Kjeldahl nitrogen
TMDL	Total Maximum Daily Load
TOC	Total organic carbon
TRE	Toxicity reduction evaluation
TSS	Total suspended solids
TST	Test of Significant Toxicity
USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey
WMA	Watershed Management Area
WQIP	Water Quality Improvement Plan

1 INTRODUCTION

The San Diego Regional Water Quality Control Board (Regional Water Board) issued Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) draining the jurisdictional areas of the Counties of Riverside and San Diego, the Riverside County Flood Control and Water Conservation District (RCFCWCD), and the Cities of Murrieta, Temecula, and Wildomar (collectively known as Copermittees) as well as the City of Menifee within the San Diego Region, Order No. R9-2013-0001 as amended by Order Nos. R9-2015-0001 and R9-2015-0100, National Pollutant Discharge Elimination System (NPDES) Permit No. CAS0109266, hereafter referred to as the Permit. This appendix establishes procedures within the Santa Margarita River (SMR) subwatershed (Hydrologic Unit No. 902) in the San Diego Region for compliance with the Monitoring and Assessment Program (MAP) requirements under Provisions B.4 and Provision D of the Permit, and is effective upon acceptance of the Santa Margarita River Watershed Management Area (WMA) Water Quality Improvement Plan (WQIP) as required by the Permit.

Implementation of the MAP will be led by the RCFCWCD in the Upper and Middle SMR subwatersheds, and by the County of San Diego in the Lower SMR subwatershed. As such, this Appendix will describe monitoring procedures for both agencies.

2 RECEIVING WATER MONITORING PROGRAM

The Receiving Water Monitoring Program is part of a regional effort by the Copermittees to implement a watershed-based monitoring program.

2.1 RECEIVING WATER MONITORING PROGRAM OVERVIEW

Samples will be collected in accordance with the Copermittees' Standard Operating Procedures (SOPs). Monitoring is intended to be compatible with the Surface Water Ambient Monitoring Program (SWAMP). Composite and grab sample times, *in-situ* field measurements, and sampling activities and observations will be recorded on a field data sheet in accordance with the Copermittees' procedures.

The Receiving Water Monitoring Program incorporates the following monitoring components:

- Receiving Water Wet Weather Monitoring and Receiving Water Dry Weather Monitoring (**Sections 2.2** and **2.3**)
- Receiving Water Sampling Teams, Equipment, and Bottles (**Section 2.4**)
- Receiving Water Data Collection (**Section 2.5**)
- Bioassessment Monitoring (**Section 2.6**)
- Hydromodification Monitoring (**Section 2.7**)
- Follow-up Analysis and Actions (**Section 0**)
- Sediment Quality Monitoring (**Section 2.9**)
- Receiving Water Monitoring Program Analysis Types (**Section 2.10**)
- Assessment and Reporting (as discussed in **Chapter 5** of the WQIP)

The Receiving Water Monitoring Program includes both wet weather and dry weather sampling for chemistry and toxicity. The Dry Weather Receiving Water Monitoring Program requires bioassessment monitoring and hydromodification monitoring at least once during the permit term. Refer to **Figure 2-1** for the long-term receiving water monitoring locations.

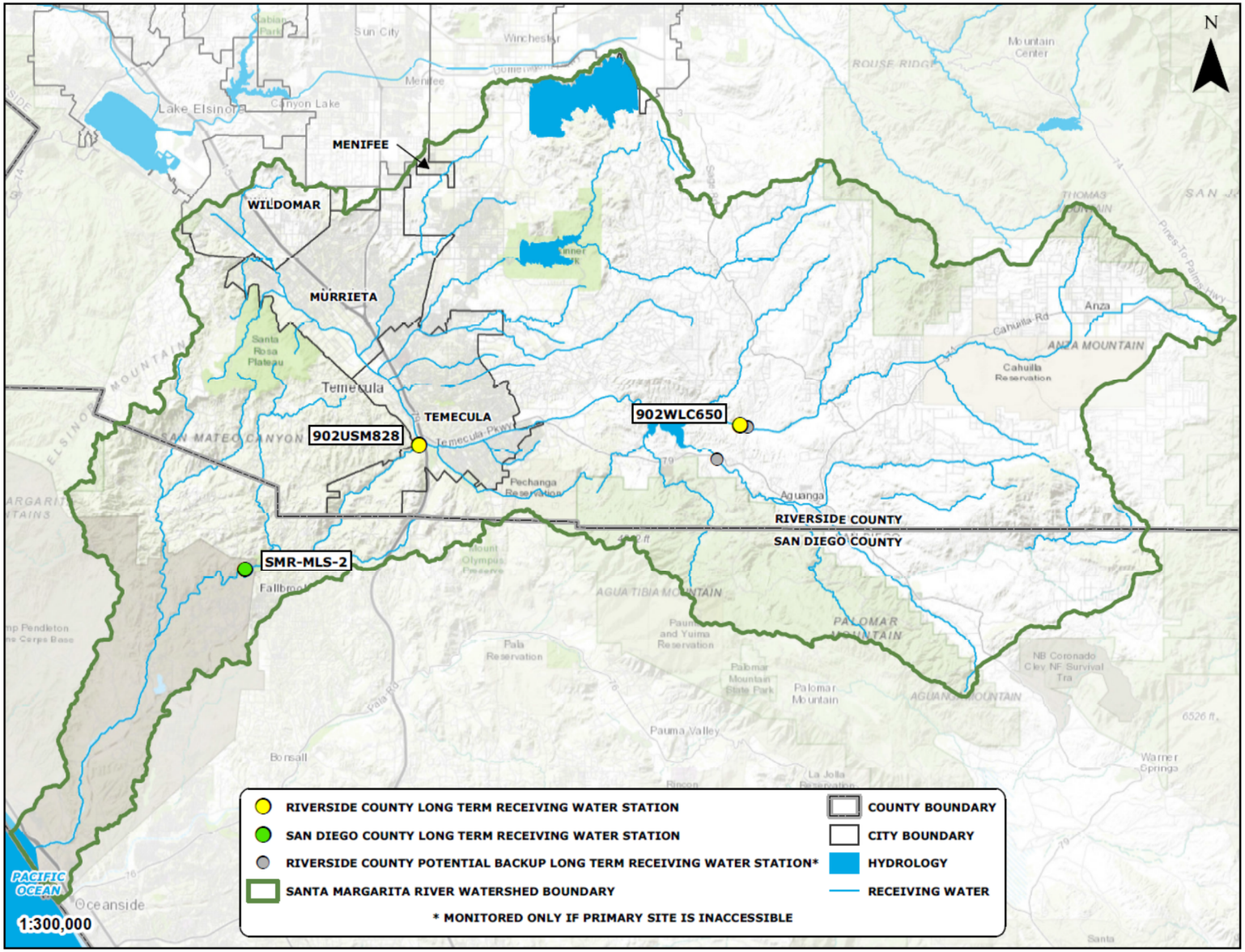

Figure 2-1. WQIP Long-term Receiving Water Monitoring Stations

2.2 RECEIVING WATER WET WEATHER MONITORING

The Permit requires monitoring during three wet weather events at the receiving water monitoring station per permit term. As discussed in **Chapter 5** of the WQIP, all three wet weather monitoring events are scheduled for the 2019-2020 reporting year. In accordance with Provision D.1.d of the Permit, wet weather receiving water monitoring must occur three times during the Permit term. One event must occur during the first wet weather event of the wet season and at least one event must occur during a wet weather event after February 1. In addition to these requirements, one wet weather event will be targeted in the Lower SMR subwatershed as weather patterns dictate, but at least 30 days after the first rainfall event.

Composite and grab samples will be analyzed for the constituents listed in **Section 2.5**. Water quality monitoring at the receiving water monitoring station also includes recording the field observations listed in **Section 2.5**.

The Permit defines the wet season as October 1st through April 30th. Monitoring stations will be sampled according to procedures described in the following **Sections 2.4** and **2.5**.

The following criteria for mobilization will be employed for a wet weather sampling event.

Upper and Middle SMR Subwatersheds Mobilization Criteria

The representative storm event was derived using average rainfall depths and durations from the United States Environmental Protection Agency (USEPA) NPDES Storm Water Sampling Guidance Document, Exhibit 2-8, "Rain Zones of the United States".[1] The derivation is presented in **Appendix 5D**.

- Pursuant to USEPA 833-B-92-001, a representative storm event for the Pacific Southwest is between:
  - 0.27" to 0.81" in depth and
  - within 6 to 18 hours in duration.
- Pursuant to RCFCWCD analysis of local rain gauge data conducted in accordance with USEPA 833-B-92-001, a representative event is between:
  - 0.38" to 1.14" in depth and
  - within 6 to 18 hours in duration.

Due to the ephemeral nature of streams in the SMR, the first storm that falls under the USEPA-recommended criteria may not result in storm induced runoff from tributary areas. Based on the Copermittees' monitoring experience, storm event forecasts of less than 0.5" in 24 hours typically do not result in measureable storm induced runoff and often result in false starts.

Monitoring will be conducted according to the mobilization criteria below for three events during the Permit term:

- If a wet weather event is forecasted by the National Weather Service (NWS) Quantitative Precipitation Statement (QPS) to be greater than 0.1" within the next 48 hours and there is

[1] Exhibit 2-8 "Rain Zones of the United States", Pacific Southwest Region. *NPDES Storm Water Sampling Guidance Document*. U.S. EPA Document No. 833-B-92-001.

at least 72 hours between the forecasted event and a previous measurable (>0.1") rainfall event:

- Then RCFCWCD will follow the procedure outlined in Exhibit 2-7 of USEPA NPDES Storm Water Guidance Document (USEPA 833-B-92-001[2]), included below as **Figure 2-2**, and as discussed in **Appendix 5D**. This decision chart references the speculation of representative storm size.
- Pursuant to NWS standard practice, "Likely" represents a Probability of Precipitation (PoP) of at least 60%.
- Mobilization will occur when the NWS QPS forecast shows likely rainfall of 0.3" in 6 hours AND/OR 0.5" in 24 hours. This gives the Copermittees the greatest chance to sample a representative storm event.
- For mobilization to occur, criteria must be met 24 hours in advance of sampling for coordination with property owners, consultants, and sampling personnel.

Additional information regarding mobilization criteria is available in **Appendix 5D**. Mobilization will occur in accordance with the USEPA Decision Chart for Storm Water Sampling, presented in **Figure 2-2,** and as stated in **Appendix 5D**.

[2] Derived from Exhibit 2-8 "Rain Zones of the United States", Pacific Southwest Region. *NPDES Storm Water Sampling Guidance Document*. U.S. EPA Document No. 833-B-92-001.

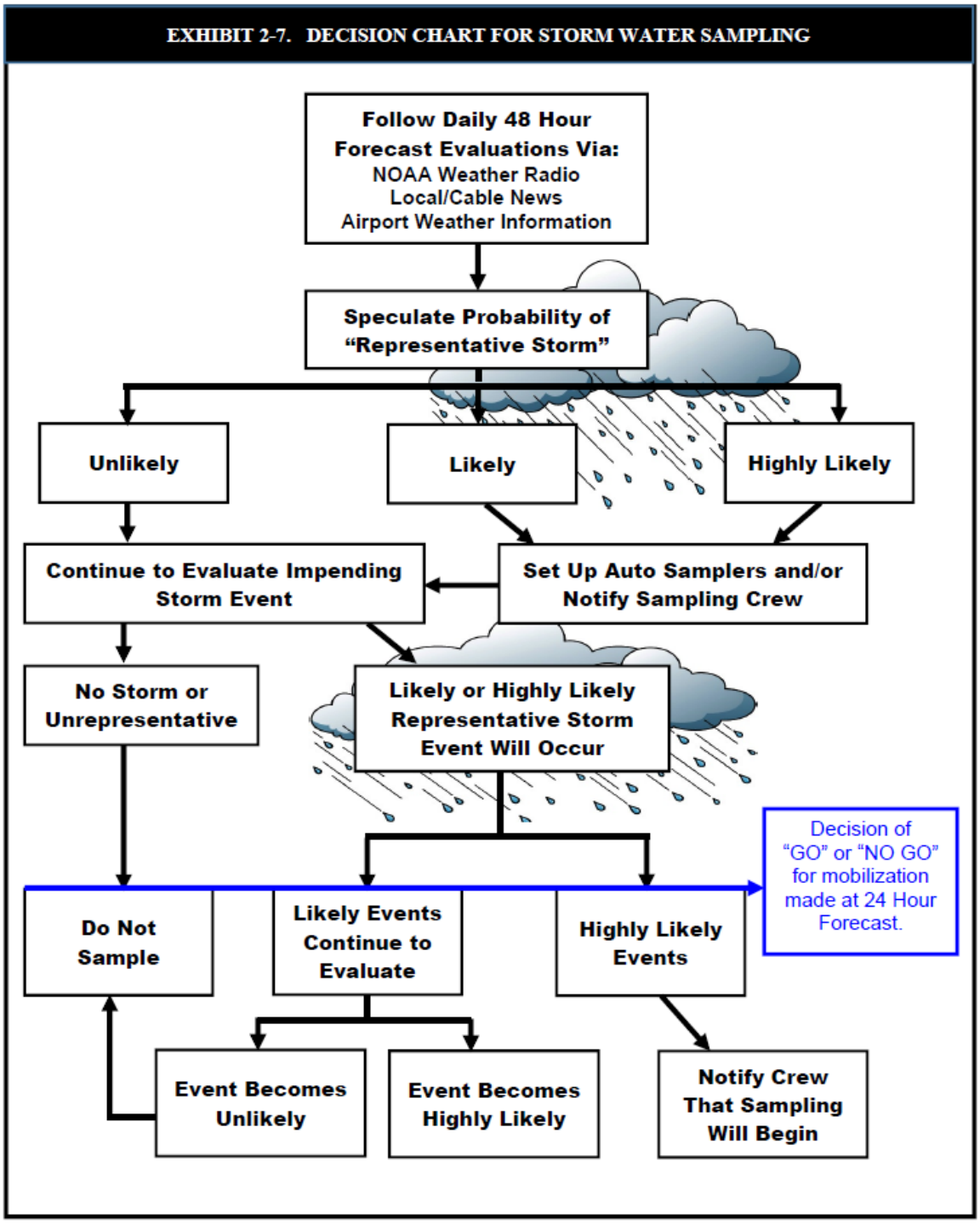

Figure 2-2. USEPA Decision Chart for Storm Event Sampling

Lower SMR Subwatershed Mobilization Criteria

Throughout the wet weather season, field teams will monitor NWS weather reports and data to predict when storms will arrive and to determine whether they will be significant enough to allow monitoring to occur. Storm events will be considered viable for mobilization if they are predicted to produce at least 0.10 inch of rainfall in the drainage area with at least a 70% chance of rainfall.

Each storm of at least 0.1 inch of rainfall must be separated by a minimum of 72 hours. These mobilization criteria must be met at least 24 hours prior to the anticipated onset of rainfall. For the purposes of these criteria, storm forecasts will be obtained from the NWS website (http://www.wrh.noaa.gov/sgx/).

2.3 RECEIVING WATER DRY WEATHER MONITORING

The Permit requires monitoring during three dry weather events at the receiving water monitoring station per permit term. For most constituents, dry weather monitoring will consist of time-weighted composites composed of 24 discrete hourly samples or 24-hour flow-weighted composite samples. Grab samples may be collected for the following constituents during monitoring: pH, temperature, specific conductivity, dissolved oxygen, turbidity, hardness, indicator bacteria, and toxicity. Composite and grab samples will be analyzed for the constituents listed in **Section 2.5**. Water quality monitoring at the receiving water monitoring station also includes recording the field observations listed in **Section 2.5**. Monitoring will be conducted three times during the permit term according to the criteria below, per Provision D.1.c of the Permit:

- At least one monitoring event will occur between May 1st and September 30th. At least one monitoring event will be conducted during a dry weather period during the wet season (October 1 – April 30), after the first wet weather event of the season.
- Dry weather monitoring events will be preceded by an antecedent dry period of at least 72 hours following a storm event producing measurable rainfall of greater than 0.1 inch.

Dry weather monitoring may occur in conjunction with regional monitoring programs, including the SMC Regional Monitoring Program, or special studies. Dry weather receiving water monitoring is scheduled for the 2019-2020 reporting year for the Lower SMR subwatershed, and for the 2020-2021 reporting year for the Upper and Middle SMR subwatersheds. One dry weather event will be targeted in the Lower SMR subwatershed during the month of September 2019, after equipment has been installed and prior to the beginning of the wet season, and one dry weather event will be targeted to occur during a dry weather period after February 1, 2020. Additional information regarding mobilization criteria in the Upper and Middle SMR subwatersheds is available in **Appendix 5D**.

2.4 RECEIVING WATER SAMPLING TEAMS, EQUIPMENT, AND BOTTLES

Sampling Teams

Monitoring teams will be comprised of two Copermittee field personnel and/or consultants. All field personnel will have current and relevant experience in all aspects of standard field monitoring, including use of relevant field equipment such as field instruments and monitoring equipment. Field personnel will be trained and have experience in the collection, handling/storage, and chain-of-custody procedures.

All samples will be delivered to the laboratory by field crews promptly following sample collection. Runners will be used as necessary to ensure samples are delivered to the laboratory within USEPA recommended holding times.

Equipment

For most constituents, wet weather monitoring will consist of flow-weighted composite samples collected over the length of the entire storm or 24-hours whichever comes first. Grab samples will

be collected for the following constituents during wet weather monitoring: pH, temperature, specific conductivity, dissolved oxygen, turbidity, hardness, salinity, and indicator bacteria. If site/monitoring conditions change, Copermittees may elect to collect toxicity via a grab sample as well. Monitoring equipment may include:

- Data-logging flow meter
- Automated composite sampler with sample tubing
- Tipping bucket rain gauge
- 12-V DC power supply
- Data telemetry unit (as necessary and/or available)
- Portable field water quality meter(s)
- Wet weather gear for wet weather events
- Ice
- Field books with field data sheets, site maps, hospital routes, sampling procedures, equipment manuals and chains of custody
- Sample bottles
- A toolbox with tools such as nitrile gloves, headlamps, zip ties, diagonal cutters, adjustable wrenches, and screwdrivers to take samples and make adjustments as needed on equipment during the storm event
- Extra autosampler bottles to make bottle changes as needed
- A cellphone to maintain communication lines with the project manager and field lead.

Installation and Maintenance

Prior to the start of each wet weather event, the electronic equipment and clean tubing will be installed at the receiving water monitoring stations in preparation for the anticipated wet weather event. Upon completion of monitoring, the equipment will be removed from the site and stored at either the Copermittee's or consultant's office. Monitoring equipment at the receiving water monitoring station may be installed during the beginning of individual dry weather monitoring events**.** Maintenance and calibration will be performed prior to monitoring each receiving water monitoring event according to the manufacturer's specifications.

A second set of equipment may be set up at the receiving water monitoring stations to collect enough volume for required toxicity analyses. The receiving water monitoring station may be equipped with eight 1-gallon bottles or two 19-liter bottles using the same protocols as above for the collection of automated composite toxicity samples. Automated equipment is recommended but not required for composite sampling.

Bottles

Composite samples may be collected directly into 19-liter bottles or into individual 1-gallon bottles that will be composited at the laboratory. Grab samples may be collected by manually operating the automated equipment to fill the appropriate bottles or by following grab sampling protocols described in **Appendix 5D** for the Upper and Middle SMR subwatersheds and **Section 2.5** for the Lower SMR subwatershed. **Appendix 5D** contains additional information regarding sample

bottles for the Upper and Middle SMR subwatersheds, and **Section 2.5** contains additional information regarding sample bottles for the Lower SMR subwatershed. **Table 2-1** provides a summary of bottles required for receiving water monitoring.

Table 2-1. Receiving Water Monitoring Bottle List

Constituent	Container Type Per Site[(1)]	Preservative	USEPA Recommended Holding Time
E. coli, Fecal Coliform, Total Coliform, *Enterococcus*	2 x 125-mL plastic (each)	$Na_2S_2O_3$	8 hours
Toxicity	7 x 1-Gallon amber glass (1 additional grab if TIE required) or 2 x 19-Liter bottle	≤6°C	48 hours
All other constituents (Chemistry)	1 x 19-Liter glass (& 1 spare 19-L glass) or 3 x 1-Gallon glass or As directed by the laboratory	≤6°C	48 hours (minimum)

1. Container Type and size may vary based on equivalent recommended by ELAP certified laboratory.

2.5 RECEIVING WATER DATA COLLECTION

The following samples and measurements will be collected at the receiving water monitoring station:

- Composite Samples
  - Chemistry time or flow weighted composite samples
  - Toxicity time or flow-weighted composite samples
- Grab samples
  - Toxicity grab samples (if composite samples are not collected)
  - Bacteriological grab samples
  - Hardness (if composite sample is not collected)
- *In-situ* field measurements
  - Temperature
  - pH
  - Specific conductivity
  - Dissolved oxygen
  - Turbidity
  - Salinity

- Wet Weather Field Observations
    - A narrative description of the station that includes the location, date and duration of the storm event(s) sampled, rainfall estimates of the storm event, and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event; and
    - The flow rates and volumes measured or estimated (data from nearby USGS gauging stations may be utilized, or flow rates may be measured or estimated).
- Dry Weather Field Observations
    - Station identification and location
    - Presence of flow, or pooled or ponded water
    - If flow is present:
        - Flow estimation (i.e. width of water surface, approximate depth of water, approximate flow velocity, flow rate)
        - Flow characteristics (i.e. presence of floatables, surface scum, sheens, odor, color)
    - If pooled or ponded water is present:
        - Characteristics of pooled or ponded water (i.e. presence of floatables, surface scum, sheens, odor, color)
    - Station description (i.e. deposits or stains, vegetation condition, structural condition, and observable biology)
    - Presence and assessment of trash in and around station

Constituents for analysis are available in **Table 2-2**.

Table 2-2. Receiving Water Constituents for Analysis

Analyte Group	Constituents
Conventionals, Nutrients	Chlorophyll-a[1,2], Total Dissolved Solids, Total Suspended Solids, Total Hardness, Total Organic Carbon, Dissolved Organic Carbon, Sulfate, Methylene Blue Active Substances (MBAS), Total Phosphorus, Orthophosphate, Total Phosphate (calc.), Nitrite[3], Nitrate[3], Total Nitrogen (calc.), Total Kjeldhal Nitrogen, Ammonia
Metals (Total and Dissolved)	Aluminum, Arsenic, Cadmium, Chromium, Chromium III[1], Chromium VI[1], Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver[1], Thallium, Zinc
Pesticides	Organophosphate Pesticides, Pyrethroid Pesticides
Indicator Bacteria	Total Coliform, Fecal Coliform, *Enterococcus*, *E. Coli*
Toxicity[4]	*Pimephales promelas* (Fathead Minnow), *Ceriodaphnia dubia* (Daphnid), *Selenastrum capricornutum* (Green Algae), Strongylocentrotus purpuratus (Purple Sea Urchin)

1. Only collected during dry weather monitoring events.
2. Collected as part of Bioassessment monitoring.
3. Nitrate and nitrite may be combined and reported as nitrite + nitrate
4. If sample has salinity less than 1ppt, then test for *Pimephales promelas*, *Ceriodaphnia dubia*, *Selenastrum capricornutum*. If sample has salinity greater than 1ppt, then test for *Strongylocentrotus purpuratus*. To determine the most sensitive test species for freshwater, all three test species will be screened for two wet weather events. After this screening period, toxicity monitoring will only be conducted using the most sensitive test species. Rescreening will occur once each permit term.

Detailed sampling methods are available in **Appendix 5D** for the Upper and Middle SMR subwatersheds. The following describes specific procedures used in the Lower SMR subwatershed for receiving water data collection:

Field measurements will be performed for pH, specific conductance, temperature, DO, and turbidity using a YSI data sonde or similar device. Calibration of the instruments will be conducted prior to each sampling event according to the manufacturer's specifications and calibrated following each sampling event. Calibration records will be kept on file.

Grab samples will be collected from the horizontal and vertical center of the channel if possible and kept clear from uncharacteristic floating debris. Because oil and grease and other petroleum hydrocarbons tend to float, oil and grease grab samples will be collected at the air–water interface. Microbiology samples will be collected using sterile techniques. Nitrile or latex type gloves will be worn during sample handling. During the sample event, a 100-milliliter (mL) sterile bacteria bottle will be used to collect the sample directly from the receiving water or using a bucket. Care will be employed to not allow contact with area structures or the bottom sediments. The container will be opened only for the needed time to collect the sample and will be closed immediately following sample collection. If it is suspected that the container was compromised at any time, the sample container will be discarded, and a new sample will be collected with a new sample bottle. The sample must be filled only to the 100-mL mark on the sample bottle (not over topped or under filled).

A single flow-weighted composite sample will be collected during the dry weather and wet weather monitoring events. During the monitoring event, sample aliquots will be collected in proportion to the rate of flow (i.e., flow-weighted) using automated equipment and Teflon-lined tubing. Dry weather flow-weighted composite samples will be collected over a typical 24-hour period. Wet weather flow-weighted composite samples will be collected by taking sample aliquots across the hydrograph of the storm event. Based on the anticipated size of the storm, a flow-proportioned pacing will be programmed into the automated sampling equipment. The first sample aliquot will be taken at or shortly after the time that stormwater runoff begins, and each subsequent aliquot of equal volume will be collected every time the pre-selected flow volume (flow-proportional pacing) discharges past the monitoring station. Some variation may occur depending on actual storm intensity and duration.

Flow-weighted water samples will be collected in pre-cleaned 20-liter (L) borosilicate graduated glass bottles. Sample bottles will be properly labeled with sample ID, date, and time; sealed with a pre-cleaned rubber stopper; and preserved on ice for transport. Approximately 19 L of sample water will be contained in a "full" bottle. If flow rate sampling adjustments are made during a sampling event, the volume of sample to be used in sample compositing will differ among the various bottles from a given station to ensure the final composite sample is properly flow-weighted. To ensure a representative sample is used, samples should be agitated and mixed prior to pouring out any liquid. A 1000-mL glass graduated cylinder will be used to measure any sample volume that will be composited if it is less than the full amount contained within a 19-L sample bottle. The mixing will be done between transfers of liquid. Samples will be agitated continuously using a pre-cleaned glass stir bar as they are poured into the large pre-cleaned Nalgene containers. After all of the samples from a specific station have been added to the compositing container, subsampling may begin. Subsamples for chemical analyses will be poured into glass containers with Teflon® lids.

2.6 RECEIVING WATER BIOASSESSMENT MONITORING

2.6.1 Receiving Water Bioassessment Monitoring Mobilization Criteria

Receiving water bioassessment monitoring will be conducted once per permit term according to the criteria below:

- Bioassessment monitoring must be preceded by at least 72 hours of dry conditions (<0.1 inch of precipitation).[3]
- Bioassessment monitoring may occur in conjunction with receiving water dry weather monitoring, and may be conducted in coordination with special studies or regional monitoring programs, such as the SMC Regional Monitoring Program, when feasible.
- Bioassessment monitoring will be conducted during the spring/summer dry season bioassessment index period, typically from April through July in Southern California.

2.6.2 Receiving Water Bioassessment Sampling Teams and Bottles

Sampling Teams

Bioassessment teams must be led by a person specifically trained in bioassessment techniques. One team comprised of two or more Copermittee field personnel (and/or consultant field personnel) will monitor each receiving water monitoring station once per permit term. Additional monitoring teams may be coordinated based on participation of the SMC Regional Monitoring Program and/or other regional monitoring programs.

All samples will be delivered to the laboratory by field crews promptly following sample collection. Runners will be used as necessary to ensure samples are delivered to the laboratory within USEPA recommended holding times.

Installation and Maintenance

For recommended chemistry samples, equipment at bioassessment monitoring stations may be installed during the beginning of individual dry weather monitoring events. Maintenance and calibration will be performed prior to monitoring each dry weather event.

Automated equipment is recommended but not required for composite sampling.

Bottles

Bioassessments and algae collection require a specific set of bottles as needed by the contracted laboratory. Qualified staff will be utilized for this specialized effort.

2.6.3 Receiving Water Bioassessment Data Collection

Bioassessment monitoring will occur once per permit term at the receiving water monitoring station. The following types of samples and measurements will be collected:

- Bioassessment

[3] Bioassessment monitoring will not be conducted in the Upper SMR and Middle SMR subwatersheds for the four weeks that follow a scouring rain event that disrupts the benthic communities. Bioassessment monitoring will not be conducted in the Lower SMR subwatershed within a two to three week period after any significant rainfall event that would initiate scouring of bed material.

- CSCI measurements for benthic macroinvertebrates
- Physical habitat characterization[4]
- Algal taxonomic composition and algal biomass
- CSCI measurements for benthic algae

- *In-situ* field measurements (covered under **Section 2.5**)
  - Temperature
  - pH
  - Specific conductivity
  - Salinity
  - Alkalinity (if not analyzed in the laboratory)
  - Dissolved Oxygen
  - Turbidity (if not analyzed in the laboratory)
- Aqueous chemistry data will be collected in the Upper SMR and Middle SMR subwatersheds in coordination with bioassessment monitoring (covered under **Section 2.5**). The full list of constituents for analysis are listed in **Table 2-2.**

Detailed bioassessment sampling procedures are available in SOPs for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat (SWAMP SOP) (Ode, Fetcher, Busse, 2016).

Refer to **Section 5** for required data records and COC information.

2.7 HYDROMODIFICATION MONITORING

2.7.1 Hydromodification Management Plan Monitoring

Hydromodification Management Plan (HMP) Monitoring will be conducted annually at two stations in the Middle SMR Watershed, through spring of 2019 as specified in Appendix K of the 2016 SMR HMP. Refer to **Figure 2-3** below for respective Hydromodification monitoring locations. HMP Monitoring will be conducted in the spring (April –June) and must be preceded by at least 72 hours of dry conditions. Hydromodification monitoring as specified in the 2011 Regional HMP for the County of San Diego did not include any monitoring sites in the SMR WMA.

2.7.2 Dry Weather Receiving Water Hydromodification Monitoring

Dry Weather Receiving Water Hydromodification Monitoring will occur once per permit term at each long-term receiving water monitoring station identified in Section 5.3.1.1 of the WQIP. Refer to **Figure 2-3** below for respective hydromodification monitoring locations. Hydromodification monitoring will occur in conjunction with receiving water dry weather monitoring, and may be conducted in coordination with special studies and regional monitoring programs, such as the SMC

[4] The "Full" suite of physical habitat characterization measurements will be collected in accordance with the SWAMP Stream Habitat Characterization Form – Full Version: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/reports/fieldforms_fullversion052908.pdf

Regional Monitoring Program, when feasible. Dry Weather Receiving Water Hydromodification Monitoring must be preceded by at least 72 hours of dry conditions (<0.1 inch of precipitation).

In general, dry weather hydromodification monitoring conducted at the long-term receiving water stations within the WMA will coincide with a dry weather monitoring event scheduled in the spring, likely in May or June, as well as the dry weather receiving water bioassessment monitoring effort. Additional information regarding mobilization criteria for the Upper SMR and the Middle SMR subwatersheds is available in **Appendix 5D.**

2.7.3 Receiving Water Hydromodification Sampling Teams and Equipment

Sampling Teams

Monitoring teams will be comprised of two Copermittee field personnel (and/or consultant field personnel). Additional monitoring teams may be coordinated based on participation of the SMC Regional Monitoring Program and/or other regional monitoring programs.

Equipment

The following equipment may be utilized for hydromodification monitoring:

- Camera
- Stadia rod
- Gravity-driven protractor
- Measuring tape
- Sight level

2.7.4 Receiving Water Hydromodification Data Collection

The following types of observations and measurements will be collected:

- Channel conditions, including
  - Channel dimensions
  - Hydrologic and geomorphic conditions
  - Presence and condition of vegetation and habitat
- Location of discharge points
- Habitat integrity
- Photo documentation of existing erosion and habitat impacts, with latitude and longitude coordinates of where photos were taken
- Measurement or estimate of dimensions of any existing channel bed or bank eroded areas, including length, width, and depth of any incisions
- Known or suspected cause(s) of existing downstream erosion or habitat impact, including flow, soil, slope, and vegetation conditions, as well as upstream land uses and contributing new and existing development

Refer to **Section 5** for required data records and COC information.

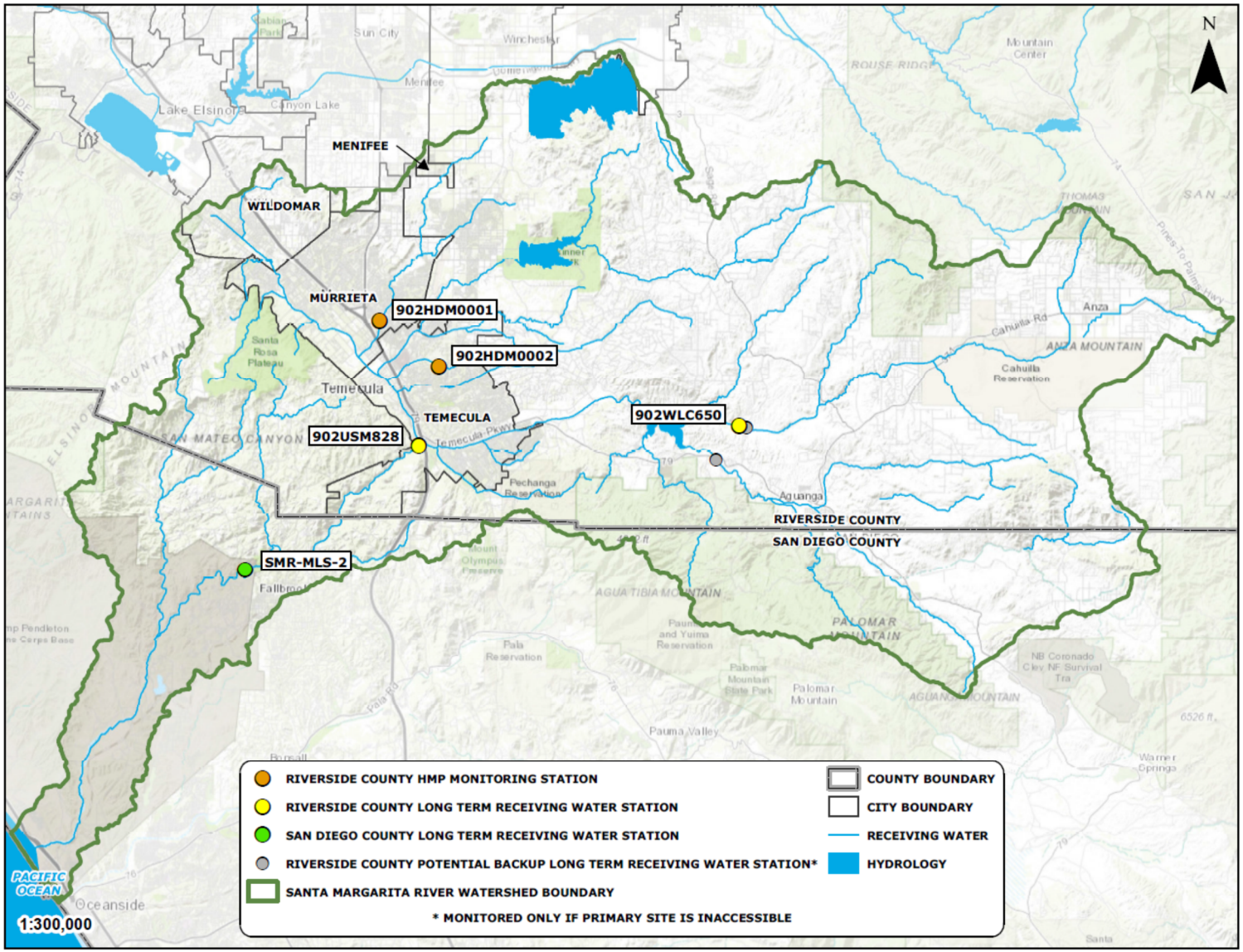

Figure 2-3. Hydromodification Monitoring Locations

2.8 FOLLOW-UP ANALYSIS AND ACTIONS

The results from the Receiving Water Monitoring Program including wet weather, dry weather, bioassessment, and hydromodification monitoring will be assessed after each monitoring event as soon as results are available and have been reviewed for quality. When chronic toxicity is detected in receiving waters, the Copermittees will discuss the need for conducting a TIE/TRE in the assessments detailed in **Chapter 5** of the WQIP. A work plan that outlines the process undertaken in the Lower SMR subwatershed to identify chronic toxicity and prioritize the need to implement TIEs/TREs based on the magnitude and persistence of chronic toxicity is included as **Appendix 5E.** A plan for implementing the TIE/TRE will be developed for the Upper SMR and Middle subwatersheds will be incorporated herein when determined by the Copermittees that one is needed.

2.9 SEDIMENT QUALITY MONITORING

Sediment quality monitoring will be conducted in the Santa Margarita Estuary in compliance with the State Water Resources Control Board's Water Quality Control Plan for Enclosed Bays and Estuaries of California – Part 1 Sediment Quality (Sediment Control Plan). The sediment quality monitoring requirements of the Permit will be fulfilled by participation in the Bight '18 Program and any necessary follow-up monitoring.

The Bight Program, which is overseen by SCCWRP, focuses on water quality, coastal ecology, sediment quality, and shoreline microbiology. Participation in the Bight Program can be used to simultaneously fulfill all or part of the sediment quality monitoring requirements of Provision D.1.e.(2) because sediment monitoring and sediment quality objectives (SQO) analyses are incorporated into the Bight Program to regionally assess the sediment quality of Southern California's enclosed bays, lagoons, and estuaries (herein referred to as waterbodies), including those waterbodies in San Diego County. Copermittees may also decide to conduct the initial sediment quality monitoring of San Diego County's water bodies independently of the Bight Program. Depending upon the outcome of the initial SQO assessments, follow-up monitoring may need to be performed to meet all of the Permit requirements.

The primary objective of the sediment monitoring program is to assess compliance with the sediment quality receiving water limits applicable to MS4 outfall discharges to enclosed bays and estuaries of San Diego County. Sediment toxicity, chemistry, and benthic community condition will be assessed using SQOs. The goals of the SQOs are to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in marine organisms to levels that may be harmful.

Analyses of chemistry, toxicity, and benthic community condition require that samples be collected, preserved, processed, and analyzed using proper field and laboratory equipment, methods, and techniques. Additionally, the selection of representative station locations is necessary to ensure proper characterization of benthic conditions. The Sediment Monitoring Plan and Sediment Monitoring Quality Assurance Project Plan (QAPP) (**Appendix 5F**) describe the collection and analysis of surface sediment samples necessary to provide representative assessments of in situ conditions for the enclosed bays and estuaries of San Diego County.

2.9.1 Sediment Sampling and Handling

Benthic sediments will be collected as surface grabs using an appropriate sampler, such as a 0.1 square meter (m^2) stainless steel Van Veen grab sampler. Sediment grabs will be collected for the following analyses: benthic infauna, chemistry, grain size, and toxicity. The entire contents of one grab sample will be utilized for benthic community analyses with a minimum penetration depth of 7 cm. Sediment samples for chemistry and toxicity testing will be collected from the top 5 cm of a grab sample using a pre-cleaned stainless steel scoop. Station location and grab event data will be recorded on field data sheets and will include the following information: station identification, station location, date, time of sample collection, depth of water, depth of penetration of grab in sediment (e.g. 5 cm), sediment composition, sediment odor and color, and sample type (e.g. sediment chemistry). It is recommended that photographs of each sediment sample be taken and stored.

All sampling equipment will be cleaned prior to sampling. Between sampling stations, the grab sampler will be rinsed with station water. Stainless steel scoops will be rinsed with seawater and rinsed with de-ionized water between stations. All sediment samples will be logged on a chain-of-custody (COC) form. Sediment chemistry and toxicity samples will be placed in a cooler on ice until delivered or shipped to the appropriate laboratories. Prior to shipping, sample containers will be placed in sealable plastic bags and securely packed inside the cooler with ice. The original signed COC forms will remain with the samples during shipment. Sediment samples will be shipped or delivered to the analytical laboratory within appropriate holding times.

2.9.2 Physical and Chemical Analysis

Physical and chemical measurements of sediment were selected to comply with the Sediment Control Plan and to provide data on chemicals of potential concern in bays and estuaries located in San Diego County. In accordance with the Sediment Control Plan, the physical and chemical analyses of sediments will include, at a minimum, the constituents outlined in polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) shown in **Table 2-3**. If sediment quality monitoring is conducted as part of the Bight Program, additional chemical analyses may be included and will be provided in Bight Workplans. Reporting limits (RLs) must be equal to or less than those listed in polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) shown in **Table 2-3**. Concentrations associated with the RLs in polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) shown in **Table 2-3** are expressed in dry-weight. Physical analyses of sediment will include grain size and percent solids. Grain size will be analyzed to determine the general size classes that make up the sediment (e.g., gravel, sand, silt, and clay), whereas percent solids will be measured to convert chemical concentrations from a wet-weight to a dry-weight basis. Chemical analyses of sediment will include total organic carbon (TOC), and the select trace metals, chlorinated pesticides, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) shown in **Table 2-3**.

Table 2-3. Sediment Quality Parameters

Parameter	Reporting Limit
Physical/Conventional Tests	
Grain Size	1.00 %
Percent Solids	0.10 %
Total Organic Carbon (TOC)	0.01 %

Parameter	Reporting Limit
Metals	
Cadmium (Cd)	0.09 mg/kg
Copper (Cu)	52.8 mg/kg
Lead (Pb)	25.0 mg/kg
Mercury (Hg)	0.09 mg/kg
Zinc (Zn)	60.0 mg/kg
Organochlorine Pesticides	
2,4′-DDD	0.50 µg/kg
2,4′-DDE	0.50 µg/kg
2,4′-DDT	0.50 µg/kg
4,4′-DDD	0.50 µg/kg
4,4′-DDE	0.50 µg/kg
4,4′-DDT	0.50 µg/kg
Chlordane-alpha	0.50 µg/kg
Chlordane-gamma	0.54 µg/kg
Dieldrin	2.5 µg/kg
trans-Nonachlor	4.6 µg/kg
PCB Congeners	
2,4'-Dichlorobiphenyl	3.0 µg/kg
2,2',5-Trichlorobiphenyl	3.0 µg/kg
2,4,4'-Trichlorobiphenyl	3.0 µg/kg
2,2',3,5'-Tetrachlorobiphenyl	3.0 µg/kg
2,2',5,5'-Tetrachlorobiphenyl	3.0 µg/kg
2,3',4,4'-Tetrachlorobiphenyl	3.0 µg/kg
2,2',4,5,5'-Pentachlorobiphenyl	3.0 µg/kg
2,3,3',4,4'-Pentachlorobiphenyl	3.0 µg/kg
2,3',4,4',5-Pentachlorobiphenyl	3.0 µg/kg
2,2',3,3',4,4'-Hexachlorobiphenyl	3.0 µg/kg
2,2',3,4,4',5'-Hexachlorobiphenyl	3.0 µg/kg
2,2',4,4',5,5'-Hexachlorobiphenyl	3.0 µg/kg
2,2',3,3',4,4',5-Heptachlorobiphenyl	3.0 µg/kg
2,2',3,4,4',5,5'-Heptachlorobiphenyl	3.0 µg/kg
2,2',3,4',5,5',6-Heptachlorobiphenyl	3.0 µg/kg
2,2',3,3',4,4',5,6-Octachlorobiphenyl	3.0 µg/kg
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	3.0 µg/kg
Decachlorobiphenyl	3.0 µg/kg

Parameter	Reporting Limit
PAHs (low molecular weight)	
Acenaphthene	20.0 µg/kg
Anthracene	20.0 µg/kg
Phenanthrene	20.0 µg/kg
Biphenyl	20.0 µg/kg
Naphthalene	20.0 µg/kg
2,6-Dimethylnaphthalene	20.0 µg/kg
Fluorene	20.0 µg/kg
1-Methylnaphthalene	20.0 µg/kg
2-Methylnaphthalene	20.0 µg/kg
1-Methylphenanthrene	20.0 µg/kg
PAHs (high molecular weight)	
Benzo(a)anthracene	80.0 µg/kg
Benzo(a)pyrene	80.0 µg/kg
Benzo(e)pyrene	80.0 µg/kg
Chrysene	80.0 µg/kg
Dibenzo(a,h)anthracene	80.0 µg/kg
Fluoranthene	80.0 µg/kg
Perylene	80.0 µg/kg
Pyrene	80.0 µg/kg

DDD - Dichlorodiphenyldichloroethane; DDE – dichlorodiphenyldichloroethylene; DDT - dichlorodiphenyltrichloroethane; mg/kg - milligrams per kilogram; µg/kg - micrograms per kilogram

2.9.3 Toxicity Testing

To evaluate the benthic condition of San Diego County's waterbodies, sediment toxicity testing will be conducted in accordance with American Society for Testing and Materials (ASTM) and USEPA methods. Toxicity testing involves a short-term survival test, a sublethal endpoint test, and an assessment of sediment toxicity. For each test type, more than one specific test is acceptable. The appropriate species tested for a sample will depend on the characteristics of the sample such as grain size, salinity, and suspected toxic constituents, if any. When historical data are available for a sample location, it is recommended that the same species be used in order to make comparisons and to conduct trend analysis. In addition, if sediment monitoring is conducted as part of the Bight Program, the species selection will be listed in the Bight Workplans. If significant toxicity is observed in the solid phase or sediment-water interface test, a TIE may be conducted. Further descriptions of the test species used in both the short-term survival test and the sublethal endpoint test are provided in the Sediment Monitoring Plan. The test species used in previous San Diego County bay and lagoon monitoring programs have consisted of the marine amphipod *Eohaustorius estuarius*, the marine bivalve *Mytilus galloprovincialis,* and the marine polychaete *Neanthes arenaceodentata*.

2.9.4 Benthic Infauna Analysis

The benthic infaunal samples will be transported from the field to the laboratory and stored in a formalin solution for a minimum of 48 hours and no longer than 5 days. The samples will then be transferred from formalin to 70% ethanol for laboratory processing. The organisms will initially be sorted using a dissecting microscope into five major phyletic groups: polychaetes, crustaceans, molluscs, echinoderms, and miscellaneous minor phyla. While sorting, technicians will keep a count for quality control purposes, as described in the following paragraph. After initial sorting, samples will be distributed to qualified taxonomists who will identify each organism to species or to the lowest possible taxon. Taxonomists will use the most recent version of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) taxonomic listing for nomenclature and orthography. Since sediment monitoring is conducted as part of the Bight Program, procedures should be in accordance with Bight Workplans.

2.10 RECEIVING WATER MONITORING PROGRAM ANALYSES TYPES

Grab and composite samples collected under the Receiving Water Monitoring Program (wet weather, dry weather, and bioassessment) will be analyzed for the constituents listed in **Sections 2.4** through **2.6**. The volume required, methods, target Reporting Limits (RLs), units, and holding times for all constituents to be monitored within the receiving water are identified in **Appendix 5D** for the Upper SMR and Middle SMR subwatersheds and **Table 2-4** for the Lower SMR subwatershed. Grab samples may be collected for pH, temperature, specific conductivity, salinity, alkalinity, dissolved oxygen, turbidity, hardness, and indicator bacteria. All other constituents will be collected as composite samples (with the potential exception of toxicity) based on program type described in **Sections 2.4** through **2.6**.

Table 2-4. Sample Volume, Analytical Methods, Project RLs, Units, and Holding Time Requirements for Analysis of Water Samples (Lower SMR Subwatershed)

Constituent	Volume Required	Method	Target Reporting Limit	Units	Max Holding Time
pH	In field	Meter	0.01	pH	N/A
Temperature	In field	Meter	0.1	° Celsius	N/A
Specific Conductance	In field	Meter	1	µS/cm	N/A
Dissolved Oxygen	In field	Meter	0.01	mg/L	N/A
Turbidity	In field	Meter	0.1	NTU	N/A
Chlorophyll-a[1]		SM 10200 H-2b	10 mg/m^2	mg/m^2	Freeze in 4H; Analyze in 28D
Total Dissolved Solids	500 mL	SM 2540C	10	mg/L	7D
Total Suspended Solids	1000 mL	SM 2540D	5.0	mg/L	7D
Total hardness	Calculated from Calcium and Magnesium	SM 2340B	0.662	mg/L	N/A
Total Organic Carbon	250 mL	SM 5310 C	0.30	mg/L	28D
Dissolved Organic Carbon	250 mL	SM 5310C	0.50	mg/L	28D
Sulfate	250 mL	USEPA 300.0	0.50	mg/L	28D
MBAS	500 mL	SM 5540C	0.050	mg/L	48H
Total Phosphorus	250 mL	USEPA 365.1	0.010	mg/L	28D
Orthophosphate	250 mL	USEPA 365.1	0.0020	mg/L	48H
Total Phosphate (calc.)					
Nitrate as N	250 mL	USEPA 353.2	0.10	mg/L	48H
Nitrite as N	250 mL	USEPA 353.2	0.10	mg/L	48H
TKN	250 mL	USEPA 351.2	0.10	mg/L	28D
Ammonia as N	250 mL	USEPA 350.1	0.10	mg/L	28D
Total Nitrogen (calc.)	N/A	N/A	N/A	mg/L	N/A
Organophosphate Pesticides	2 L	USEPA 625M	0.01	µg/L	7/40D[2]
Pyrethroid Pesticides	2 L	GC/MS NCI-SIM	2-10	ng/L	7/40D[2]

Constituent	Volume Required	Method	Target Reporting Limit	Units	Max Holding Time
Aluminum (Al) Total and Dissolved	250 mL	USEPA 200.8	0.0004	mg/L	6M
Arsenic (As) Total and Dissolved	250 mL	USEPA 200.8	0.0004	mg/L	6M
Cadmium (Cd) Total and Dissolved	250 mL	USEPA 200.8	0.0001	mg/L	6M
Chromium (Cr) Total and Dissolved	250 mL	USEPA 200.8	0.0002	mg/L	6M
Chromium III (Cr)	Calculated from Total Chromium and Chromium VI			mg/L	N/A
Chromium VI (Cr)	250 mL	USEPA 218.6	0.0003	mg/L	28D
Copper (Cu) Total and Dissolved	250 mL	USEPA 200.8	0.0005	mg/L	6M
Iron (Fe) Total and Dissolved	250 mL	USEPA 200.7	0.010	mg/L	6M
Lead (Pb) Total and Dissolved	250 mL	USEPA 200.8	0.0002	mg/L	6M
Manganese (Mn) Total and Dissolved	250 mL	USEPA 200.8	0.0002	mg/L	6M
Mercury (Hg) Total and Dissolved	250 mL	USEPA 245.1	0.00005	mg/L	28D
Nickel (Ni) Total and Dissolved	250 mL	USEPA 200.8	0.0008	mg/L	6M
Selenium (Se) Total and Dissolved	250 mL	USEPA 200.8	0.0004	mg/L	6M
Silver (Ag) Total and Dissolved	250 mL	USEPA 200.8	0.0002	mg/L	6M
Thallium (Tl) Total and Dissolved	250 mL	USEPA 200.8	0.0002	mg/L	6M
Zinc (Zn) Total and Dissolved	250 mL	USEPA 200.8	0.005	mg/L	6M
Total coliforms	100 mL	SM 9221	20	MPN/100mL	8H
Fecal coliforms	100 mL	SM 9221	20	MPN/100mL	8H
Enterococcus	100 mL	SM 9230B	20	MPN/100mL	8H
E. coli	100 mL	SM 9221	20	MPN/100mL	8H
Larval Survival and Growth with *Pimephales promelas*	15L	EPA-821-R-02-013	N/A	Pass/Fail	36hr
Survival and Reproduction with *Ceriodaphnia dubia*	4L	EPA-821-R-02-013	N/A	Pass/Fail	36hr

Constituent	Volume Required	Method	Target Reporting Limit	Units	Max Holding Time
Embryo-Larval Development with *Strongylocentrotus purpuratus*	4L	EPA-600-R-95-136	N/A	Pass/Fail	36hr
Growth with *Selenastrum capricornutum*	4L	EPA-821-R-02-013	N/A	Pass/Fail	36hr

1. Collected and analyzed in conjunction with the Bioassessment monitoring.
2. 7 days for sample extraction and 40 days holding for extract to be analyzed.

2.10.1 Chemistry and Toxicity Composite Samples

Chemistry and toxicity composite samples will be time-weighted or flow-weighted composites comprised of a series of sample aliquots. Time-weighted sample aliquots will be collected at predetermined intervals over the duration of the monitoring period. Flow-weighted sample aliquots will be collected according to a sample pacing which will be determined based on the amount of flow anticipated to occur during the monitoring event. Samples may be composited at the laboratory. Further detail regarding standard flow-weighted and time-weighted composite sampling is provided in **Appendix 5D**.

The toxicity tests will be conducted on the cladoceran *Ceriodaphnia dubia*, the freshwater minnow *Pimephales promelas,* and the freshwater plant *Selenastrum capricornutum* if sample salinity is less than (<) 1 part per thousand (ppt). If sample salinity is greater than or equal to (≥) 1 ppt, the purple sea urchin *Strongylocentrotus purpuratus* will be used for toxicity testing. Toxicity data collected under the long-term monitoring requirements of the Permit will be analyzed using the Test of Significant Toxicity (TST) (USEPA, 2010) and given a Pass or Fail assessment. In accordance with Permit Provision D.1.c.4.f, a Toxicity Identification Evaluation (TIE) or Toxicity Reduction Evaluation (TRE) may be required if significant toxicity is repeatedly observed in a sample and the cause has not been previously investigated.

2.10.2 Grab Samples

Grab samples may be collected for the constituents previously identified in **Section 2.4** through **2.6**. If flows are too shallow to submerge the sample container directly, a secondary, pre-cleaned, sample vessel may be used to transfer sample water into the sample containers. Receiving water grab samples will be collected using protocols outlined in **Appendix 5D**. Grab samples should be collected and delivered to the laboratory in accordance with **Sections 2.4** through **2.6**.

Grab samples will not be collected if flow and/or depth are found to be insufficient. Depth at sample point must be sufficient to collect sample via submerging the collection container/scoop without disturbing substrate along bottom of stream or channel bed. Flow at sample point must be sufficient to observe surface velocity (unless ponded samples are required).

2.10.3 *In-situ* Field Measurements

In-situ water quality field measurements will be collected at each receiving water station once during each monitoring event. *In-situ* field measurements will be collected concurrently with grab sample collection.

Standard procedures for collecting *in-situ* water quality parameters are described in **Appendix 5D**. If meter failure occurs, the field team will attempt to use a back-up meter or another team's meter. As a last resort, the laboratory will be instructed to analyze for any missing parameters according to the methods provided in **Appendix 5D**.

2.10.4 Flow and Precipitation Monitoring

During wet weather monitoring, flow and precipitation data will be recorded throughout the monitoring event, when possible. Flow and precipitation monitoring will commence during the pre-event preparation and will terminate upon completion of sampling.

Additional flow measurement information for the Upper SMR and Middle SMR subwatersheds is presented below:

Flow meters will be programmed to record stage (to be converted to flow values based on channel dimensions). Where automated equipment is not used, flow will be estimated by collecting the following measurements:

- Width of the water surface,
- Approximate depth of the water, and
- Approximate flow velocity.

Alternatively, visual estimates may be made per the procedures detailed in **Appendix 5D**. Ponded water will be indicated by 0.0 cubic feet per second (cfs). No flow or no discharge will be indicated by "DRY" and 0.0 cfs.

Additional flow measurement information for the Lower SMR subwatershed is presented below:

Flow rates will be monitored using American Sigma (or comparable) flowmeters with an area-velocity sensor, ultrasonic sensor, bubbler, or submerged pressure transducer as the primary measuring device. The primary sensor will continuously measure stage and relay that information to the flowmeter. The flowmeter will continually calculate flow rates by inserting the stage information into the preprogrammed discharge equation. Using this system, the flowmeter will be able to actuate the sampler to achieve a flow-weighted composite sample. Sampling and flow equipment will be monitored remotely, and data will be transferred to a permanent data system by cellular modem or manual download.

The mass loading station (MLS) equipment installed and used for monitoring during dry weather will remain in place during the course of the monitoring year (except where stations are located specifically for dry weather only sampling). The MLS monitoring period is approximately September 1 through June 30. Continual flow data will be downloaded remotely from the station once every two weeks to verify equipment functionality, reduce data gaps, ensure accuracy, and identify maintenance and calibration needs. Flow data will be entered into the data management system. Equipment will be maintained throughout the year to ensure it is in proper working order.

Stream Ratings

The flow rate at the monitoring station will be determined by stream stage sensors that are typically secured to the bottom of the channel. To quantify flow rates based on stream stage, a relationship between flow and stage will be derived using the standardized stream rating protocols developed by the U.S. Geological Survey (USGS) (Rantz, 1982; Oberg et al., 2005). Instantaneous flow

measurements will be taken at various stages. The measurements will be combined to produce and calibrate the rating curve for the station.

To accurately measure flow in streams, the following three critical elements are needed to develop the rating curves:

- An accurate survey of the stream channel cross section and longitudinal slope.
- Accurate level measurements based on a fixed point.
- Measurements of velocity and flows at several points throughout the rating curve, including low flow, mid flow, and peak flow conditions.

To measure instantaneous flows during low flow and base flow conditions, two velocity measurement instruments are typically used—a Marsh-McBirney Model 2000 Portable Flowmeter connected by a cable to an electromagnetic open channel velocity sensor and the SonTek (YSI) FlowTracker Acoustic Doppler Velocimeter. The FlowTracker is a high-precision, shallow-water flowmeter that measures velocity in three dimensions and features an automatic discharge computation.

To make an instantaneous flow measurement, a tape measure is stretched across the stream, perpendicular to flow and secured on both banks of the stream. The tape is positioned so that it is suspended approximately 1 foot (ft) above the surface of the water. The distance on the tape directly above the waterline (i.e., where the water meets the bank) is recorded as the initial point. The first measurement is made at the first point where there is adequate water depth (i.e., at least 0.2 ft) and measurable velocity. At this point, three measurements are made, including water depth, velocity, and distance from the bank (the initial point). Subsequent depth, velocity, and distance measurements are made incrementally across the entire width of the channel. Data from the field measurements are entered into a computer model that calculates the stream's cross-sectional profile from the depth and distance from bank measurements. Total flow across the channel is determined by integrating the velocity measurements over the cross-sectional surface area of the stream channel. The result is an instantaneous flow measurement in cubic feet per second.

A StreamPro Acoustic Doppler Current Profiler (ADCP) is used to measure mid- and high-stage flow conditions. The StreamPro ADCP is the USGS instrument of choice for measuring flows nationwide (Oberg et al., 2005). The instrument is pulled across the stream either by walking across a bridge or attaching the unit to a tagline. Data are collected in real time and transmitted by a wireless data link to a PC. Data can be viewed in real time and are typically post-processed following the field event in the office.

Rating curves are extended to high stream stages not measured using site-specific survey information and the Chézy–Manning formula (Linsley et al., 1982). The Chézy–Manning formula is an empirical formula for open channel flow, or flow driven by gravity, as follows:

$$Q = (1.486/n)AR^{2/3}S^{1/2}$$

where:

Q	=	flow
n	=	Manning Roughness coefficient
A	=	cross-sectional area

R = hydraulic radius

S = hydraulic slope

The hydraulic radius is derived as follows:

$R = A/P$

where:

A = cross-sectional area of flow (ft^2)

P = wetted perimeter (ft)

The Chézy–Manning formula was developed for conditions of uniform flow in which the water surface profile and energy gradient are parallel to the streambed and the area, hydraulic radius, and depth remain constant throughout the reach. Field surveys of the channel geometry of each MLS will be conducted to compute the channel characteristics for each station.

Channel Surveys

Channel surveys will be conducted at the MLS station to gather basic hydraulic measurements of the receiving water channels and to derive stream discharge using the Chézy–Manning formula. Channel surveys will be conducted using a DeWalt self-leveling rotary laser. The cross-section survey involves placing endpoints at the highest point of the channel on each bank. A measuring tape is stretched between the endpoints such that the zero end of the tape is attached to the endpoint on the left bank of the channel (looking downstream). Channel depth is measured across the channel from a stadia rod that is vertical and level from the channel bottom. The channel thalweg surveys are conducted for the reach upstream and downstream of the cross-section. The average channel slope is calculated from the survey data.

Channel survey data are used with the Chézy–Manning formula to produce a rating curve for each sampling station. Each rating curve is calibrated using instantaneous flow measurements by adjusting the formula roughness coefficient.

United States Geological Survey Watersheds

SMR-MLS-2 is located downstream of two USGS flow monitoring stations on the Santa Margarita River. The flow data from SMR-MLS-2 will be compared to the data obtained at the USGS gauging stations. These USGS gauging stations are used to estimate the annual flow volumes for the watershed. Data from the USGS gauging stations will also be used to validate flow monitoring data collected at the MLS since both use standard flow rating techniques for the watershed.

2.10.5 Bioassessment

Dry weather receiving water bioassessment monitoring will be conducted in accordance with Provisions D.1.c.(5) and D.1.e.(1)(a) of the Permit. Dry weather receiving water bioassessment monitoring will include bioassessment at the receiving water monitoring stations and participation in the SMC Regional Monitoring Program. In-stream bioassessment analyses are used to assess the cumulative impacts of discharges to aquatic species including benthic invertebrates, algae, fish, and plants. They are designed to directly measure the biological and physical condition of a watershed. Additionally, bioassessments indirectly measure the impacts of cumulative, sub-lethal doses of pollutants and may detect impacts that chemical and toxicity monitoring cannot. However, there are some limitations to the current procedures. Per the USEPA's Rapid Bioassessment

Protocol guidance, an accurate assessment of stream biological data is difficult because natural variability cannot be controlled.

The following paragraphs describe the details of how bioassessment monitoring will be conducted in the Upper SMR and Middle SMR subwatersheds.

Bioassessments involve assessment of the physical in-stream and riparian habitat, benthic macroinvertebrates, and algae. Bioassessments will be conducted according to the most current SWAMP SOP, which includes assessment techniques for benthic macroinvertebrates, algae, and physical habitat. CSCI scores will be calculated from benthic macroinvertebrate and algae data. The SWAMP SOP for bioassessment and algal assessment is provided in **Appendix 5D**. Bioassessments may be conducted in accordance with the SMC Regional Bioassessment monitoring program. Refer to the Monitoring Annual Reports for updates and status of special studies.

Benthic Macroinvertebrate Sampling and CSCI Metrics

Benthic macroinvertebrates, which include crustaceans such as crayfish, mollusks such as clams and snails, aquatic worms and the larval forms of aquatic insects such as stonefly and mayfly nymphs, are collected from the streams using specialized nets. A monitoring reach is delineated and then 21 transects are spaced equidistant across the reach. Prior to any other disturbance of the stream, field crews begin at the downstream transect and proceed upstream, disturbing a 1-foot square section of substrate at every other transect, resulting in one composite sample. The contents of the net are then placed into sample jars that are labeled and preserved prior to delivery to the laboratory for sample analyses. Detailed protocols may be found in **Appendix 5D**. At the laboratory, the organisms are sorted and identified, and the count of organisms in each taxon is recorded. The counts are used to calculate the CSCI score.

Bioassessment: Physical Habitat Characterization

Physical habitat data collected as part of the current SWAMP Bioassessment protocol consist of a wide variety of measures of both in-stream and associated riparian areas. This is done by first collecting in-stream water quality measurements with field meters. The stream reach is then partitioned into 11 main and 10 inter-transects, each spaced either 7.5 or 12.5 meters apart (depending upon the stream width). At each main transect, three measurements of stream size are collected: wetted width, bankfull width, and bankfull height. Water depth and particle size are recorded at five equidistant point counts along each of the 21 transects at the left bank, 25%, 50%, and 75% of stream width, and at the right bank. The presence of coarse particulate organic matter (CPOM), percent cobble embeddedness, microalgae, macroalgae, and macrophytes are also recorded at each of the five points. A measure of overhead canopy cover is taken from the center of each main transect with a handheld densiometer while facing upstream, downstream, and towards the left and right banks (from the downstream perspective). Riparian vegetation coverage on each bank, human influence, and in-stream habitat complexity are all recorded using a categorical scoring system. In addition to these measurements, flow habitats present are recorded at each inter-transect according to a categorical classification system.

Once physical habitat observations have been collected at each of the main and inter-transects, reach-wide data are collected, including stream sinuosity, stream discharge, and gradient. The final habitat characterization task is to score each station qualitatively for three parameters: epifaunal cover, sediment deposition, and channel alteration.

Bioassessment: Algae Sampling

Algal indicators can be monitored as part of a bioassessment including percent algal cover, algal taxonomic composition, and algal biomass. The percent algal cover can be recorded during the standard physical habitat assessment with sample collection. The SWAMP SOP describes how to collect a composite algae sample that can be used to quantify chlorophyll a, AFDM, diatom assemblage, and/or soft-bodied algal assemblages depending on the purpose of the study. After CSCI samples have been collected, algae samples are collected in the same manner, with field crews working upstream from transect to transect collecting a sample from an undisturbed location. Samples are kept out of the sun to reduce degradation of chlorophyll a, limit cell division post-collection, and protect algae from desiccation. The SWAMP SOP for collecting stream algae samples describes methodology to collect and preserve a quantitative algal sample from various types of substrates and when different forms of algae are present and are described in detail in **Appendix 5D**.

The following paragraphs describe the details of how bioassessment monitoring will be conducted in the Lower SMR subwatershed.

Bioassessment surveys will be conducted during the spring/summer dry season bioassessment index period, typically from April through July in Southern California. Bioassessment monitoring at the LTMS will be conducted once (during one monitoring season) during the five year Permit cycle. SMC bioassessment monitoring will be conducted annually throughout the course of the Permit.

The SWAMP sampling protocol includes the collection of stream benthic macroinvertebrates (BMI) and algae and also assesses the physical quality and condition of the streambed and banks in detail. California Rapid Assessment Method (CRAM) assessments incorporate broader buffer zone and land use attributes than SWAMP, and also provide a numerical quality score for each station. BMI reside in streams for periods ranging from a month to several years, and have varying sensitivities to the multiple stressors associated with urban runoff. Using species specific tolerance values and community species composition, numerical biometric indices are calculated, allowing for comparison of relative habitat health among streams in a region. By assessing the invertebrate and algal community structure of a stream, a cumulative measure of stream habitat health and ecological response is obtained.

A general description of the methods incorporated in the bioassessment sampling program are presented below. If any of the protocols listed below are updated as of 2019, the current version of the referenced documents should be used. Sampling protocols for the collection of BMI, algae, and physical habitat data will follow the SWAMP SOP. Physical habitat quality of the monitoring stations will be assessed using the CRAM for riverine wetlands (Collins et al., 2012). Laboratory sample processing will incorporate the SWAMP laboratory SOP (Woodward et al., 2012). Taxonomic identifications are to be to the standard taxonomic level II (species or genus level for most insects, genus level for Chironomidae, and class or order for most non-insects) as defined by the most recent version of the *Southwestern Association of Freshwater Invertebrate Taxonomists* (SAFIT) *List of Macroinvertebrate Taxa from California and Adjacent States and Ecoregions; and Standard Taxonomic Effort* (Richards and Rogers, 2011). Biological community scoring indices will be calculated for BMI using the California Stream Condition Index (CSCI) (Mazor et al., 2016a), and algae taxonomy data will be analyzed using the Southern California Algal Index of Biotic Integrity (IBI) (SCCWRP, 2014; Fetcher et al., 2014). The current SMC Workplan *Bioassessment Survey of the Stormwater Monitoring Coalition, Workplan for Years 2015 through 2019, Version 1.0* (SMC Workplan) (SCCWRP, 2015) will expire for the 2019-2020

bioassessment monitoring season (spring/summer of 2020). It is anticipated that the SMC will generate/revise the workplan with support from the SMC Executive Committee and Workgroup to cover the 2020 spring/summer monitoring season.

Laboratory analyses includes BMI taxonomy, BMI taxonomic quality control (QC) analysis by the California Department of Fish and Wildlife (CDFW) Aquatic Bioassessment Laboratory, benthic algae taxonomy (soft algae and diatoms), and chemistry analyses. Algae samples will be collected and processed for ash-free dry mass (AFDM) and chlorophyll-a analysis in addition to taxonomy. BMI data analyses include a taxonomic listing of all BMIs identified in the surveys and calculation of associated biological metrics, including the Index of Biological Integrity (IBI) and the California Stream Condition Index (CSCI). The CSCI is a newly developed analytical tool, finalized in 2013 (Mazor et al., 2016), that is applicable statewide in California and is now being utilized in place of the IBI to assess the health of freshwater streams. The CSCI combines a predictive multi-metric index (pMMI) (a measure of ecological structure) with a predictive observed to expected ratio (O/E) index (a measure of taxonomic completeness), and also incorporates local watershed geology and climate factors. The predictive components of the CSCI scoring tool allow for comparisons of the site being scored to a subset of other sites in California that the CSCI determines to be most similar. Algal data analyses includes a taxonomic listing of all taxa identified and calculation of algal metrics and three algal IBIs (Fetscher et al., 2014). These data are typically available in February of the year following the survey (i.e., in February 2021 for the 2019-2020 monitoring year).

Water quality parameters are also analyzed as part of the physical habitat quality assessment at each station. Field parameters are measured using a multi-parameter water quality meter (YSI Model 6920v2, or similar) and include water temperature, specific conductivity, salinity, pH, turbidity, and DO. Stream flow velocity is measured with a portable flowmeter, or visually estimated when the water is too shallow for use of the flowmeter. Parameters are compared to applicable Basin Plan water quality objectives.

2.10.6 Hydromodification Monitoring

2.10.6.1 HMP Monitoring Methods (2016 HMP Stations)

The following information is specific to hydromodification data collection from the Meadowview Stream and Warm Springs Channel stations within the Middle SMR subwatershed in accordance with the 2016 HMP:

In order to complete the HMP Monitoring outline in Section 5.3.1.3 of the WQIP, stream surveys will be conducted using an alternative method employing an Unmanned Aerial Vehicle. With the help of aerial photography captured using UAV technology, photogrammetric techniques can be utilized to extract 3D data in a defined coordinate system. The UAV can achieve 5cm absolute vertical accuracy, and slightly heightened horizontal accuracy. In applying this technology to hydromodification monitoring, heat maps can be created as well as cut/fill exhibits showing temporal change in grade over the entire monitoring site, rather than solely relying on cross-section positions.

2.10.6.2 Dry Weather Receiving Water Hydromodification Monitoring Methods (Upper SMR and Middle SMR Stations)

The following information is specific to hydromodification monitoring data collection from the long-term receiving water station in the Upper SMR subwatershed and the Middle SMR:

Most of the methods which will be utilized during Dry Weather Receiving Water Hydromodification Monitoring at the long-term receiving water stations are borrowed from standardized protocols which are also being applied in the 2015-2019 Stormwater Monitoring Coalition (SMC) Regional Monitoring Program. By using protocols consistent with the SMC Regional Program, the results from the hydromodification monitoring may be compared to other SMC stream condition data.

The primary standard protocol used for hydromodification monitoring will be *Hydromodification Screening Tools: Field Manual for Assessing Channel Susceptibility* (Bledsoe et al., 2010). Key components of this protocol include methods for the measurement of the following:

1. Bank angle
2. Bank height
3. Stream gradient at the assessment reach scale
4. Median substrate particle size (d_{50})
5. Vertical susceptibility
6. Lateral susceptibility

In addition to the field measures, the following landscape GIS metrics will be calculated:

1. Contributing drainage area above the point of interest
2. Mean annual area-weighted precipitation
3. Geomorphic confinement: valley bottom width at site
4. Valley slope (longitudinal gradient) at 500 m scale
5. Upstream land use coverage

To provide a standardized assessment of the presence and condition of vegetation and habitat integrity, relevant attributes of the California Rapid Assessment Method (CRAM) module for riverine wetland (Collins et al., 2013) will be applied. These included the hydrology, physical structure, and biotic structure attributes of the protocol. These attributes evaluate metrics including channel stability, riverine entrenchment ratio, structural patch richness, topographic complexity, and plant community composition and structure. CRAM is a protocol developed and calibrated to be used state-wide and is thereby applicable to the wide variety of ecological and climate regimes present in California. However, as a result of much of Riverside County being in a relatively arid part of the state, those CRAM attributes related to rainfall totals such as riparian vegetation and floodplain characteristics may be naturally biased towards lower scores, independent of anthropogenic impacts, particularly in ephemeral streams.

Channel gradient and habitat characterizations for substrate complexity, sediment deposition and channel alteration will be assessed using the relevant components and methods of the SWAMP SOP. Additional attributes of the sites that will be documented included simple measurements of channel width and depth, dimensions of eroded bank areas, as well as photo-documentation of erosion and habitat impacts.

A stream reach will be delineated using the lesser of either approximately 20 bankfull widths or 200 meters within a stream segment that will be considered hydrogeomorphically homogeneous. Once the stream reach is delineated, the risk potential for mass wasting (erosion) will be quantified.

At three representative transects, bank angle and height will be measured on both left and right banks using a stadia rod and gravity-driven protractor. Photographs will be taken of each transect where bank angle is measured to document conditions for later reference. To estimate the median particle size (d_{50}), the stream substrate will be assessed at 100 points throughout each reach. Observations to assist in determining vertical and lateral susceptibility to bank wasting will then be assessed. Vertical susceptibility will first be evaluated by recording the status of three streambed parameters: composition of the stream substrate, armoring potential (i.e. bed consolidation), and grade control presence and effectiveness. Lateral susceptibility will then be assessed through a decision tree using a combination of vertical susceptibility rating, bank stability threshold, and valley width index to determine the lateral susceptibility on a scale of 1 to 5 (a rating of 5 indicates a stream bank that has a very high susceptibility to wasting).

Alternatively, stream surveys may be conducted using the Unmanned Aerial Vehicle method similar to that used for the HMP Monitoring. With the help of aerial photography captured using UAV technology, photogrammetric techniques can be utilized to extract 3D data in a defined coordinate system. The UAV can achieve 5 cm absolute vertical accuracy, and slightly heightened horizontal accuracy. In applying this technology to hydromodification monitoring, heat maps can be created as well as cut/fill exhibits showing temporal change in grade over the entire monitoring site, rather than solely relying on cross-section positions.

2.10.6.3 Dry Weather Receiving Water Hydromodification Monitoring Methods (Lower SMR Station)

The following are details pertaining to hydromodification data collection in the Lower SMR subwatershed:

Channel surveys will be conducted using a DeWalt self-leveling rotary laser. The cross-section survey involves placing endpoints at the highest point of the channel on each bank. A measuring tape will be stretched between the endpoints such that the zero end of the tape is attached to the endpoint on the left bank of the channel (looking downstream). Channel depth will be measured across the channel from a stadia rod that is vertical and level from the channel bottom. The channel thalweg surveys will be conducted for the reach upstream and downstream of the cross-section. The average channel slope will be calculated from the survey data. Measurements or estimates of dimensions of any bed or bank eroded areas, including length, width, and depth of any incisions, will be also be conducted during the channel survey.

The geomorphic assessment will be conducted to characterize the susceptibility of the channel and gather basic hydraulic measurements of the receiving water channels. The geomorphic assessment is comprised of the channel survey and the SCCWRP channel assessment tool. The SCCWRP Field Manual (Bledsoe et al., 2010) will be used to assess the vertical and lateral susceptibility of the receiving water channels. A suite of field measurements will also be made to characterize the channel bed and banks, and overall stability state. Sediment samples will be collected to characterize bed materials. Fixed-interval pebble counts will be performed for each reach where the channel bed is comprised of gravel or coarser material, and channel beds comprised of fine material will be noted as sand or cohesive materials (bed gradations are not required for channels with $D_{50} < 2$ mm).

Known or suspected cause(s) of existing downstream erosion or habitat impact, including flow, soil, slope, and vegetation conditions, as well as upstream land uses and contributing new and

existing development, will be assessed during a geographic information system (GIS) desktop exercise and the SCCWRP channel assessment tool.

Photographs will be taken using a digital camera with a built-in global positioning system (GPS), altimeter, and compass. Photo documentation will be conducted using the general procedures outlined in San Diego Water Board Stream Photo Documentation Procedures for 401 Water Quality Certifications Standard Operating Procedure (CARCD, 2001).

The following information will be recorded for each photograph: Project name, location, photographer and field team members, photo number, date, and time. At a minimum, photographs of channel surveys will be taken of the following:

- Long view up or down the stream (from stream level) showing changes in the stream bank and vegetation;
- Long view and medium view of streambed changes (e.g., thalweg, gravel, meanders);
- Long views from a bridge or other elevated position;
- Medium and close views of structures and plantings;
- Medium views of bars and banks, with a person (preferably holding a stadia rod) in view for scale; and
- Close views of streambed with a ruler or other common object in the view for scale

3 MS4 OUTFALL MONITORING PROGRAM

3.1 MS4 OUTFALL PROGRAM OVERVIEW

The program has the following components:

- MS4 Outfall Wet Weather Monitoring (**Section 3.2**)
- Dry Weather MS4 Outfall Discharge Field Screening Monitoring (**Section 3.3**)
- NSW Persistent Flow MS4 Outfall Discharge Monitoring (**Section 3.4**)
- MS4 Outfall Monitoring Program Sampling and Analysis Types (**Section 3.5**)
- Assessment and Reporting (as discussed in **Section 5.5** of the WQIP)

Sampling under this monitoring program will begin when the SMR WQIP is accepted by the Regional Water Board and will continue to be implemented through the permit term. The MS4 Outfall Monitoring Program will be implemented in the Middle SMR subwatershed and Lower SMR subwatershed areas only, as there are no major outfalls in the Upper SMR subwatershed area.

3.2 MS4 OUTFALL WET WEATHER MONITORING

This section will cover elements that are specific to wet weather monitoring events at the MS4 outfall monitoring stations. Detailed descriptions of standard procedures regarding equipment, staffing, logistics, sampling, and laboratory QA/QC can be found in **Appendix 5D**. Related elements that are specific to this monitoring program are discussed in the following sections.

3.2.1 MS4 Outfall Wet Weather Monitoring Mobilization Criteria

Wet weather monitoring will be conducted according to the mobilization criteria stated in **Section 2.2**. Additionally, if receiving water wet weather monitoring is conducted during a given monitoring year, then an attempt will be made to conduct MS4 outfall wet weather monitoring sampling concurrently with the receiving water monitoring, where possible, to improve assessments.

If upon a scheduled monitoring event, an MS4 outfall is found to be dry, the sampling event will be documented with monitoring results of zero, and appropriate findings will be documented in the Monitoring Annual Report.

3.2.2 MS4 Outfall Wet Weather Sampling Teams, Equipment, and Bottles

Sampling Teams

Teams will be comprised of two Copermittee and/or consultant field personnel. All samples will be delivered to the laboratory by field crews promptly following sample collection, and compositing, if applicable. Runners will be used as necessary to ensure samples are delivered to the laboratory within USEPA recommended holding times.

Wet Weather Sampling Equipment

Possible suggestions for equipment at any MS4 outfall wet weather monitoring station include the following:

- Data-logging flow meter
- Automated composite sampler with sample tubing
- Tipping bucket rain gauge
- 12-V DC power supply
- Data telemetry unit (as necessary)
- Portable field water quality meter(s)
- Wet weather gear
- Ice
- Field books with field data sheets, site maps, hospital routes, sampling procedures, equipment manuals and chains of custody
- Sample bottles
- A toolbox with tools such as nitrile gloves, headlamps, zip ties, diagonal cutters, adjustable wrenches, and screwdrivers to take samples and make adjustments as needed on equipment during the storm event
- Extra autosampler bottles to make bottle changes as needed
- A cellphone to maintain communication lines with the project manager and field lead.

Where practicable, automated equipment will be installed prior to a forecasted storm event that meets the criteria pursuant to **Section 2.4**. Detailed descriptions of monitoring equipment operation and functions are provided in **Appendix 5D.**

Installation and Maintenance

Wet weather MS4 discharge monitoring equipment may be installed as described in **Appendix 5D** for use during wet weather events. Prior to the start of each wet weather event the electronic equipment and clean tubing will be installed at each station. Upon completion of monitoring, the equipment will be removed from the site and stored at either the Copermittee's or consultant's office. Maintenance and calibration will be performed prior to monitoring each wet weather event per **Appendix 5D**.

Bottles

MS4 outfall wet weather composite samples may be collected directly into a 19-liter bottle or into individual ½-gallon bottles that will be composited at the laboratory. **Appendix 5D** contains additional information regarding sample bottles. **Table 3-1** below provides a summary of bottles required for MS4 outfall wet weather monitoring.

Table 3-1. MS4 Outfall Wet Weather Monitoring Bottle List

Constituent	Middle SMR Subwatershed	Lower SMR Subwatershed	Preservative	USEPA Recommended Holding Time
	Container Type Per Site[1]			
All other constituents (Chemistry)	1 x 19-Liter glass (& 1 spare 19-L glass) or 3 x 1-Gallon glass or As directed by the laboratory		≤6°C	48 hours (minimum)
Bacteriological	2 x 125-mL plastic (each)		$Na_2S_2O_3$	8 hours
Total Hardness (as $CACO_3$)[2]	1 x 1 L amber glass	2 x 1 pint poly	HNO_3	180 days

1. Container Type may vary based on equivalent recommended by ELAP certified laboratory.
2. As per Table C-5 of Provision C.2.a, sampling will include a measure of receiving water hardness.

3.2.3 MS4 Outfall Wet Weather Data Collection

For most constituents, wet weather monitoring will consist of composite samples collected for a duration adequate to be representative of changes in pollutant concentrations and runoff flows using one of the following techniques:

- Time-weighted composite samples composed of discrete samples collected over the length of the storm or the first 24-hour period, whichever is shorter,
- Flow-weighted composite samples collected over the length of the storm or a typical 24-hour period, whichever is shorter, or
- If automated compositing is not feasible, composite samples may be collected using a minimum of four grab samples, collected during the first 24 hours of the storm water discharge, or for the entire storm water discharge if the storm event is less than 24 hours.

Grab samples may be collected for the following constituents during wet weather monitoring: pH, temperature, specific conductivity, dissolved oxygen, turbidity, hardness, and indicator bacteria. If the stormwater runoff is less than 2 hours, the grab sample will be collected as close to the peak of flow as possible. MS4 outfall monitoring will occur during the wet season as required to capture one wet weather event. The following types of samples will be collected at each MS4 outfall:

- Composite Samples
  - Chemistry time-weighted, flow-weighted, or four-grab sample composite samples
- Grab samples
  - Bacteriological grab samples
  - Hardness (if composite sample is not collected)
- *In-situ* field measurements
  - Temperature
  - pH

- Specific conductivity
- Dissolved oxygen
- Turbidity

- Field Observations
  - A narrative description of the station that includes the location, date and duration of the storm event(s) sampled, rainfall estimates of the storm event, and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event.
- Flow Measurements
  - The flow rates and volumes measured or estimated (data from nearby USGS gauging stations may be utilized, or flow rates may be measured or estimated in accordance with the USEPA Storm Water Sampling Guidance Document [EPA-833-B-92-001], Section 3.2.1).

Constituents for analysis and detailed sampling methods for the Middle SMR subwatershed are available in **Table 3-2** and **Appendix 5D**, respectively. Constituents for analysis and detailed sampling methods for the Lower SMR subwatershed are available in **Table 3-3** and **Section 3.5**, respectively.

Table 3-2. MS4 Outfall Wet Weather Monitoring Constituents for Analysis in the Middle SMR Subwatershed[1]

Analyte Group	Constituents
Conventionals	Total Dissolved Solids, Turbidity, Sulfate
Nutrients	Total Phosphorus, Nitrate + Nitrite, Total Nitrogen, Orthophosphate, Total Kjeldahl Nitrogen, Ammonia
Hardness	Total Hardness[2]
Metals (Total and Dissolved)	Aluminum, Cadmium, Copper, Iron, Lead, Manganese, Selenium, Silver, Zinc
Pesticides	Chlorpyrifos, Diazinon
Indicator Bacteria	Total Coliform, Fecal Coliform, *Enterococcus*, *E. Coli*
N/A	Constituents identified to be the cause for impairment for CWA section 303(d) Listings within the WMA related to non-pollutants[3]

1. The constituents to be monitored during MS4 outfall wet weather monitoring will be adapted as the constituents contributing to the highest priority water quality condition (based on the assessment procedures outlined in Chapter 2 of the WQIP), Clean Water Act 303(d) list, and storm water action level constituents change over time. Changes to the constituent list will be described within the Annual Report and implemented the following reporting year.
2. As described in Footnote 2 of **Table 3-1**, sampling will include a measure of receiving water hardness.
3. Certain 303(d) listings within the San Diego Region correspond to non-pollutants (e.g., toxicity, benthic community effects). Upon identification of the constituent which is the cause of the non-pollutant 303(d) listing within the WMA, that constituent will be monitored during MS4 outfall wet weather monitoring.

Table 3-3. MS4 Outfall Wet Weather Monitoring Constituents for Analysis in the Lower SMR Subwatershed

Analyte Group	Constituents
Conventionals	Total Dissolved Solids, Total Suspended Solids, Total Organic Carbon, Dissolved Organic Carbon, Sulfate, MBAS
Nutrients	Total Phosphorus, Nitrate + Nitrite, Total Nitrogen, Orthophosphate, Total Kjeldahl Nitrogen, Ammonia
Hardness	Total Hardness (as $CACO_3$)[1]
Metals (Total and Dissolved)	Aluminum, Cadmium, Copper, Iron, Lead, Manganese, Selenium, Silver, Zinc
Pesticides	Chlorpyrifos, Diazinon
Indicator Bacteria	*E. coli*, Fecal Coliform, *Enterococcus*, Total Coliform
N/A	Constituents identified to be the cause for impairment for CWA section 303(d) Listings within the WMA related to non-pollutants[2]

1. As per Table C-5 of Provision C.2.a., certain SALs for MS4 discharges to receiving waters will be developed on a case-by-case basis based on site-specific water quality data (receiving water hardness). As such, sampling will include a measure of receiving water hardness.
2. Certain 303(d) listings within the San Diego Region correspond to non-pollutants (e.g., toxicity, benthic community effects). Upon identification of the constituent which is the cause of the non-pollutant 303(d) listing within the WMA, that constituent will be monitored during MS4 outfall wet weather monitoring.

Continuous flow monitoring may occur at the MS4 outfall during the period of sample collection. Constituents for analysis and detailed sampling methods are available in **Appendix 5D**. Refer to **Section 5** for required data records and COC information.

The following are specific procedures followed within the Lower SMR subwatershed for wet weather MS4 outfall data collection:

In the Lower Santa Margarita Watershed, the County of San Diego proposes to monitor at the outfall to the brow ditch HST01 (**Table 3-4**). HST01 discharges to Rainbow Creek and is a TMDL monitoring location in dry weather. Wet weather monitoring under the transitional monitoring program began at this station during the 2016-2017 monitoring year in order to develop baseline concentrations prior to potential BMP implementation. The drainage area of this station is primarily rural residential and agriculture. This station also receives flow from MS4-SMG-089, which will be sampled separately if it flows during the monitoring event. The drainage area of this station is smaller as shown in **Table 3-4**. Samples will be composited between the two stations based on the runoff observed from each area to represent the flow-weighted composite at HST01.

Table 3-4 Wet Weather MS4 Monitoring Locations

Station ID	Latitude	Longitude	Location	Outfall Size (in)	Drainage Area (acres)
HST01	33.41526	-117.15204	Brow Ditch to Rainbow Creek @ Huffstatler St.	36	93.2
MS4-SMG-089*	33.41532	-117.15192	Channel across from HST01 @ Huffstatler St.	36	30.3

*Station will be monitored if flow is observed and a composite will be developed that represents the total drainage to HST01.

Automated samples for chemistry will be collected with a Sigma 900MAX autosampler (or similar type device). Teflon-lined tubing will be installed and secured at each monitoring location prior to the wet weather event. The autosampler will be deployed by the field team upon arrival at each site. Samples will be pumped with the autosampler into a clean glass bottle. The sample bottle will be appropriately labeled with the sample identifier, date, and time, and will be preserved on ice for transport to the laboratory. After compositing, samples will be subsampled into the appropriate bottles for analysis. Grab samples will be collected using either the Sigma 900MAX autosampler or a glass bottle connected to a sample pole that will be used to collect the sample directly from the outfall location. Nitrile or latex gloves will be worn during sample handling.

Field parameter measurements will be made using a YSI Inc. 6600 series water quality probe or similar type device. Calibration of the instruments will be conducted prior to each sampling event according to the manufacturer's specifications, and the instruments will be calibrated following each sampling event. Calibration records must be kept on file.

Microbiology samples will be collected using sterile techniques. Nitrile or latex type gloves will be worn during sample handling. During the sampling event, a 100-mL sterile bacteria bottle will be secured to a sample pole that will be used to collect the sample directly from the outfall location. Care will be employed to not allow contact with area structures or the bottom sediments. The container will be opened only for the needed time to collect the sample and will then be closed immediately following sample collection. If it is suspected that the container was compromised at any time, the sample container will be discarded, and a new sample will be collected with a new sample bottle. The sample bottle must be filled only to the 100-mL mark on the bottle (not over topped or under filled).

3.3 DRY WEATHER MS4 OUTFALL DISCHARGE FIELD SCREENING MONITORING

The Permit requires that each Copermittee continue to perform the dry weather MS4 outfall discharge field screening monitoring which has already commenced. Detailed descriptions of standard procedures regarding staffing, logistics, and flow estimation procedures can be found in **Appendix 5D**. Dry weather MS4 outfall discharge field screening monitoring must be preceded by at least 72 hours of dry conditions (<0.1 inch of precipitation). The following visual observations will be collected at each MS4 outfall discharge monitoring station inspected:

- Station identification and location
- Presence of flow, or pooled or ponded water
- If flow is present:
    - Flow estimation (i.e. width of water surface, approximate depth of water, approximate flow velocity, flow rate)
    - Flow characteristics (i.e. presence of floatables, surface scum, sheens, odor, color)
    - Flow source(s) suspected or identified from non-storm water source investigation
    - Flow source(s) eliminated during non-storm water source identification, if applicable
- If pooled or ponded water is present:
    - Characteristics of pooled or ponded water (i.e. presence of floatables, surface scum, sheens, odor, color)

- Known or suspected source(s) of pooled or ponded water

- Station description (i.e. deposits or stains, vegetation condition, structural condition, and observable biology)
- Presence and assessment of trash in and around station
- Evidence or signs of illicit connections or illegal dumping

Based on the visual observations collected during dry weather MS4 outfall discharge field screening monitoring, Copermittees will conduct the following follow-up actions (consistent with the IDDE requirements of the Permit):

- Immediately conduct field investigations for obvious illicit discharges to identify potential sources of NSW discharges,
- Maintain records and a database of the following information:
  - Location of incident, including hydrologic subarea, portion of MS4 receiving the non-storm water or illicit discharge, and point of discharge or potential discharge from MS4 to receiving water
  - Source of information initiating the investigation (e.g., public reports, staff or contractor reports and notifications, field screening, etc.)
  - Date the information used to initiate the investigation was received
  - Date the investigation was initiated
  - Dates of follow-up investigations
  - Identified or suspected source of the illicit discharge or connection, if determined
  - Known or suspected related incidents, if any
  - Result of the investigation, if applicable
  - If a source cannot be identified and the investigation is not continued, document the response and submit a summary of the non-storm water discharges and illicit discharges and connections investigated and eliminated within its jurisdiction with each Water Quality Improvement Plan Annual Report,
- Seek to identify the source(s) of NSW discharges from the MS4 when there is evidence of NSW having been discharged into or from the MS4,
- Update the Copermittee's MS4 outfall station inventory as necessary given the information collected, and
- Evaluate field observations together with existing information available from prior reports, inspections and monitoring results to determine whether any observed flowing, pooled, or ponded waters are likely to be transient or persistent flow.[5]

[5] Persistent flow is defined as the presence of flowing, pooled, or ponded water more than 72 hours after a measureable rainfall event of 0.1 inch or greater during three consecutive monitoring and/or inspection events. All other flowing, pooled, or ponded water is considered transient.

3.4 NON-STORMWATER PERSISTENT FLOW MS4 OUTFALL DISCHARGE MONITORING

This section will cover elements that are specific to NSW persistent flow MS4 outfall discharge monitoring. Detailed descriptions of standard procedures regarding equipment, staffing, logistics, sampling, and laboratory QA/QC can be found in **Appendix 5D**. Related elements that are specific to this monitoring program are discussed in the following sections.

3.4.1 Non-Storm Water Persistent Flow MS4 Outfall Discharge Monitoring Mobilization Criteria

If receiving water dry weather monitoring is conducted during the monitoring year, NSW persistent flow MS4 outfall discharge monitoring will be conducted in coordination with the receiving water monitoring event, where possible, to improve assessments. NSW persistent flow MS4 outfall discharge monitoring must be preceded by at least 72 hours of dry conditions (<0.1 inch of precipitation). Additional information regarding mobilization criteria is available in **Appendix 5D**. If upon a scheduled monitoring event, an MS4 outfall is found to be dry, the sampling event will be documented with monitoring results of zero, and appropriate findings will be documented in the Annual Report. No future attempts to repeat that MS4 outfall sampling will be conducted within the subject monitoring year.

3.4.2 Non-Storm Water Persistent Flow MS4 Outfall Discharge Monitoring Sampling Teams, Equipment, and Bottles

Sampling Teams

Monitoring teams will be comprised of two Copermittee or consultant field personnel. Additional teams may be implemented, as necessary. All samples will be delivered to the laboratory by field crews promptly following sample collection. Runners will be used as necessary to ensure samples are delivered to the laboratory within USEPA recommended holding times.

Dry Weather Sampling Equipment

Possible suggestions for equipment at any NSW persistent flow MS4 outfall discharge monitoring station include the following:

- Handheld velocity meter (if sufficient flow exists)
- Measuring tape and stop watch (if velocity meter is unavailable)
- A bucket with bucket liners and a funnel (if safety concerns prevent *in situ* sample collection)
- Portable water quality field meter(s)
- Pre-cleaned secondary sample collection vessel (optional - used in very low flows)
- Ice
- Field books with field data sheets, site maps, hospital routes, sampling procedures, equipment manuals and chains of custody
- Sample bottles
- Nitrile gloves

- Extra autosampler bottles to make bottle changes as needed
- A cellphone to maintain communication lines with the project manager and field lead.

Detailed descriptions of monitoring equipment operation and functions are provided in **Appendix 5D**.

Installation and Maintenance

Monitoring locations will not require equipment installation as grab samples will be collected. If safety concerns prevent field crews from collecting *in situ* grab samples, a bucket with clean bucket liners may be used to collect grab samples, which will be poured into respective sample containers through a thoroughly field rinsed funnel. Maintenance and calibration will be performed prior to each NSW persistent flow MS4 outfall discharge monitoring event per **Appendix 5D**.

Bottles

All samples will be collected as grab samples. Bottles are identified in **Table 3-5.**

Table 3-5. NSW Persistent Flow MS4 Outfall Discharge Monitoring Bottle List

Constituent	Container Type[1]	Preservative	Holding Time
Bacteriological	2 x 125-mL plastic (each)	$Na_2S_2O_3$, ≤6°C	8 hours
Total and Dissolved Metals Total Hardness (as $CACO_3$)[2]	2 x 1-pint poly	HNO_3, ≤6°C	180 days
OP Pesticides	5 x 1 L amber glass	≤6°C	7 days
TDS, TSS, Nitrite as N, Nitrate as N, MBAS	1 x 1 quart	≤6°C	TDS, TSS – 7 days; Nitrate, MBAS, Nitrite – 2 days
Nitrogen-Kjeldahl, Ammonia, Total Phosphorus, Orthophosphate	2 x 1-pint poly	H_2SO_4, ≤6°C	28 days

1. Container type may vary based on equivalent recommended by ELAP certified laboratory.
2. As per Table C-3 of Provision C.1.a.(2), certain NALs for MS4 discharges to freshwater receiving waters will be developed on a case-by-case basis based on site-specific water quality data (receiving water hardness). As such, total hardness will be collected in the respective receiving water as well as at the outfall.

3.4.3 Non-Storm Water Persistent Flow MS4 Outfall Discharge Monitoring Data Collection

NSW persistent flow MS4 outfall discharge monitoring will occur semi-annually per station, according to the schedule described in **Section 3.4.2**. One sample from the downstream receiving water of the MS4 outfall will be collected and analyzed for hardness. Per instruction received from the Regional Board (phone conversation on 11/04/14):

- If the downstream receiving water station is ponded, one grab sample (for hardness analysis) will be collected and the observation recorded as ponded on the field data sheet.
- If the receiving water station is dry, and the only contributing flows in the receiving water streambed are from the outfall then one grab sample (for hardness analysis) will be collected downstream of the outfall station where flowing water can be sampled before it infiltrates in a pond, and the observation recorded as ponded on the field data sheet.

- If the MS4 outfall's immediate receiving water be dry with no flow connectivity from the MS4 discharge, then one grab sample will be collected from the corresponding receiving water monitoring station (for hardness analysis).

The following types of samples will be collected at each MS4 outfall:

- Grab samples
  - Chemistry grab samples
  - Bacteriological grab samples
  - Hardness
- *In-situ* field measurements
  - Temperature
  - pH
  - Specific conductivity
  - Dissolved oxygen
  - Turbidity
- Field Observations
  - Station identification and location
  - Presence of flow, or pooled or ponded water
  - If flow is present:
    - Flow estimation (i.e. width of water surface, approximate depth of water, approximate flow velocity, flow rate)
    - Flow characteristics (i.e. presence of floatables, surface scum, sheens, odor, color)
    - Flow source(s) suspected or identified from non-storm water source investigation
    - Flow source(s) eliminated during non-storm water source identification
  - If pooled or ponded water is present:
    - Characteristics of pooled or ponded water (i.e. presence of floatables, surface scum, sheens, odor, color)
    - Known or suspected source(s) of pooled or ponded water
  - Station description (i.e. deposits or stains, vegetation condition, structural condition, and observable biology)
  - Presence and assessment of trash in and around station
  - Evidence or signs of illicit connections or illegal dumping

Constituents for analysis are available in **Table 3-6**, respectively. Detailed sampling methods are available in **Appendix 5D** and **Section 3.5** for the Middle and Lower SMR subwatersheds, respectively.

Table 3-6. NSW Persistent Flow MS4 Outfall Discharge Monitoring Constituents for Analysis[1]

Analyte Group	Constituents
Conventionals	Total Dissolved Solids, Total Suspended Solids, Total Hardness[2], Sulfate, MBAS
Nutrients	Total Phosphorus, Orthophosphate, Nitrate + Nitrite, Total Kjeldahl Nitrogen, Ammonia, Total Nitrogen
Metals (Total and Dissolved)	Aluminum, Cadmium, Copper, Chromium (III), Chromium (VI), Iron, Manganese, Lead, Nickel, Selenium, Silver, Zinc
Pesticides	Chlorpyrifos, Diazinon[3]
Indicator Bacteria	Total Coliform, Fecal Coliform, *E. Coli*, *Enterococccus*
N/A	Constituents identified to be the cause for impairment for CWA section 303(d) Listings within the WMA related to non-pollutants[4]

1. The constituents to be monitored during NSW persistent flow MS4 outfall discharge monitoring will be adapted as the highest priority water quality condition, Clean Water Act 303(d) list, and non-storm water action level constituents change over time. Changes to the constituent list will be described within the Annual Report and implemented the following reporting year.
2. As described in Footnote 2 of **Table 3-5**, hardness will be monitored within the receiving water and at the outfall.
3. To be obtained in the Middle SMR subwatershed only.
4. Certain 303(d) listings within the San Diego Region correspond to non-pollutants (e.g., toxicity, benthic community effects). Upon identification of the constituent which is the cause of the non-pollutant 303(d) listing within the WMA, that constituent will be monitored during NSW persistent flow MS4 outfall discharge monitoring.

Refer to **Section 5** for required data records and COC information.

3.5 MS4 OUTFALL MONITORING PROGRAM SAMPLING AND ANALYSES TYPES

Sections 3.2 through **3.4** describe the specific analyses and sample types applicable to MS4 outfall monitoring. **Appendix 5D** includes the units, methods, and RLs for constituent analysis for wet weather and dry weather samples collected under the Middle SMR subwatershed MS4 Outfall Monitoring Program. **Table 2-4** includes the units, methods, and RLs for constituent analysis for wet weather and dry weather samples collected under the Lower SMR subwatershed MS4 Outfall Monitoring Program.

Chemistry Composite Samples

Further detail regarding standard time-weighted composite sampling is provided in **Appendix 5D**. NSW persistent flow MS4 outfall discharge samples will not be composited (subject to change as needed).

Grab Sampling

NSW persistent flow MS4 outfall discharge monitoring grab samples will be collected using protocols and methods outlined in **Appendix 5D**. Sample containers will be determined according to the type of monitoring conducted under **Sections 3.2** through **3.4**.

If the flow cannot be accessed directly, a grab pole may be used with the sample container attached to collect the sample or grab samples may be collected by manually operating the automated equipment to fill the appropriate bottles. If flows are too shallow to submerge the sample container directly, a secondary, pre-cleaned, sample vessel may be used to transfer sample water into the sample containers. If ponded water is observed at a monitoring location, conditions must be recorded on the field data sheet.

***In-situ* Field Measurements**

In-situ water quality field measurements may be collected at each sampling point once during each monitoring event. *In-situ* field measurements will be collected concurrently with grab sample collection.

Standard procedures for collecting *in-situ* water quality parameters are described in **Appendix 5D**. Duplicate field meters will be carried when possible. If meter failure occurs, the field team will attempt to use a back-up meter or another team's meter. As a last resort, the laboratory will be instructed to analyze for any missing parameters according to the methods provided according to **Appendix 5D**.

Flow Monitoring

The following describes flow monitoring conducted within the Middle SMR subwatershed:

Flow monitoring may be performed at the MS4 outfall monitoring stations to record stage, velocity (where applicable), and instantaneous flow, which is calculated by the flow meter. Hydrologic connectivity with the receiving water will also be assessed, where possible. Continuous flow measurements may be collected during composite sampling for the length of the sampling event. Flow measurements may also be collected with the use of a handheld velocity meter and measuring the width and depth of the monitored waters.

At a minimum, instantaneous flow measurements will be collected once during each monitoring event at each of the NSW persistent flow MS4 outfall discharge monitoring stations, and receiving water sampling points. If a flow meter is not available, flow is insufficient to conduct composite sampling, or ponded water is present, flow may be estimated on the field data sheet by measuring:

- Width of the water surface,
- Approximate depth of the water, and
- Approximate flow velocity.

Ponded water will be indicated by 0.0 cfs. No flow or no discharge will be indicated by "DRY" and 0.0 cfs (i.e., will be documented as Visited, Not Sampled).

The following describes flow monitoring conducted within the Lower SMR subwatershed:

Flow will be monitored at HST01 and MS4-SMG-089 to determine the volume of runoff of the storm events. Flow will be estimated with a Sigma 920 Flow Meter (or similar type device) with an area velocity sensor and pressure transducer (**Figure 3-1**). The sensor measures water level and velocity. Flow will be calculated based on the cross-sectional area of the pipe, level of water, slope, and velocity and used to set sample collection during storm events. The sensor will be secured to the bottom of each channel or pipe (site dependent) (**Figure 3-2**).



Figure 3-1. Sigma 910 Flow Meter and Area/Velocity Pressure Sensor



Figure 3-2. Example of Sensor Installation

At each site, the pipe diameter and slope will be measured and recorded. Level and flow measurements will be logged at five-minute intervals for the duration of the monitoring event when using continuous logging devices. Data downloads will occur after the monitoring event is complete. Due to the velocities and potential for debris to be carried by storm flows, it is possible that the flow sensor may be damaged during storm flows. Damage to a flow sensor may result in a data gap of actual recorded flows. In this event, flows from the respective drainage area will be modeled for any data gaps based on the drainage area and impervious cover. If manual sampling techniques are used, periodic level measurements will be made throughout the event at specific intervals (e.g., with every grab sample, or every 15 minutes, 30 minutes, or hourly throughout the event).

4 TMDL MONITORING

4.1 TMDL RECEIVING WATER MONITORING OVERVIEW

The TMDL monitoring program for Rainbow Creek includes the following water quality monitoring: field observations, photo documentation, analytical water sample collection, flow measurements, and physicochemical measurements. Monitoring in the watershed to assess compliance with the nutrient waste load allocations and receiving water quality targets in the TMDL is to be conducted according to the *Sampling and Analysis Plan for Rainbow Creek Nutrient Reduction TMDL Implementation Water Quality Monitoring* (TMDL Monitoring Plan) required initially by the 319(h) grant agreement and more recently by the MS4 Permit. The results of the monitoring will be used to assist in characterizing baseline conditions, evaluating best management practice (BMP) effectiveness to reduce nutrient loading to the creek, and to track changes in water quality and the trajectory to attaining the TMDL goals over time.

4.1.1 TMDL Sampling Teams, Equipment, and Bottles

Monitoring teams will consist of trained and qualified field personnel. TMDL sampling will follow the Sampling and Analysis Plan for Rainbow Creek Nutrient Reduction TMDL Implementation Water Quality Monitoring (County of San Diego, 2010) (TMDL Monitoring Plan) and the QAPP for Nutrient Source Reduction Program in the Rainbow Creek Watershed Water Quality Monitoring (County of San Diego, 2013).

Water quality monitoring will include field observation, photo documentation, analytical water sample collection, flow measurements, and physicochemical measurements. Qualitative field observations will be made during each site visit whether or not ponded or flowing water is present. These observations are intended to provide a general assessment of the site and include variables such as odor, water clarity, presence or absence of floatable matter, visible deposits/ stains, vegetative density, and biological status.

4.1.2 Receiving Water Sampling Locations and Sampling Frequency

Samples will be collected during dry weather at the fourteen sampling locations specified by the TMDL Monitoring Plan and **Chapter 5** of the WQIP at a minimum frequency of once per month at approximately 30-day intervals. Monitoring will not be conducted during any rain event greater than 0.1 inches, and samples are not to be collected following the rain event until the water level at the sampling location returns to within approximately 10% of the pre-rain creek level. Stations HST01 and HST02 monitor MS4 discharges, whereas the remaining twelve stations are located in the receiving water.

4.1.3 Sampling Techniques and Field and Laboratory Water Quality Constituents

When water is present, all sampling locations will be monitored for in-situ parameters (pH, temperature, conductivity, turbidity, and DO). Grab samples will be collected for the constituents as summarized in **Table 4-1**. A hand-held flow meter or the floating leaf technique will be used to measure current velocity.

Table 4-1. Water Quality Analytical Parameters for Rainbow Creek TMDL

Parameter	Sample Type	Analytical Method
Field Monitoring		
pH	Analyzed in Field	YSI 6920 Water Quality Data Sonde- Use per Manufacturer's instructions
Temperature	Analyzed in Field	
Conductivity	Analyzed in Field	
Dissolved Oxygen	Analyzed in Field	
Turbidity	Analyzed in Field	
Laboratory Monitoring		
TDS	Grab	SM 2340 C
Iron	Grab	EPA 200.7
Sulfate	Grab	SM 4500 SO4 E
Nitrate-N	Grab	SM 4500 NO3 E
Nitrite-N	Grab	SM 4500 NO2 B
TKN	Grab	SM 4500 N C
Ammonia-N	Grab	SM 4500 NH3 B, C
Total Nitrogen	Calculated	Calculated
Total Phosphate	Calculated	SM 4500 P B, E
Orthophosphate-P	Grab	SM 4500 P E

Each site will be photographed to provide additional information and documentation of site conditions. Estimated flow rates will be used to calculate pollutant mass loading, and will help to prioritize storm drains for future investigations and to identify significant changes in flow that may be indicative of an illegal release upstream.

Water physicochemical properties will be measured at each site where water is flowing or ponded. The parameters will be measured be measured *in situ* or from a collection cup using a YSI 6920 V2 data sonde. All data will be recorded on the Field Data Sheet.

4.2 DRY WEATHER MS4 OUTFALL MONITORING IN THE RAINBOW CREEK SUBWATERSHED

Progress toward compliance with the Nutrient TMDL in Rainbow Creek may be demonstrated in several ways, as outlined in Attachment E.3 of the Permit. One of these pathways to demonstrate compliance is to show that there is "no direct or indirect discharge from the Responsible Copermittee's MS4 to the receiving water". To this end, dry weather monitoring at MS4 outfalls in the Rainbow Creek watershed will continue to be conducted to determine whether there are direct or indirect dry weather discharges from the County of San Diego's MS4 to Rainbow Creek.

4.2.1 Dry Weather Storm Drain Outfall Monitoring

MS4 outfall monitoring is to be conducted during dry weather (i.e., not within 72 hours of a rain event totaling 0.1 inch or greater). At stations where flow is observed, flow rates will be measured or estimated using either a portable flow meter or the leaf method. Field parameters measured using a YSI water quality probe will include pH, temperature, conductivity, DO and turbidity. Grab samples will be collected and analyzed for ammonia, nitrate as N, nitrite as N, TKN, and orthophosphate as P. Total nitrogen and total phosphate as P will be calculated once laboratory results are received (Michael Baker, 2016). Data collected during the 2017-2018 monitoring year will be combined with all previous data collected at these outfalls.

4.2.2 Monitoring Locations and Sampling Frequency

As summarized in the *Rainbow Creek Nutrient Reduction and Management Plan* (Michael Baker, 2016), MS4 outfalls discharging to Rainbow Creek were identified through desktop analysis and field reconnaissance where field crews identified specific locations of all outfalls and MS4 segments with the potential to discharge to Rainbow Creek during dry weather. The inventory of MS4 outfalls voluntarily monitored under the program is presented in **Table 4-2** and shown in **Figure 4-1**.

Table 4-2. List of Rainbow Creek MS4 Monitoring Locations

Station ID	Latitude	Longitude	Location
MS4-SMG-056	33.41741	-117.15581	Outfall at Old Hwy. 395; 20' south of 2nd St.
MS4-SMG-057	33.42032	-117.15387	Outfall at Old Hwy. 395; 1,160' north of 2nd St.
MS4-SMG-058	33.42533	-117.15020	Outfall at Old Hwy. 395; 3,290' north of 2nd St.
MS4-SMG-061	33.42957	-117.14476	Outfall at Rainbow Valley Blvd.; 1,025' west of Old Hwy. 395.
MS4-SMG-063	33.40928	-117.16562	Outfall at Rainbow Glen Rd.; 535' west of Rainbow Hills Rd. (Under Bridge).
MS4-SMG-086	33.41813	-117.14783	Channel at 2526 Rainbow Valley Blvd.
MS4-SMG-087/ SMG19	33.42356	-117.14336	Channel at 2826 Rainbow Valley Blvd.
MS4-SMG-088	33.41769	-117.15201	Channel at Huffstatler Street and Second Street.
MS4-SMG-089*	33.41532	-117.15192	Channel across from HST01 at Huffstatler Street.
MS4-SMG-091*	33.40338	-117.20411	Outfall at Willow Glen Rd.; 125' north of Red Mountain Heights Dr.
MS4-SMG-092*	33.40931	-117.16584	Outfall in ceiling of west box culvert at Rainbow Glen Rd.; 200' east of Oak Crest Rd.
MS4-SMG-094*	33.41925	-117.15460	Outfall at Old Hwy. 395, 700' north of 2nd Street
MS4-SMG-095*	33.42198	-117.15277	Outfall at Old Hwy. 395, 1,800' north of 2nd Street
MS4-SMG-096*	33.42249	-117.15237	Outfall at Old Hwy. 395, 2,000' north of 2nd Street
MS4-SMG-097*	33.42376	-117.15146	Outfall at Old Hwy. 395, 2,600' north of 2nd Street
MS4-SMG-098*	33.42755	-117.14764	Outfall at Old Hwy. 295; 1,350 south of West Rainbow Valley Blvd.
MS4-SMG-099*	33.42933	-117.14470	Outfall on hillside of Old Highway 395; 50' south of West Rainbow Valley Blvd.
MS4-SMG-100*	33.42957	-117.14459	Outfall on hillside at intersection of Old Hwy. 395 and West Rainbow Valley Blvd.
MS4-SMG-101*	33.42275	-117.14398	Outfall at 2855 Rainbow Valley Blvd. (Rainbow Valley Nursery entrance)
HST01	33.41526	-117.15204	Brow Ditch to Rainbow Creek at Huffstatler Street.
HST02	33.41174	-117.15196	Pipe from nursery along Huffstatler Street.

*New site added in 2016-2017

Source: Rainbow Creek Nutrient Reduction and Management Plan (Michael Baker, 2016) and County of San Diego Department of Public Works (County of San Diego Outfall Monitoring at Rainbow Creek, 2017).

All MS4 monitoring locations listed in **Table 4-2** will be monitored during dry weather (no daily precipitation greater than 0.1 inches within 72 hours prior to the visit). As this is a voluntary monitoring program, the County will conduct, at a minimum, quarterly monitoring. However, if field staff are available, more frequent monitoring will be conducted to demonstrate progress toward meeting the goals of the Rainbow Creek TMDL.

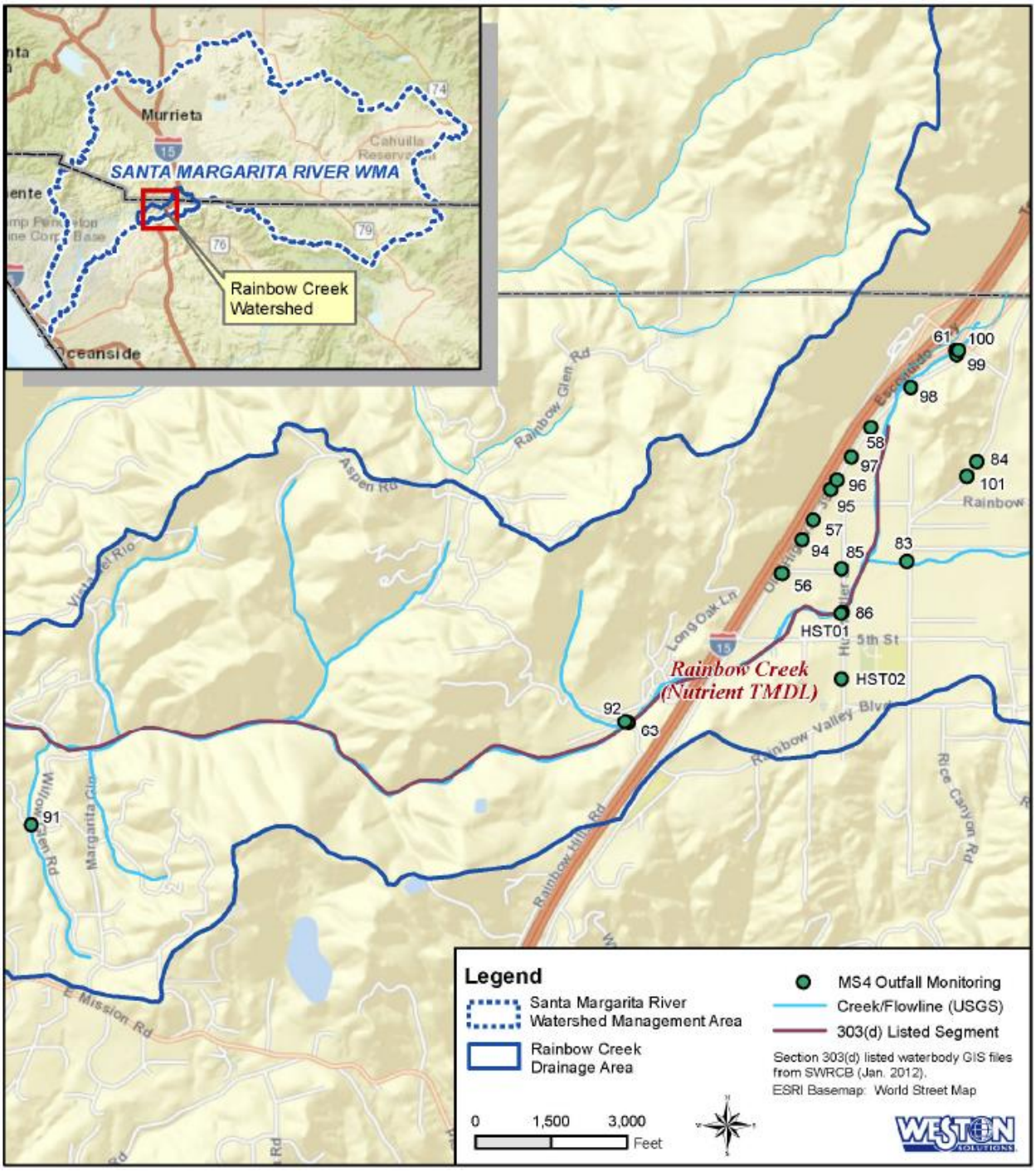

Figure 4-1. Rainbow Creek Dry Weather MS4 Outfall Monitoring Locations

5 DATA RECORDS AND MANAGEMENT

Detailed data records and management requirements for the Upper SMR and Middle SMR subwatersheds are provided in **Appendix 5D**.

The following sections outline the data records and management requirements for the Lower SMR subwatershed.

5.1 EVENT DATA RECORDS AND CHAINS OF CUSTODY (COCS)

Achieving a high-quality data set requires rigorous documentation of field activities and defensible COCs, as well as timely review of laboratory data. This section reviews the data required to be recorded on the field data sheets, sample labels, COCs, and laboratory turnaround time for data reports and Electronic Data Deliverables (EDDs) (i.e., simple text EDDs and SWAMP compatible).

5.1.1 Field Data Sheets

During sampling activities, a record of the monitoring event, including grab sample times, and *in-situ* field measurements, will be kept on a field data. Field data sheets will document site or station ID, station name, sample ID(s), sample date, sample time, site conditions, including flow and/or ponded water, connectivity between MS4 discharges and surface receiving waters, sources of water and relative contribution of sources (including rising groundwater) the presence of trash, and any other applicable issues and information. Field data sheets and COCs will be reviewed immediately following each mobilization, and discrepancies will be resolved.

5.1.2 Chain of Custody Procedures

Samples will be considered to be in custody if they are (1) in the custodian's possession or view, (2) retained in a secured place (under lock) with restricted access, or (3) placed in a container and secured with an official seal such that the sample could not be reached without breaking the seal. The principal documents used to identify samples and to document possession will be COC records, field logbooks, and field tracking forms. COC procedures will be used for samples throughout the collection, transport, and analytical process.

COC procedures will be initiated during sample collection. A COC record will be provided with each sample or group of samples. Each person who will have custody of the samples will sign the form and ensure the samples will not be left unattended unless properly secured. Documentation of sample handling and custody includes the following:

- Sample identifier.
- Sample collection date and time.
- Any special notations on sample characteristics or analysis.
- Initials of the person collecting the sample.
- Date the sample was sent to the analytical laboratory.
- Shipping company and waybill information.

Completed COC forms will be placed in a plastic envelope and kept inside the cooler containing the samples. Once delivered to the analytical laboratory, the COC form will be signed by the person receiving the samples. The condition of the samples will be noted and recorded by the receiver.

COC records will be included in the final reports prepared by the analytical laboratories and are considered an integral part of the report.

5.1.3 Sampling Transport, Shipping, and Storage Procedures

All samples collected in the field will initially be placed on ice and stored in the dark. Prior to shipping or transport, sample containers will be packed inside coolers with ice. COC forms will be filled out, and the original signed COC forms will be inserted in a sealable plastic bag and placed inside the coolers. The cooler lids will be securely taped shut and then samples will be delivered or shipped on ice to the appropriate analytical laboratory for analysis.

5.1.4 QA/QC Field Procedures

Field measurements will be made using a water quality probe, such as a YSI data sonde, that has been calibrated according to manufacturer specifications. Operation of field equipment will be conducted as per manufacturer instructions. Calibrations will be performed and recorded to ensure accurate functionality. Proper storage and maintenance procedures will be followed.

QA/QC for sampling processes begins with proper collection of the samples to minimize the possibility of contamination. Samples will be collected in appropriate containers, kept on wet ice during the sampling event, and placed into coolers along with completed COC for transfer to the analytical laboratory. Field crews will ensure that sampling containers are being filled properly and the requirement to avoid contamination of samples at all times is met. The field data log sheets will include empirical observations of the site and water quality characteristics. Field duplicates will be collected at a minimum of 5% of total project sample count. A minimum of one equipment blank will be collected during monitoring events.

5.1.5 QA/QC Laboratory Analyses

The laboratory analysis of the samples will be performed under the guidelines of the analytical laboratory's respective SOPs and QAPPs as well as meet the quality objectives set forth in this Monitoring and Assessment Plan. This includes analyzing the appropriate QC laboratory controls for each analysis in accordance with SWAMP criteria such as laboratory blanks and duplicates, matrix spike/matrix spike duplicates (MS/MSDs), certified or standard reference materials, and surrogates.

5.2 DATA MANAGEMENT

Each Copermittee or their subcontractor(s) will document and track the aspects of the sample collection process, including generating field logs at each site and COC forms for the samples collected. COC forms will accompany samples to the appropriate laboratory for analysis. Each laboratory will document and track the aspects of receipt and storage, analyses, and reporting related to their respective samples.

A database of information collected during the monitoring will be maintained by each Copermittee or their subcontractor(s). The database will include field observations, data sheets, COC records, and analytical results. The original data sheets, statistical worksheets, and reports produced will be accumulated into project-specific files maintained in file cabinets following submittal of the draft report. Data from outside contractors will be kept exactly as received. Monitoring data and analytical results will be uploaded into California Environmental Data Exchange Network (CEDEN).

Copies of the final report, including laboratory results and field records, will be maintained for a minimum of five years after project completion.

The Copermittee or Contractor Project Manager will document and track the aspects of the sample collection process, including generating field logs at each site and COC forms for the samples collected. COC forms will accompany samples to the appropriate laboratories for analysis. Each analytical laboratory will document and track the aspects of sample receipt and storage, analyses, and reporting. Each analytical laboratory's results will be stored in a database system at their office and will be provided to the Copermittee or Contractor Project Manager both electronically and by hard copy. Further details of each laboratory's data management protocols can be found in each laboratory's respective QAPP.

Field logs and analytical data will be entered into or transferred to the Copermittee or Contractor's database. After the data is added to the database, the Contractor Project QA Officer will validate the data by checking for errors and ensure the data is complete. The database will be updated with finalized data. The results of the laboratory QC analyses will be reported with the final data. Any QC samples that fail to meet specified QC criteria will be identified, and the corresponding data will be appropriately qualified in the final report. All QA/QC records will be kept on file for review by regulatory agency personnel. Once data is finalized, all monitoring data and analytical results will be formatted and uploaded into CEDEN. All records should be maintained for at least five years.

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Appendix 5B – Riverside County

Santa Margarita Region Hydromodification Management Plan

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April 2016

Santa Margarita Region Hydromodification Management Plan

In compliance with Order No. R9-2010-0016, this HMP has been developed by the Riverside County Copermittees

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ACRONYMS, ABBREVIATIONS AND DEFINITIONS

2010 SMR MS4 Permit	The SMR MS4 Permit requires the Copermittees to develop and implement a stormwater management program to reduce the contamination of stormwater runoff and prohibit illicit discharges
ACCWP	Alameda Countywide Clean Water Program
Adequate Sump	
ALERT	Automated Local Evaluation in Real Time: a local flood warning system for a local agency such as a county or a city
Alternative Compliance Option	
Alternative Performance Standard	
BAHM	Bay Area Hydrology Model
Bed Sediment	Term to define the coarse-grained portion of the sediment load
Bed Sediment Load	The Bed Sediment (material that moves along the bed by sliding or saltating) and part of the suspended sediment load including particle size fractions in the channel Bed Sediments.
BMP	Best Management Practice
CALVEG	A California statewide system for describing vegetation types in mapping their general distributions
CCCWP	Contra Costa Clean Water Program
CEM	Channel Evolution Model
Channel Stability Performance Standard	Requires that geomorphic stability within a channel will not be compromised as a result of receiving runoff from a PDP
Comprehensive Regional BMP	Regional runoff management systems that address water quality, hydrologic, and fluvial geomorphologic requirements for PDPs larger than 100 acres.
Copermittees	County, District, and Cities of Murrieta, Temecula and Wildomar
Critical Shear Stress	Threshold above which motion of bed sediment is initiated.
D_{50}	Median grain size diameter
DAMP	Drainage Area Management Plan
DCV	Design Capture Volume
Ep	stream erosion potential
Erosion	The process by which soil and rock are removed from the Earth's surface by exogenic processes such as wind or water flow, and then transported and deposited in other locations
ESA	Environmentally Sensitive Areas
FSURMP	Fairfield-Suisun Urban Runoff Management Program
GIS	Geographical Information System
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
HMP	Hydromodification Management Plan

HMP Criteria	All PDPs must use continuous simulation to ensure that post-project runoff flow rates and durations for the PDP shall not exceed pre-development, naturally occurring, runoff flow rates and durations by more than 10% over more than 10% the length of the flow duration curve, from 10% of the 2-year runoff event up to the 10-year runoff event.
HMP Management Bank	
HMP Performance Standard	The Hydrologic Performance and Sediment Supply Performance Standards
HR	Hydraulic Radius
HRU/GLU Analysis	Hydrologic Response Units/Geomorphic Landscape Units
HSPF	Hydrologic Simulation Program FORTRAN, distributed by USEPA
Hydrologic Control BMPs	A technique, measure or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff
Hydrologic Performance Standard	Consists of matching or reducing the flow duration curve of post-development conditions to that of pre-existing, naturally occurring conditions, for the range of geomorphically significant flows (10% of the 2-year runoff event up to the 10-year runoff event).
Hydromodification	The change in the natural watershed hydrologic processes and runoff characteristics (i.e., interception, infiltration, overland flow, interflow and groundwater flow) caused by urbanization or other land use changes that result in increased stream flows and sediment transport. In addition, alteration of stream and river channels, such as stream channelization, concrete lining, installation of dams and water impoundments, and excessive streambank and shoreline erosion are also considered Hydromodification, due to their disruption of natural watershed hydrologic processes.
IMP	Integrated Management Practices
K	Soil erosion factor
LEED	Leadership in Energy and Environmental Design
LID	Low Impact Development
LSPC	Loading Simulation Program in C++
Management Bank	A Bank consisting of regional HMP management projects where PDPs can buy HMP management credits if it is determined that implementing onsite Hydrologic Control BMPs is infeasible.
MHHW	Mean Higher High Water
MS4	Municipal Separate Storm Sewer System
MSHCP	Western Riverside County Multi-Species Habitat Conservation Plan
MUSLE	Modified Universal Soil Loss Equation. A mathematical model that describes soil erosion processes
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
PDP	Priority Development Project
Project Specific WQMP	Project Specific Water Quality Management Plan
Q or Qw	Flow
Qcrit - Qc	Critical flow
Qcp	Geomorphically critical flow – 10% of the 2-year flow
District	Riverside County Flood Control and Water Conservation District
Receiving Water	Water of the United States

RGO	Retail Gasoline Outlets: A category 2 PDP less than one acre that uses BMPs to reduce or eliminate pollution
RWQCB	Regional Water Quality Control Board
Saltation	
SCCWRP	Southern California Coastal Water Research Project
SCS	Soil Conservation Service
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SDRWQCB	San Diego California Regional Water Quality Control Board
SDHM	San Diego Hydromodification Model
Sediment Supply BMP	Site design principles to preserve onsite first-order or higher order streams that have been identified as significant contributors of bed sediment load.
Sediment Supply Performance Standard	Consists of maintaining the pre-project bed sediment supply to the downstream channel reach.
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
SMR	Santa Margarita Region
SMRHM	Santa Margarita Region Hydrology Model
SOHM	South Orange Hydrology Model
SSMP	Standard Stormwater Mitigation Plan, also known as WQMP (Water Quality Management Plan)
STOPPP	San Mateo County Stormwater Pollution Prevention Program
SUSMP	Standard Urban Stormwater Mitigation Plan
SWM SWMM	Stanford Watershed Model Stormwater Management Model; distributed by USEPA
SWMP	Stormwater Management Plan
SWRCB	State Water Resources Control Board
SWWM	Stormwater Management Model
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
User	The person using this guidance document to prepare analyze a projects and prepare a WQMP
USGS	United States Geological Survey
Wash Load	The portion of the total sediment load carried continuously in suspension by the flow, and generally consists of the finest particles.
WQMP	Water Quality Management Plan
WWHM	Western Washington Continuous Simulation Hydrology Model

Note to the User:

The Santa Margarita Region Hydromodification Management Plan (SMR HMP) uses the term "User" to refer to any public or private entities seeking the discretionary approval of new development or significant redevelop projects (Priority Development Projects [PDP]) by the Copermittee with jurisdiction over the project site. The SMR HMP employs the term "User" to identify the person responsible for submitting the Water Quality Management Plan (WQMP) that meets the performance standards set forth in the SMR HMP.

Simplified HMP Roadmap for User

The Copermittees continue to reduce Hydromodification and flood risk through master planning and evaluating specific development projects to manage stormwater runoff. Additionally, the Santa Margarita Region Hydromodification Management Plan (SMR HMP) was developed by the Copermittees in response to Provision F.1.h of the 2010 SMR Municipal Separate Storm Sewer System (MS4) Permit (Order R9-2010-0016) to manage increases in runoff discharge rates and durations from Priority Development Projects (PDPs). The 2010 SMR MS4 Permit contains requirements specifying the methodology to be employed in the development of the HMP, including the development of hydrologic and sediment supply performance standards that will support maintenance of geomorphic stability in channels receiving runoff from PDPs.

The simplified HMP roadmap guides the User through the steps and the sections of the SMR HMP to be followed to:

1. Identify if the development project is subject to the requirements of the HMP; and
2. When required, guide the User in meeting the HMP requirements.

A User, who must meet Low Impact Development (LID) and Hydromodification requirements simultaneously, may refer to the SMR WQMP.

How to identify if my project is subject to the requirements of this HMP?

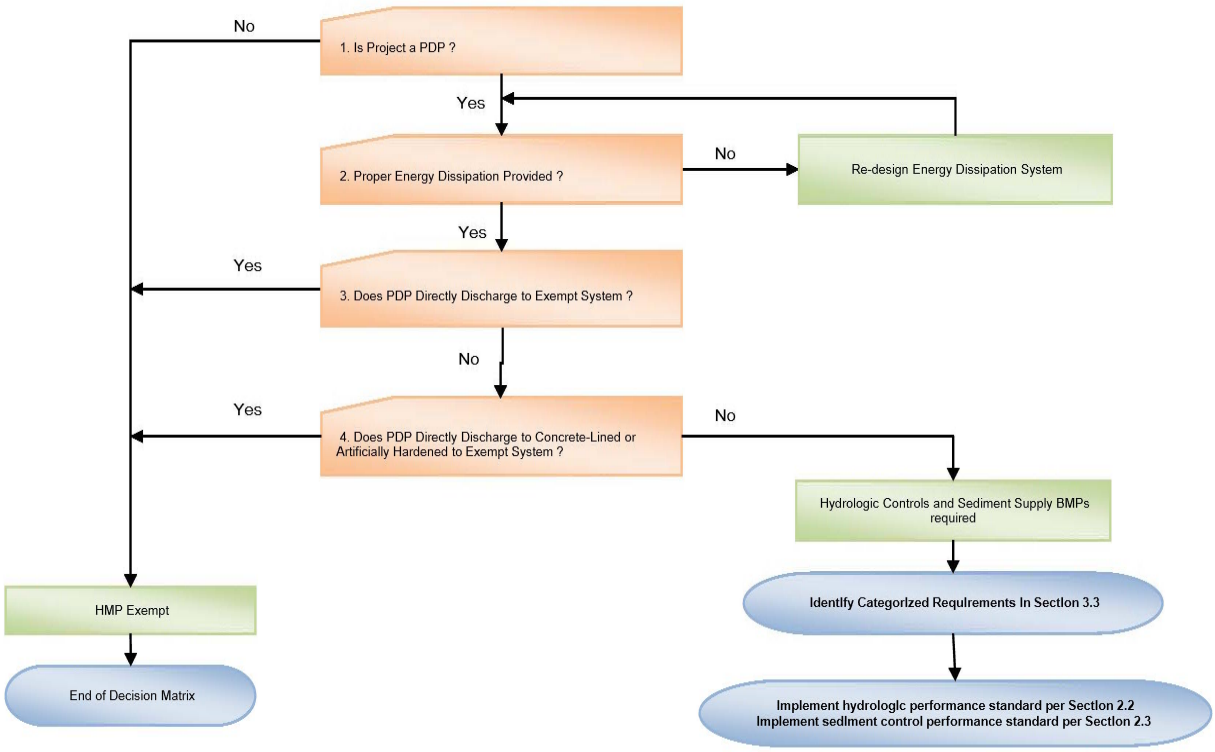
The User may refer to the HMP Decision Matrix presented in **Figure 1** to identify if the PDP is exempt from the requirements of the SMR HMP.

Conditions for exemption of development projects from HMP requirements must be documented by the User and may only be considered by the Copermittee with jurisdiction over the project site if:

- The project is not classified as PDP per Permit Provision F.1.d.;
- The proposed project discharges runoff directly to an exempt channel such as an exempt river reach, or an exempt reservoir. Or, if the proposed project discharges to an concrete-lined or artificially hardened channel, that extends to an exempt river reach or reservoir (See **Section 3.2.i**);
- The project discharges to a large river per the definition provided in Section 3.2.ii;

If the project is not exempt, the User should identify the categorized requirements that apply. For specific categorized requirements, the User may refer to **Section 3.3**. These requirements direct the User to implement, when required, Hydrologic Control BMPs and Sediment Supply BMPs following the approach listed in **Section 2.0**.

Figure 1. HMP Decision Matrix



What are the HMP Performance Standards that PDPs must meet?

Users must demonstrate compliance with the overall HMP Performance Standard, thus demonstrate compliance with the ***Hydrologic Performance Standard*** and the ***Sediment Supply Performance Standard***, respectively.

The Hydrologic Performance Standard consists of matching or reducing the flow duration curve of post-development conditions to that of pre-existing, naturally occurring conditions, for the range of geomorphically significant flows (10% of the 2-year runoff event up to the 10-year runoff event). The Sediment Supply Performance Standard consists of maintaining the pre-project Bed Sediment supply to the channel receiving runoff from the project site.

PDPs are categorized based on their size and type. Specific requirements are associated with each of the two categories. The User should refer to **Section 3.3** to identify the specific categorized requirements.

How to meet the Hydrologic Performance Standard?

This HMP includes a tool to provide continuous simulation of peak flow rates, from 10% of the 2-year runoff event up to the 10-year runoff event for PDPs. The tool is the Santa Margarita Region Hydrology Model (SMRHM), which is a Hydrologic Simulation Program FORTRAN (HSPF)

model based on the South Orange County Hydrology Model. This model allows Users to demonstrate compliance with the HMP Performance Standards through interactive graphic user interface. Details about how to use the model are provided in the 2013 SMRHM Guidance Document (see APPENDIX F).

In some situations, onsite Hydrologic Control BMPs may not be feasible due to identified constraints. In this case the User must investigate the feasibility of alternative options and must implement offsite Hydrologic Control BMPs or in-channel restoration or rehabilitation projects. The User should refer to **Section 2.2** for additional information.

How to meet the Sediment Supply Performance Standard?

The User may follow a three-step process, as identified in **Section 2.3,** to attain maintenance of the pre-project sediment supply to the channel receiving runoff from the project:

1. Determine whether the project site is a significant source of Bed Sediment load to the receiving channel.
2. Avoid significant Bed Sediment supply areas in the site design.
3. Replace significant Bed Sediment supply areas that are eliminated through development of the PDP.

If the three-step process is deemed infeasible, an alternative compliance option allows the User to model the site conditions and the receiving channel and provide additional management in site runoff to compensate for the reduction (or addition) of Bed Sediment Load. Specifics are detailed in **Section 2.3.ii**.

How to initiate compliance with the requirements of this HMP?

The User must integrate Hydrologic Control and Sediment Supply BMPs into the PDP design, and define the design specifics in the preliminary WQMP that should be submitted to the Copermittee with jurisdiction over the project site. The Copermittee with jurisdiction over the project site may approve the proposed design upon identification of compliance with the requirements of this HMP.

The User may refer to the SMR WQMP for complete guidelines on how to develop a WQMP for the PDP.

1.0 Introduction

1.1 SMR HMP Context

The SDRWQCB jurisdiction covers the portion of Riverside County that is located within the Santa Margarita Watershed referred to as the SMR. The Copermittees regulated under the 2010 SMR MS4 Permit are the Cities of Murrieta, Temecula, and Wildomar, as well as the County of Riverside and the Riverside County Flood Control and Water Conservation District (District).

The 2010 SMR MS4 Permit defines Hydromodification as:

> *The change in the natural watershed hydrologic processes and runoff characteristics (i.e., interception, infiltration, overland flow, interflow and groundwater flow) caused by urbanization or other land use changes that result in increased stream flows and sediment transport. In addition, alteration of stream and river channels, such as stream channelization, concrete lining, installation of dams and water impoundments, and excessive streambank and shoreline erosion are also considered Hydromodification, due to their disruption of natural watershed hydrologic processes.*

In addition to urban development activities, anthropogenic activities that may result in Hydromodification may include agriculture, forestry, mining, water withdrawal, climate change, and flow regulation by upstream reservoirs. Hydromodification can result in impacts on receiving channels, such as erosion, sedimentation, and potentially degradation of in-channel habitat. The degree to which a channel will erode or aggrade is a function of the increase or decrease in work (shear stress), the resistance of the channel bed and bank sediments – including vegetation (critical shear stress), the change in sediment delivery, and the geomorphic condition (soil lithology) of the channel.

Not all flows cause significant movement of Bed Sediment—only those which exceed the Critical Shear Stress of the sediments found in the channel bank and bed. Critical Shear Stress is the threshold above which motion of Bed Sediment is initiated. Urban development may increase the discharge rate, amount and timing of runoff, and associated shear stress exerted on the receiving channel by channel flows, may reduce sediment delivered to the channel, and can trigger erosion in the form of incision (channel downcutting), aggradation (deposition of sediment), widening (bank erosion), or both. Flow velocities that generate shear below Critical Shear Stress levels will not result in the channel's degradation and may result in aggradation.

The Copermittees continue to reduce factors that may lead to Hydromodification and reduce flood risk through master planning and evaluating specific development projects to manage stormwater runoff. Additionally, program Provision F.1.h of the Santa Margarita Region (SMR) Municipal Separate Storm Sewer System (MS4) Permit (Order R9-2010-0016) (2010 SMR MS4 Permit) issued by the San Diego California Regional Water Quality Control Board (SDRWQCB) requires that "Each Copermitee shall collaborate with the other Copermittees to develop and implement a Hydromodification Management Plan (HMP) to manage increases in runoff discharge rates and durations from all Priority Development Projects (PDPs)." Where receiving channels are already unstable due to natural or anthropogenic processes, Hydromodification

management may be thought of as a method to avoid accelerating or exacerbating existing Hydromodification. Where receiving channels are in a state of dynamic equilibrium, Hydromodification management may prevent the onset of accelerated erosion, sedimentation, lateral bank migration, aggradation, or impacts to in-channel vegetation.

The 2010 SMR MS4 Permit contains requirements specifying the methodology to be employed in development of the HMP. The 2010 SMR MS4 Permit requires the Copermittees to develop an HMP to address all PDPs (with certain exemptions) and to develop a HMP Performance Standard including a geomorphically-significant flow range that ensures the geomorphic stability within the channel. Supporting analyses must be based on continuous hydrologic simulation modeling. The loss of sediment supply due to the PDP must also be considered.

The SMR HMP addresses the impacts of Hydromodification on the channels receiving stormwater runoff from a PDP. As identified in **Section 1.2**, other anthropogenic stressors to the channels in the SMR are outside of the jurisdictional purview of the Copermittees.

The SMR HMP will serve as the technical documentation for Hydromodification aspects to support the LID BMP Design Handbook and the SMR WQMP. The LID BMP Design Handbook will be updated with Hydrologic Control and Sediment Supply BMPs. For BMP sizing and site planning purposes, Users and plan checkers may refer directly to the LID BMP Design Handbook and the SMR WQMP. The methodology for meeting LID and Hydromodification requirements, or LID requirements alone, will be identified in these documents.

1.2 SMR History and Historic Hydromodification Impacts

The Southern California Coastal Water Research Project (SCCWRP) characterizes the Santa Margarita River as one of the largest rivers in southern California whose course has remained unobstructed by dams and other artificial infrastructure from its confluence of Temecula Creek and Murrieta Creek to the Pacific Ocean (SCCWRP, 2007). The Santa Margarita River begins at the confluence of Temecula Creek and Murrieta Creek, in Southern Riverside County, and flows southwest successively through Temecula Canyon, a large floodplain in Camp Pendleton Marine Corps Base, and ultimately discharges into the Pacific Ocean. The Santa Margarita River Watershed drains a tributary area of 746-square miles and is physiologically split into a mountainous highland and broad, flat topped sea terrace. The boundary between the upper drainage basin and the coastal drainage basin transitions at the border between Riverside County and San Diego County. The construction of Vail Dam and Skinner Reservoir and historical urbanization within the SMR have progressively and significantly altered the hydrology and sediment transport regimes in the downstream channels. The intent of this section is not to quantify these impacts, but rather to describe the existence of these historic modifications.

1.2.i Water Reservoirs

Runoff from approximately 65% of the SMR has been controlled by the construction of Vail Dam and Skinner Reservoir. In 1974, the 44,200 acre-feet Lake Skinner was formed by construction of

a dam on Tucalota Creek. Skinner Lake creates a sump for surface flows and Bed Sediment that has been transported from the upper reaches of Tucalota Creek. Vail Lake is a 49,370 acre-feet reservoir located at the confluence of Temecula Creek, Wilson Creek, and Kolb Creek. The reservoir was built in 1949 by Vail Ranch to develop an irrigation system for expanding their agricultural activities. Since 1978, the reservoir has been operated by the Rancho California Water District to help replenish local groundwater.

Vail Lake and Skinner Lake are operated based on water supply and groundwater recharge considerations, and not for flood control purposes. Virtually all runoff received in these reservoirs is conserved for municipal, industrial, and agricultural use. Nonetheless, the storage capacity of each reservoir induces a management of peak flow rates and durations during storm events. The potential increases in flood flows resulting from urban development in the SMR are offset by the storage effect of the reservoirs (PWA, 2004).

1.2.ii Existing Surface Water and Groundwater Conditions

In 2013 the District conducted field reconnaissance to identify perennial channel segments within the SMR. These investigations identified that 97.3% of the stream segments in the SMR are ephemeral. Sources of dry-weather runoff, if any, were identified as predominantly from urban and agricultural irrigation runoff. The channel segments exhibiting dry weather flow were observed to be short and discontinuous, with the minor flows evaporating and/or infiltrating. There was no continuity of flow from the MS4 to the confluence of Murrieta and Temecula Creeks. Dry weather flows in the Santa Margarita River consist of deliveries of imported water by the Rancho California Water District to Camp Pendleton augmented with minor amounts of rising groundwater that occur in the vicinity of the confluence of Murrieta and Temecula Creeks.

Surface runoff from the SMR does not augment the dry weather flows in the Santa Margarita River. Dry-weather runoff in the SMR evaporates and infiltrates prior to the confluence of Murrieta and Temecula Creeks. The creeks in the urbanized areas of the watershed, located primarily in the valley, are ephemeral and flows are observed only during and immediately after significant storm events. During major storms, after initial wetting, periods of intense rainfall result in rapid increases in channel flow in steep foothill and mountain areas. Runoff in channels in the watershed is derived primarily from rainfall, and as a result, channel flow exhibits monthly and seasonal variations similar to those shown by the precipitation records. There is a rapid decrease in channel flow at the conclusion of the winter precipitation season. Following severe storms, discharge in the larger channels often increases in a few hours from no flow, to a rate of thousands of cubic feet per second. Channel flows vary greatly from month to month and from season to season.

1.2.iii Historical Urbanization in the SMR

The Riverside County Drainage Area Management Plan (2007 DAMP) assumes that 92% of the SMR remained undeveloped as of 2010. Much of the remaining SMR lands will ultimately be incorporated into the Western Riverside County Multi-Species Habitat Conservation Plan

(MSHCP), which requires the ongoing conservation of 500,000 acres within the County. For the average annual event, it is estimated that approximately 89% of the volume of runoff in the SMR is due to non-urban land uses not regulated under the federal stormwater program (2007 DAMP).

1.3 SMR HMP Organization

The HMP is organized in two major sections, supported with technical appendices. The first major section identifies the HMP Performance Standards and identifies the applicable tools and measures to meet these standards. The second major section establishes specific categorized requirements for a User, based on a classification of the PDP and the susceptibility to Hydromodification of the channels receiving stormwater runoff from the PDP. The technical appendices reference the HMP development process and reporting requirements per 2010 SMR MS4 Permit Provision F.1.h.(5), provide a literature review of the state of the Hydromodification science per 2010 SMR MS4 Permit Provisions F.1.h.(1)(g) and F.1.h(1)(k), and incorporate the findings of HMP studies performed to classify channel segments per susceptibility category. The HMP also is required to identify areas with historic Hydromodification of Receiving Waters and that are tributary to documented low or very low Index of Biotic Integrity scores for potential opportunities for channel restoration or rehabilitation per Permit provisions F.1.h(1)(a) and F.1.h(1)(h), respectively.

It should be noted that this HMP has in large part been based on the San Diego HMP, which was developed by the San Diego Copermittees and the South Orange County HMP developed by the Copermittees of South Orange County. The San Diego HMP was approved by the SDRWQCB and served as the starting point for development of the SMR HMP.

2.0 SMR HMP Criteria and Performance Standards

The objective of this section is to identify the specific HMP criteria and Performance Standards for Hydromodification to be implemented. PDPs are required to implement Hydrologic Control BMPs so that post-project runoff flow rates and durations are similar to those found in pre-development conditions, i.e. naturally occurring conditions, flow rates and durations where they would result in an increased or decreased potential for erosion or significant impacts to Beneficial Uses (Permit Section F.1.h.). The purpose of this chapter is to identify the HMP criteria, detail the HMP applicability requirements, and provide a framework for alternative compliance.

2.1 HMP Criteria and Performance Standards

The HMP Criteria is designed to manage changes in runoff discharge rates and durations from PDPs:

> All PDPs must use continuous simulation to ensure that post-project runoff flow rates and durations for the PDP must not exceed pre-development, naturally occurring, runoff flow rates and durations by more than 10% over more than 10% the length of the flow duration curve, from 10% of the 2-year runoff event up to the 10-year runoff event.

Section F.1.h.(1)(d) of the 2010 SMR MS4 Permit identifies that PDPs are required to implement Hydrologic Control and Sediment Supply BMPs to meet the following Performance Standards such that that geomorphic stability within a channel will not be compromised as a result of receiving runoff from a PDP:

1. The Hydrologic Performance Standard, which consists of demonstrating flow duration matching for the range of geomorphically-significant flows. This HMP includes a tool to provide continuous simulation of peak flow rates, from 10% of the 2-year runoff event up to the 10-year runoff event for PDPs. The tool is the SMR Hydrology Model (SMRHM), which is a Hydrologic Simulation Program FORTRAN (HSPF) model based on the South Orange County Hydrology Model. This model allows Users to demonstrate compliance with the Hydrologic Performance Standard defined below through interactive graphic user interface. Details about how to use the model are provided in the 2013 SMRHM Guidance Manual (See APPENDIX G).

2. The Sediment Supply Performance Standard, which consists of the approximate maintenance of pre-project Bed Sediment supply. The general approach that a User must follow to demonstrate compliance with the Sediment Supply Performance Standard is described in **Section 2.3**.

Users managing a PDP must demonstrate compliance with the Hydrologic Performance Standard and the Sediment Supply Performance Standard. Compliance with these standards constitutes compliance with the overall HMP criteria.

As demonstrated in APPENDIX C , the lower flow threshold ($0.1Q_2$) satisfies Section F.1.h.(1)(b) in that it corresponds with the critical channel flow that produces the Critical Shear Stress that initiates channel Bed Sediment movement or that erodes the toe of channel banks of a soft-bottomed channel.

In addition, the Copermittees have selected the lower flow threshold ($0.1Q_2$) based on the results from the Flow Control Threshold Analysis performed for the San Diego HMP. The analysis evaluated the geomorphic stability of a channel under 170 scenarios that are representative of the typical watershed sizes, receiving channel dimensions, channel Bed Sediment, and rainfall conditions in San Diego County. As identified in Appendix C, the SMR is located within the Peninsular Ranges geomorphic zone; hence the results from the San Diego HMP Flow Control Threshold Analysis are applicable to the SMR. A copy of the Flow Control Threshold Analysis is available in APPENDIX J .

Alternatively, the User may put forth other low flow thresholds for individual PDPs, but other low flow thresholds will require site-specific justification, at the User's expense, using modeling or field tests to support the unique threshold value. For those PDPs that chose to perform a site-specific analysis, the selected lower flow threshold must also ensure that it meets the requirements of Section F.1.h.(1)(b) of the 2010 SMR MS4 Permit, i.e. the selected lower flow threshold must correspond to the critical channel flow that produces the critical shear stress that initiates channel Bed Sediment movement or that erodes the toe of channel banks. For a channel segment that is lined but not exempt by this HMP, the low flow threshold must be computed based on a comparable natural channel. The User may consult APPENDIX I to identify a site-specific low-flow threshold, as follows:

- A simplified approach, which consists of a critical flow sensitivity assessment, which provides the User with a general indication that a site-specific low flow threshold may be appropriate, but is not sufficient to quantify the threshold. The approach is consistent with the Flow Control Threshold Analysis, also referenced in APPENDIX J .

- Guidelines for performing a full-scale geomorphic assessment of the stability of the channel receiving runoff from a PDP that may be considered by the Copermittee with jurisdiction over the project site.

The HMP Performance Standard is also applicable to those PDPs that are unable to implement flow duration controls onsite or via a regional or sub-regional BMP that accepts discharges from the project, but is located outside of the project boundaries, but seek compliance through offsite Hydrologic Control BMP projects. The offsite Hydrologic Control BMP project must be capable of matching or reducing the equivalent flow duration curves from the PDP.

This HMP offers an alternate Hydrologic Performance Standard to those PDPs that are unable to implement flow duration matching onsite and offsite, only if the infeasibility is demonstrated and documented to the Copermittee with jurisdiction over the project site. The alternative Hydrologic Performance Standard consists of implementing projects to restore or rehabilitate channels with historic Hydromodification that are tributary to documented low or very low Index of Biotic Integrity scores. The performance equivalency of a restoration or rehabilitation project must be demonstrated to the Copermittee.

PDPs that either fail to meet both the Hydrologic Performance Standard and the Sediment Supply Performance Standard OR that do not qualify for the Alternate Performance Standard are required to redesign the project.

2.2 Meeting the Hydrologic Performance Standard

The User should consider the full suite of Hydrologic Control BMPs to manage runoff from the post-development condition and meet the Hydrologic Performance Standard identified in this section. The intent of the HMP is not to specify the types of Hydrologic Control BMPs that can be used but rather identify the criteria that must be met, allowing flexibility for PDPs to use the full suite of BMPs to meet the Hydrologic Performance Standard. The User may consider the following in identifying the Hydrologic Control BMPs for incorporation in the design of the PDP:

- LID principles as defined in Section 3.2. of the SMR WQMP;
- Structural LID BMPs that may be modified or enlarged, if necessary, beyond the Design Capture Volume (DCV)
- Structural Hydrologic Control BMPs are distinct from the LID BMPs. The LID BMP Design Handbook provides information not only on Hydrologic Control BMP design, but also on BMP design to meet the combined LID and Hydromodification requirements. The handbook specifies the type of BMPs that can be used to meet the Hydrologic Performance Standard.

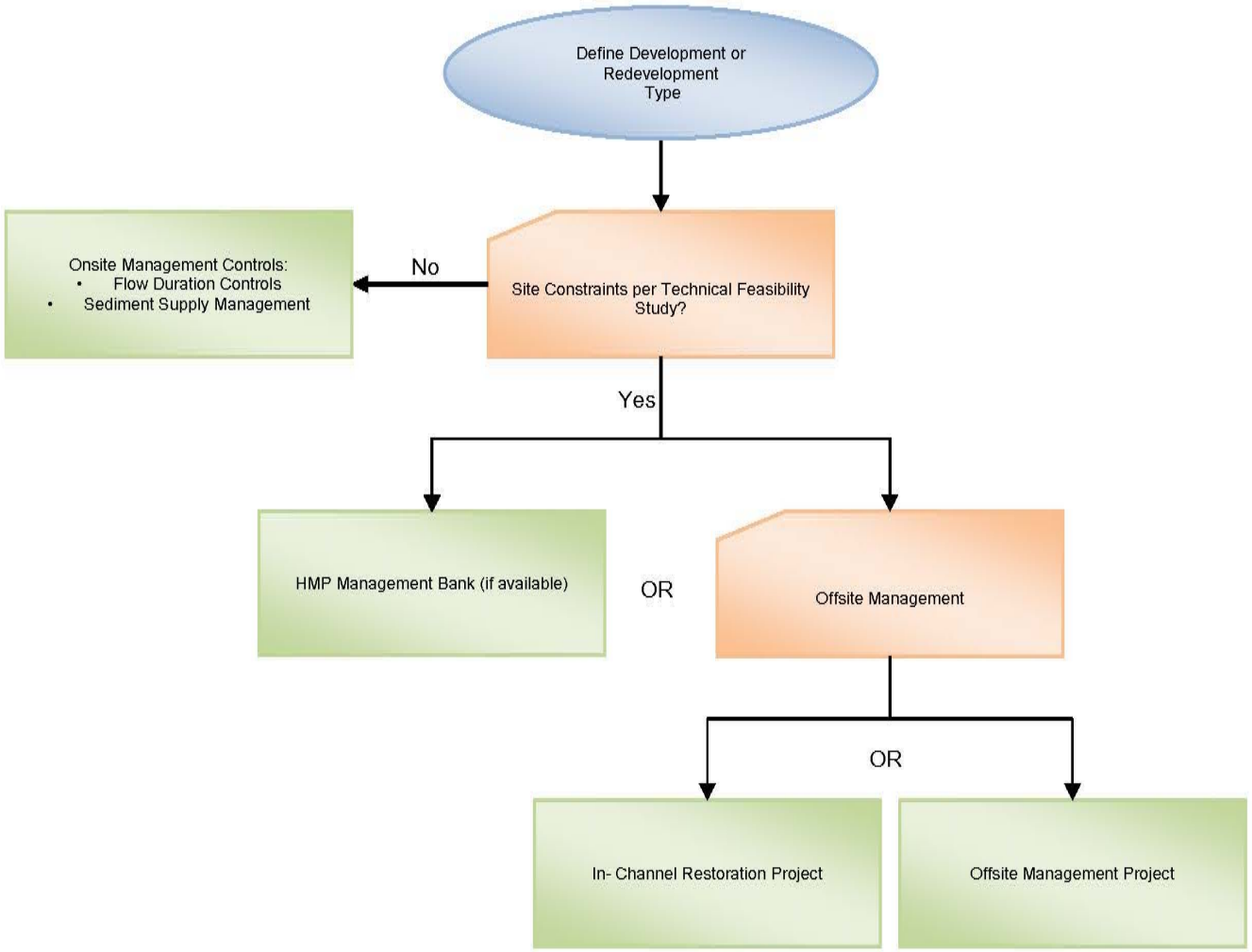
LID principles, structural LID BMPs, and structural Hydrologic Control BMPs can each be modeled in the SMRHM. SMRHM has been developed as the primary tool to assist the User in selecting and sizing Hydrologic Control BMPs. SMRHM can be used by the User not only to meet the Hydrologic Performance Standard, but also to meet the LID requirements. SMRHM incorporates additional BMPs that may be investigated by the User. For example, buffer zones for those PDPs adjacent to channels can be modeled and sized the meet the Hydrologic Performance Standard. The User may refer to the SMRHM User Guidance Manual in APPENDIX G for further details on the BMPs available to meet the Hydrologic Performance Standard.

For some PDPs, implementation of onsite Hydrologic Control BMPs consistent with the HMP may not be feasible due to site constraints. There are two Alternative Compliance Options for PDPs that cannot implement onsite Hydrologic Control BMPs:

- Identify and construct offsite Hydrologic Control BMPs; and
- Pay into an HMP management bank, if an HMP management bank is available to the PDP.

The decision matrix that Users should follow to meet the Hydrologic Performance Standard is summarized in **Figure 2**.

Figure 2. Hydrologic Performance Standard – Decision Matrix



2.2.i Continuous Simulation Modeling

Introduction to the SMR Hydrology Model

Permit Provision F.1.h.(1)(b) identifies that the Hydrologic Performance Standard should be demonstrated based on continuous hydrologic simulation over the entire available rainfall record. As part of the HMP development, an integrated Hydrologic Control BMP sizing tool, SMRHM, has been prepared. The SMRHM has been developed to help Users comply with Hydromodification requirements. This modeling approach is different from the District's calibrated rainfall-runoff procedures and criteria for drainage design, flood control design, and hydrologic management purposes. HMP requirements specified in the 2010 SMR MS4 Permit are separate from the requirements for hydrologic management within the SMR for development effects of runoff per the District's Hydrology Manual. Specific evaluation criteria were developed for the design and analysis of Hydrologic Control BMPs using continuous simulation hydrologic modeling.

Continuous simulation modeling uses an extended time series of recorded precipitation data as input and generates hydrologic output, such as surface runoff, infiltration, and evapotranspiration, for each model time step. Continuous hydrologic models are typically run using either 1-hour or 15-minute time steps. Based on a review of available rainfall records in the SMR, the SMRHM uses 15-minute time series of rainfall data. Continuous models generate model output for each time step. In this case, hydrologic output is generated at each time step (15 minutes) of the continuous model.

Use of the continuous modeling approach allows for the estimation of the frequency and duration by which flows exceed the significant flow range (with a lower flow threshold adopted as 10% of the 2-year flow for this plan, and an upper flow valued adopted as 100% of the 10-year flow for this plan, which is considered the significant flow range). The limitations to increases of the frequency and duration of flows within that geomorphically significant flow range represent the key component to the SMR approach to Hydromodification management.

The SMRHM, along with a SMRHM Guidance Document explaining how to operate the model, is made available to all Users at no cost. The SMRHM is the only software that is approved by the Copermittees. However, the User may opt to develop its own model using publicly-available software, which performs continuous hydrologic simulations over the available period of rainfall record (over 30 years). The use of a different model than the SMRHM is subject to prior approval by the Copermittee with jurisdiction over the project site. The following public domain software models may be used:

- Hydrologic Simulation Program – FORTRAN (HSPF), distributed by the United States Environmental Protection Agency (USEPA)
- Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS), distributed by the USACE Hydrologic Engineering Center
- Stormwater Management Model (SWMM); distributed by USEPA

Peak Flow and Duration Statistics

To assess the effectiveness of Hydrologic Control BMPs to meet the Hydrologic Performance Standard, peak flow frequency statistics are required. Peak flow frequency statistics estimate how often flow rates exceed a given threshold. In this case, the key peak flow frequency values are the lower and upper bounds of the geomorphically significant flow range. Peak flow frequency statistics can be developed using either a partial-duration or peak annual series. Partial-duration series frequency calculations consider multiple storm events in a given year while the peak annual series considers just the peak annual storm event.

Flow duration statistics are also summarized to determine how often a particular flow rate is exceeded. To determine if a Hydrologic Control BMP meets the Hydrologic Performance Standard, peak flow frequency and flow duration curves are generated for the pre-development (naturally occurring) condition and the post-project condition. Both pre-development and post-project simulation runs are extended for the entire length of the rainfall record.

The need for partial-duration statistics is more pronounced for Hydrologic Performance Standards based on more frequent return intervals (such as the 2-year runoff event), since the peak annual series does not perform as well in the estimation of such events due to the bimodal nature of the precipitation in Southern California (few wet years with many events, many dry years with few events). This problem is especially pronounced in the SMRs semi-arid climate. After a review of supporting literature, the use of a partial-duration series is recommended for semi-arid climates similar to the climate in the SMR, where prolonged dry periods can skew peak flow frequency results determined by a peak annual series for more frequent runoff events.

For the statistical analysis of the rainfall record, partial duration series events have been separated into discrete unrelated rainfall events assuming the following criteria.

1. A minimum interval of 24 hours between peaks is applied to capture those peaks generated from back-to-back storms.
2. The Weibull plotting method is used to rank the selected peaks by the partial duration method as this method is the most adequate for statistical analysis of Southern California channels, in which wet-weather and dry-weather years produce two populations of flood events.

Rainfall Data

The SMRHM integrates local rainfall data to design Hydrologic Control BMPs. To provide for clear climatic distinction between the Temecula Valley, the western plateau, the northern valley, and the eastern slopes of the SMR, historical records for a series of three rainfall data stations located within or in close proximity to the SMR were compiled, formatted, modulated, and quality controlled for analysis.

Long-term rainfall records of 15-minute intervals have been prepared and made available by the District for these three rainfall stations. The District operates and maintains several rainfall stations, which feed into the Riverside County Automated Local Evaluation in Real Time

(ALERT) telemetry system rain gauges, the California Climatic Data Archive, National Oceanic and Atmospheric Administration (NOAA), the National Climatic Data Center, and the Western Regional Climate Center. For the selected three stations, the length of the overall rainfall station record is a minimum of 37 years.

Gauge selection was further governed by minimum continuous simulation modeling requirements, including the following:

- The selected precipitation gauge data set should exhibit similar meteorological and rainfall trends, especially in terms of intensity and total precipitation depth, to ensure that long-term rainfall records are similar to the anticipated rainfall patterns for the project site. When available, gauges were selected near areas planned for future development and redevelopment.
- Reporting frequency for the gauge data set should be at least hourly, if not at a 15-minute interval. Most of the rainfall stations operated by the District report precipitation in real-time.
- The gauge rainfall data set should extend for the entire length of the record, with a minimum of 37 years.
- Use of the most applicable long-term rainfall gauge data, along with regional scaling of rainfall patterns from a reference station, is required to account for the diverse rainfall patterns across the SMR.

Four meteorological zones were identified and delineated from the rainfall patterns observed from NOAA Atlas 14 precipitation-frequency maps, isohyetal maps from the District's Hydrology Manual (1978), and the professional knowledge of the District's Hydrologic Data Collection Section. Only three precipitation stations were identified as viable for the purpose of continuous simulation because of the available length of precipitation records. Out of the three stations, only one station (Temecula, ID#217) is located within the SMR; the two other stations, Elsinore (ID#067) and San Jacinto (ID#186), are located in close proximity to the SMR. The four meteorological zones are: the Western Plateau covering the Santa Rosa Plateau area, the Temecula Valley, the Wildomar/North Murrieta area, and the Eastern Slopes covering the eastern part of the SMR. For each meteorological zone, a correction factor, which accounts for the variations in depths and intensity observed on the isohyetal maps, is applied independently to the associated precipitation records. The location of the three selected rain gauge stations and the delineation of the four meteorological zones are shown in **Figure 3**.

Table 1 lists the meteorological zones and the associated rainfall stations. In addition, the period of available record is presented.

Table 1 - SMR Meteorological Zones & Associated Rainfall Stations

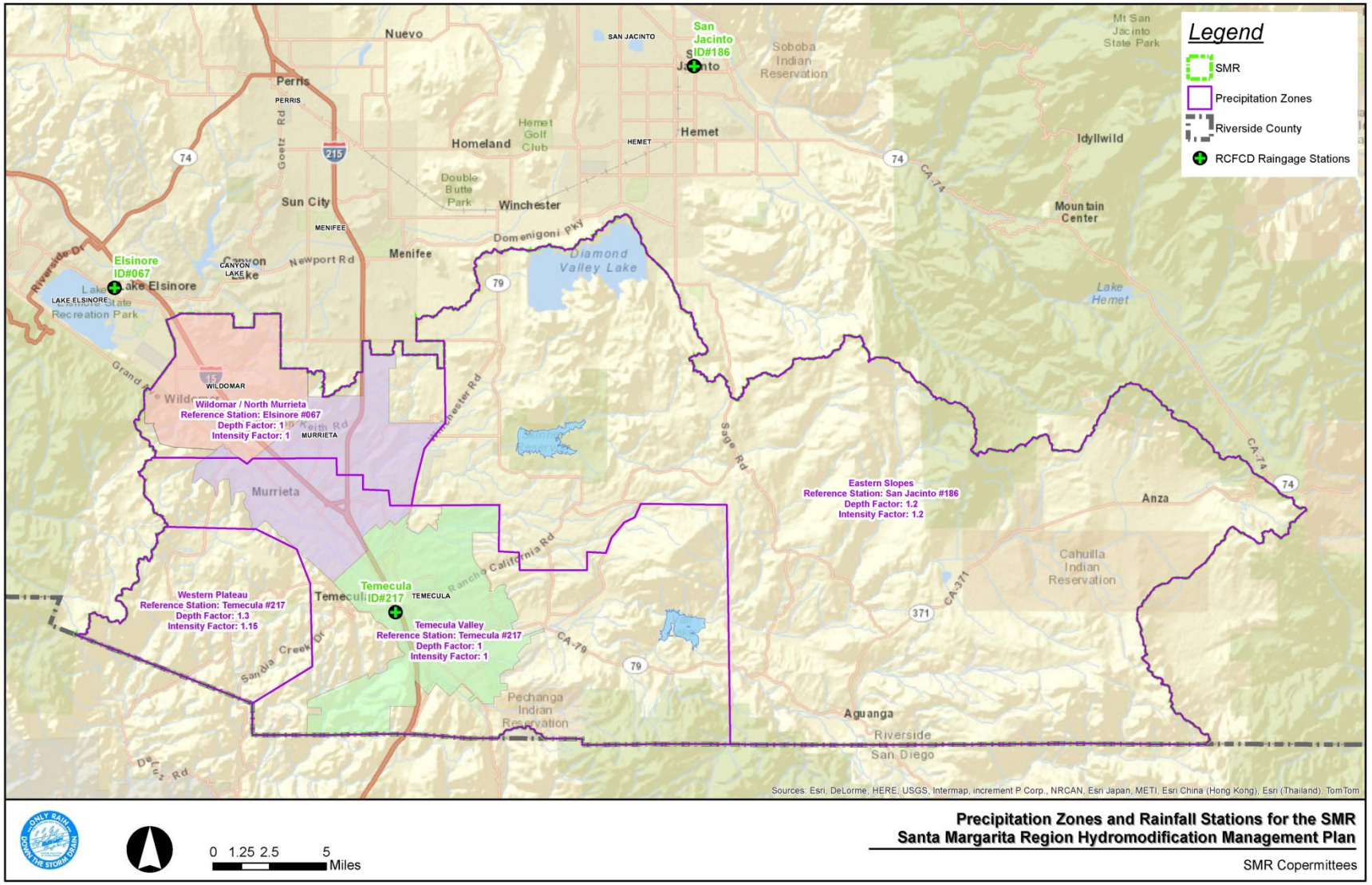
Meteorological Zone	Station	15-minute data span
Western Plateau	Temecula (ID#217)	January 1974 – July 2012
Wildomar/North Murrieta	Elsinore (ID#067)	January 1940 – July 2012
Temecula Valley	Temecula (ID#217)	January 1974 – July 2012
Eastern Slopes	San Jacinto (ID#186)	January 1940 – July 2012

All the presented factors have been considered in the selection of the appropriate rainfall data set before inclusion into the SMRHM. For a given project location, the User should refer to the rainfall station map shown in **Figure** and identify the meteorological zone where the proposed project is located. The meteorological zones are integrated in the SMRHM and the appropriate rain gauge station will be automatically selected by the model upon pinpointing the location on the model's map.

If desirable, the User is allowed to design a project-specific continuous simulation model and must comply with the factors and precipitation zones presented in this section when selecting the associated rain gauge station.

A rainfall station map associated with this HMP is presented in **Figure 3** for public use. Where possible, rainfall data sets located in the same meteorological zone as the project should be selected.

Figure 3 - Precipitation Zones and Rainfall Stations for the Santa Margarita Region



Evapotranspiration Parameters

Hydrologic Performance Standards developed as part of this HMP to control runoff peak flows and durations are based on a continuous simulation of rainfall runoff using locally derived parameters for evaporation and evapotranspiration. Known data sources for potential evapotranspiration data in proximity to the SMR are listed below.

Historical potential evapotranspiration at Elsinore station (CA042805) is considered to best represent the evapotranspiration conditions within the SMR.

Other gauging stations that record potential evapotranspiration were not selected because the period of record did not match with that of the precipitation station, or the local meteorological patterns are not representative of those observed in the SMR. The potential evapotranspiration will be coupled with historical records of temperature to determine the actual daily evapotranspiration. **Table 2** summarizes available sources for potential evapotranspiration in the SMR.

Table 2 - Available Evapotranspiration Sources

Station Name ID	Data Type	Data Source	Recording Frequency	Hourly data span
Elsinore (CA042805)	Potential Evapotranspiration	BASIN	Hourly	August 1948 – November 2005

Long-term evaporation / evapotranspiration data sets are being generated to correspond with long-term rainfall records. The final selection of rainfall loss parameters and evaporation data is part of the SMRHM development process.

In summary, the published literature reviewed as part of this study support the methods and approach taken in developing the SMR HMP.

2.2.ii Identification of naturally-occurring conditions

Section F.1.h.(d) of the 2010 SMR MS4 Permit requires that estimated post-project runoff discharge rates and durations shall not exceed pre-development (naturally occurring) discharge rates and durations. Compliance with this Permit requirement should be based on the results of continuous simulation and the use of the SMRHM or an approved equivalent model. As part of developing the supporting hydrology model for a PDP, a User must identify and document, using professional knowledge, pre-development (naturally occurring) conditions in terms of geology, topography, soils, and vegetation.

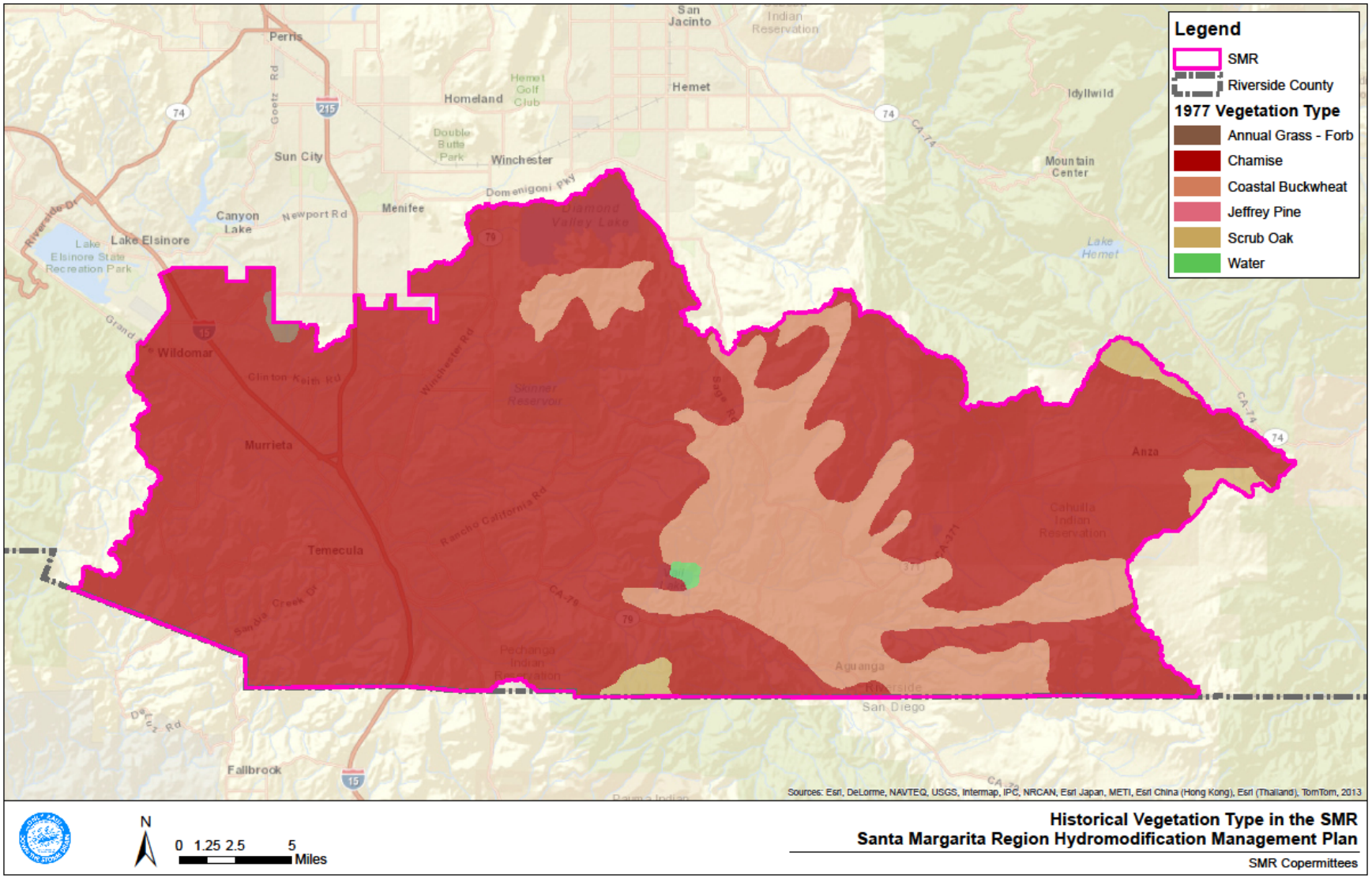
Several publicly-available information sources may help the User characterize pre-development conditions, including:

- Soil database (#678, #679, and #680) from the Natural Resources Conservation Service (NRCS). Among the parameters of interest, the database identifies the type, the original range of observed topographic slopes, the soil erosion factor K, and, if available, plant

community information for the native or pre-development soil. The database is accessible through the Web Soil Survey page (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm).

- Vegetation and ecoregional GIS information listed by the U.S. Forest Services. The USEPA Ecoregion database information locates the SMR in the Southern California Mountains and Valleys Ecoregion and references the climate of humid and temperate Mediterranean type. The USEPA Ecoregion database identifies also the vegetation province of the SMR within the California Coastal Range Open Woodland-Shrub-Coniferous Forest-Meadow province. A historical CALVEG GIS vegetation layer is available for the year 1977 (USFS, 2000). The historical vegetation layer reveals a majority of evergreen chaparral shrub and scrub oak within the watershed. For those areas located within the Urban Land and Agriculture vegetation area, the User may select the shrub vegetation for pre-development, naturally occurring, conditions. **Figure 4.** Historical Vegetation and Ecoregions in the Santa Margarita Region delineates the distribution of historical vegetation types in the SMR. GIS-based layers are available on the USFS website: (http://www.fs.usda.gov/detail/r5/landmanagement/gis/). Consistent with historical aerials, the User should select Shrub as the native vegetation, if the PDP is located in an urban/agricultural area on the 1977 CALVEG GIS layer.
- Other historical USGS topographic maps and aerial photos of Riverside County, specifically of the SMR area, are publicly available from the USGS website.

Figure 4. Historical Vegetation and Ecoregions in the Santa Margarita Region



2.2.iii Hydrologic Control BMPs

As identified in **Section 2.2.i**. PDPs are encouraged to use the full suite of Hydrologic Control BMPs available to meet the Hydrologic Performance Standards. The intent of the HMP is not to specify the types of Hydrologic Control BMPs that can be used but rather identify the criteria that must be met.

Selection and design of Hydrologic Control BMPs is an iterative process that can be facilitated using the SMRHM. The SMRHM has a comprehensive menu of site design LID BMPs and Hydrologic Control BMPs that can be selected for PDPs. The design parameters for these Hydrologic Control BMPs have been incorporated into the model and can be modified to an extent based on site constraints. The User is invited to refer to the SMRHM Guidance Document that is referenced in APPENDIX G for SMRHM specific questions.

Hydrologic Control BMPs must be maintained for optimal operation. PDPs are conditioned to provide verification of inspections and maintenance operations as defined in Section H of the SMR WQMP Template that must be completed in its entirety prior to the issuance of a grading permit. The list of such inspections and maintenance operations must be included in the WQMP for the PDP submitted by the User. Maintenance activities must ensure that the Hydrologic Control BMPs are functioning as designed.

2.2.iv Alternative Compliance Options

The use of Alternative Compliance Options will require coordination with the Copermittee with jurisdiction over the project site and may also require coordination with other Copermittee(s) with jurisdiction over an offsite location where a Hydrologic Control BMP may be proposed. For some PDPs, implementation of onsite Hydrologic Control BMPs consistent with the HMP may not be feasible due to site constraints. These projects require alternatives to onsite Hydrologic Control BMPs. There are two Alternative Compliance Options for PDPs that cannot implement onsite Hydrologic Control BMPs. One option is for the User to identify and construct offsite Hydrologic Control BMPs. The other option is for the PDP to pay into an HMP Management Bank, if an HMP Management Bank option is available.

HMP Alternative Compliance Option 1: Offsite Hydrologic Control Management

A progression through a defined process is required to document eligibility then implementation of alternative HMP compliance. Offsite Hydrologic Control management is based on completing a series of steps to meet compliance that is consistent with Section F.1.h.(3) of the 2010 SMR MS4 Permit. These steps include the following:

1. Technical feasibility study of onsite Hydrologic Control BMPs; and
2. Offsite Hydrologic Control BMP project within the same hydrologic unit as the PDP or in-channel restoration of a channel receiving runoff from the PDP.

Step 1: Conduct a technical feasibility study for onsite Hydrologic Control BMPs

A technical feasibility study is required to identify why onsite Hydrologic Control BMPs cannot be incorporated into the PDP. The technical feasibility study must include the project constraints and provide detailed technical justification as to why the project constraints prevent implementation of onsite Hydrologic Control BMPs. The technical feasibility study will be submitted to the Copermittee with jurisdiction over the project site for review as part of the Preliminary WQMP. The Copermittee must approve the findings of the technical feasibility study before the PDP moves on to Step 2.

The Hydrologic Control BMP technical feasibility study will be incorporated into the SMR WQMP Template and integrated with the LID feasibility analysis; however, it should be noted that the criteria for Hydrologic Control BMP and LID requirements are different. The feasibility analysis for both Hydrologic Control BMPs and LID will be integrated into one feasibility study for the PDP and submitted with the Preliminary WQMP.

The technical feasibility study should:

- Provide a narrative regarding the applicability of LID principles onsite as required by the SMR WQMP;
- Evaluate the feasibility of infiltration to capture partially or in its entirety the DCV based on the presence of either low infiltrating soils or high groundwater level, proximity to a water well or a contaminated plume, or a geotechnical report precluding effective and safe infiltration;
- Evaluate the feasibility of harvest-and-use BMPs based on local water demands;
- Evaluate the feasibility of implementing detention or retention BMPs onsite based on critical geotechnical considerations such as collapsible soil, expansive soil, slopes, liquefaction and other factors identified by a registered Geotechnical Engineer. The feasibility to implement Hydrologic Control BMPs and meet the Hydrologic Performance Standard onsite may be principally dictated by the geotechnical considerations.

Step 2: Implement offsite Hydrologic Control BMP projects within the same channel system as the PDP (2a) or implement in-channel restoration or rehabilitation of the PDP receiving water (2b)

For those PDPs where the Hydrologic Control BMP technical feasibility study for onsite controls has been approved by the Copermittee with jurisdiction over the project site, step 2 is to either (a) implement an offsite Hydrologic Control BMP project within the same channel system as the PDP, or (b) implement an in-channel restoration project for the channel receiving runoff from the PDP. The process for these options under Step 2 is detailed below:

HMP Alternative Compliance Option 1 – Step 2a: Implement Offsite Hydrologic Control Project within the Channel System receiving runoff from the PDP

In choosing this option, the PDP must investigate potential locations for implementation of an offsite Hydrologic Control project within the channel system receiving runoff from the PDP. If the User demonstrates that an offsite Hydrologic Control project is not feasible in the channel system receiving runoff from the PDP, then an offsite Hydrologic Control project in the same hydrologic unit as the PDP may be approved. The offsite Hydrologic Control project must manage the incremental impact from not achieving the pre-development (naturally occurring) runoff flow rates and durations for the project site. Sizing of offsite Hydrologic Control projects may be accomplished using the SMRHM. The User will evaluate and identify potential sites in the channel system receiving runoff from the PDP, and if not feasible, then evaluate projects in the same hydrologic unit for implementation of an offsite Hydrologic Control project that has the capacity to provide the PDPs Hydrologic Performance Standard requirements. If an Adequate Sump is identified in the channel system receiving runoff from the PDP, the User will submit a report detailing:

- That the offsite Hydrologic Control project manages the incremental impact from the pre-development (naturally occurring) runoff flow rates and durations for the project site;
- Conceptual plans for the offsite Hydrologic Control project as part of an amended WQMP for review and approval;
- If the PDP is a redevelopment project, that the post-project runoff flow rates and durations do not exceed pre-project runoff flow rates and durations; and
- If no potential offsite Hydrologic Control project sites are identified in the channel system receiving runoff from the PDP, that there is an offsite Hydrologic Control project in the same hydrologic unit.

If no potential offsite Hydrologic Control project sites are identified in the same hydrologic unit as the PDP, the PDP must implement Option 2(b), a restoration or rehabilitation project in the channel system with historic Hydromodification and receiving runoff from the PDP.

HMP Alternative Compliance Option 1 – Step 2b: Implement In-Channel Restoration or Rehabilitation of the Channel Receiving Runoff from the PDP

In choosing this option, the PDP investigates the potential for implementation of an in-channel restoration or rehabilitation project for the channel receiving runoff from the PDP. It must be determined that the channel receiving runoff from the PDP has experienced historic Hydromodification. The in-channel restoration or rehabilitation project must be located in the channel receiving runoff from the PDP. The PDP must submit a report detailing the historic Hydromodification, as well as conceptual plans for the in-channel restoration or rehabilitation project to the Copermittee with jurisdiction over the project site for review. The Copermittee is responsible for ensuring that the level of restoration or rehabilitation is adequate given the potential Hydromodification impacts of the PDP. Copermittees maintain individual processes

consistent with their approval procedures to ensure that the User's obligations under the HMP alternative compliance process are completed prior to approval of the PDP.

Once the project conceptual plans have been approved by the Copermittee with jurisdiction over the project site, the User must submit required permit applications to the appropriate regulatory agencies (e.g., SDRWQCB, California Department of Fish and Wildlife, USACE) for review and approval. If the PDP identifies no opportunities for in-channel restoration or rehabilitation in the channel receiving runoff from the PDP, then the PDP must implement Option 2(a), an offsite Hydrologic Control project within the same hydrologic unit as the PDP.

HMP Alternative Compliance Option 2: HMP Management Bank Alternative Compliance Option

(Note: Option 2 is available only if an HMP management bank has been developed and is available to the PDP.)

The Copermittees have the option to develop an HMP Management Bank or multiple HMP Management Banks. A HMP Management Bank will develop regional HMP management projects where PDPs can buy HMP management credits if it is determined that implementing onsite Hydrologic Control BMPs is infeasible. The development and operation of an HMP Management Bank will include the identification of potential regional Hydrologic Control projects; the planning, design, permitting, construction, and maintenance of regional Hydrologic Control projects; the development of a fee structure for PDPs participating in the HMP Management Bank; and managing the HMP Management Bank fund. Regional Hydrologic Control projects can also serve as projects for an LID waiver program if site conditions allow for implementation of LID-type projects.

If PDPs are unable to meet the Hydrologic Performance Standard by incorporating onsite Hydrologic Control BMPs, and a HMP Management Bank is available, the PDP can apply to participate in the Bank. The application must include a technical feasibility study to identify why onsite Hydrologic Control BMPs cannot be incorporated into the PDP. The technical feasibility study must include the project constraints and detailed technical justification as to why the project constraints prevent implementation of onsite Hydrologic Control BMPs. The technical feasibility study will be submitted to the Copermittee with jurisdiction over the project site for review as part of the Preliminary WQMP. The Copermittee must approve the Hydrologic Control BMP technical feasibility study for the PDP to participate in a HMP Management Bank.

2.3 Meeting the Sediment Supply Performance Standard

Bed Sediment Supply from PDPs plays a role in the stability of alluvial channels. As identified in APPENDIX C , a change in Bed Sediment Load may cause instability in the receiving channel manifested through general scour or aggradation. Lateral bank migration may also result from changes in Bed Sediment Load as the channel slope increases or decreases.

Bed Sediment typically includes coarse sand (1-2 mm) and thicker sediment sizes. The User may refer to the classification table (Table 14 of APPENDIX I) for a full listing of sediment sizes and associated critical shear stresses.

Bed Sediment Supply to a receiving channel during construction may increase as land surface is cleared and the potential for erosion is increased. Once the land surface is urbanized, the potential for Bed Sediment Supply may be reduced as compared to the pre-development condition. The purpose of this portion of the HMP is to maintain the pre-development supply of Bed Sediment to receiving channels following urban development. Total Sediment Load consists of the Bed Sediment Load that includes both material moving along the bed by rolling, sliding or Saltation) and coarse sand (1-2 mm) that is transported in near-suspension by the velocity of flow, and the Wash Load that includes clays, silts and fine sand (under 1 mm). Bed Sediment Load is a primary variable controlling channel morphology. Wash Load is the portion of the total sediment load carried continuously in suspension by the flow. Changes in Wash Load are not likely to significantly affect the channel stability, and reductions in Wash Load are generally assumed to improve habitat function.

The resiliency of channels to forestall changes due to urban development varies with the magnitude of the change and characteristics of the channel (bed and bank sediment, vegetation, channel cross-section and slope). It is difficult to quantitatively predict the response in a channel receiving runoff from urban development to changes in the fundamental variables described by Lane (1955) of discharge, Bed Sediment grain size, channel slope and Bed Sediment Load. Accordingly, the most effective approach to ensuring channel stability may be to avoid changes in the fundamental variables (Lane's interrelationship) during urban development through the implementation of channel management guidelines. In the case of Bed Sediment Load, this will be accomplished by avoiding development in areas that are a Significant Source of Bed Sediment Supply to a channel. The User must identify the areas on the project site that are a Significant Source of Bed Sediment Supply. The determination will be performed following the three-step process, as described in **Section 2.3.i**.

The general approach to ensure maintenance of the pre-project Bed Sediment Supply is a three-step process:

1. Determine whether the portion of the site is a Significant Source of Bed Sediment Load to the channel receiving runoff from the PDP.
2. Avoid areas identified as Significant Sources of Bed Sediment Supply in the PDP design.
3. Site-specific alternative compliance measures.

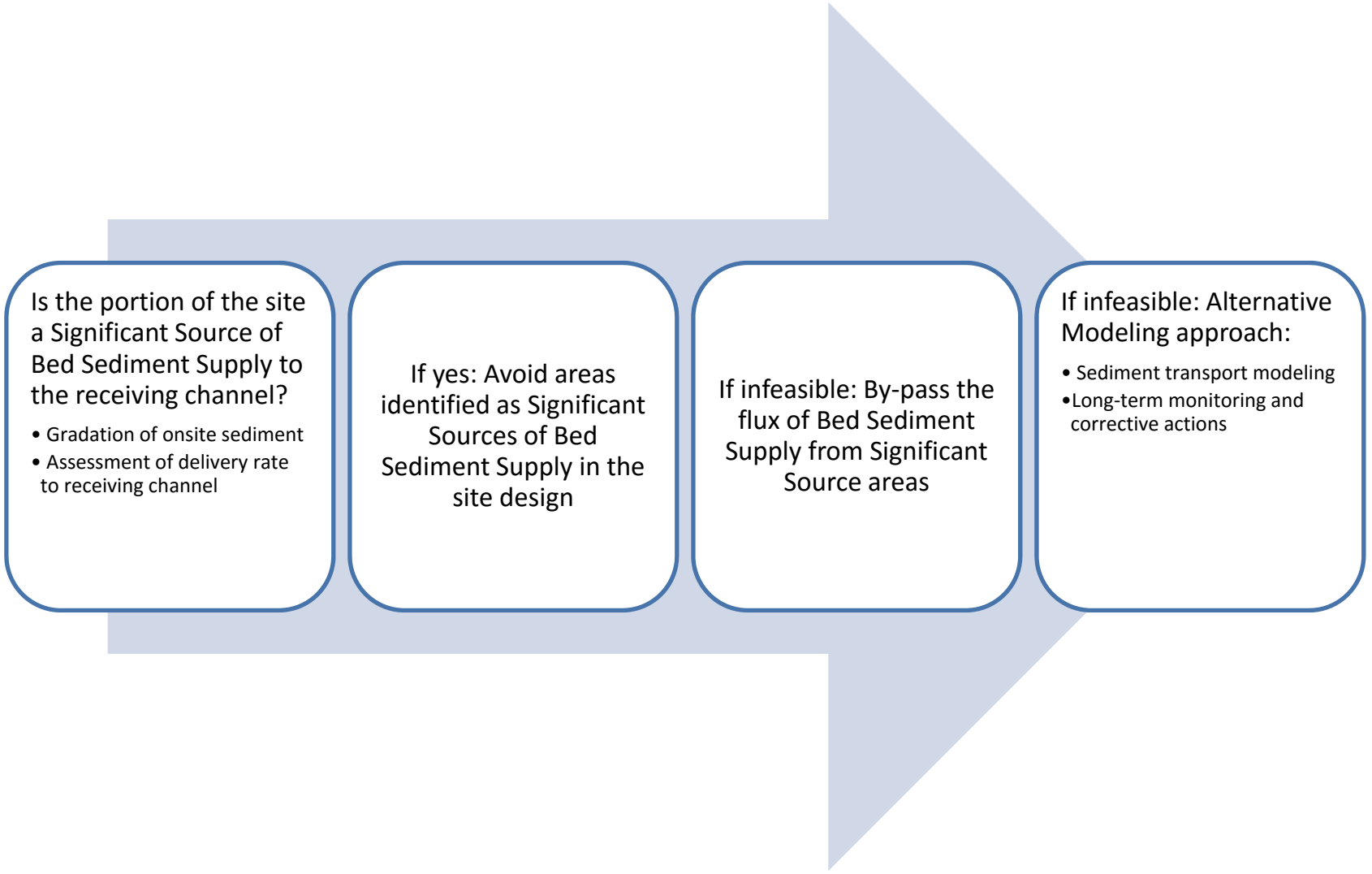
In the event of a projected reduction in Bed Sediment Supply, the User must investigate the feasibility of Sediment Supply BMPs, including bypassing the flux of Bed Sediment Supply from Significant Source areas onsite, otherwise maintaining pre-project Bed Sediment Supply from the site, or providing additional management of site runoff to accommodate the reduced Bed Sediment Supply. Specific guidance on sediment management measures will be provided in the SMR WQMP Template. Specifically, the SMR WQMP Template includes a Section for performing a Bed Sediment Supply assessment, which:

- Identifies the conditions for exemption from the Sediment Supply Performance Standard, if any;
- Summarizes the results of the three-step approach and identifies, for each step, the documentation required for approval of the evaluation by the Copermittee with jurisdiction over the project site. Documentation may include:
    - Results from the geotechnical and sieve analysis, the soil erodibility factor, a description of the topographic relief of the project area, and the lithology of onsite soils;
    - Results from the analyses of the sediment delivery potential to the channel receiving runoff from the project site, including the sediment source, the distance to the receiving channel, the onsite channel density, the PDP watershed area, the slope, length, land use, and rainfall intensity;
    - Quantification of the bank stability investigation, including the degree of incision, a gradation of the Bed Sediment, and identification if the receiving channel is sediment supply-limited.
- Provides a site map that identifies all onsite channels and highlights those that were identified as a Significant Source of Bed Sediment Supply. The site map must demonstrate if feasible, that the site design avoids those project site channels that may be a Significant Source of Bed Sediment Supply. In addition, the User must describe the characteristics of each channel on the project site identified as a Significant Source of Bed Sediment Supply. If the design plan cannot avoid the channels on the project site, the User should provide a rationale for each channel individually.

An Alternative Compliance Option allows the User to model the site conditions and the channel receiving runoff from the project site and provide additional management of site runoff to compensate for the reduction (or addition) of Bed Sediment Load. This option may only be used if the general approach outlined above is deemed infeasible by the Copermittee with jurisdiction over the project site, or if the project site design requires significant alteration of channel(s) on the project site. Step 1 of the three-step approach describes how channels on the project site should be identified and characterized by the User.

The stepwise approach that Users should follow to meet the Sediment Supply Performance Standard is summarized in **Figure 5**.

Figure 5 - Sediment Supply Performance Standard – Stepwise Approach



2.3.i Three-Step Process

The User must determine the location of the alluvial channel receiving runoff from the project site. The first such channel that is unlined (invert, side slopes or both) will serve as the "assessment" or "receiving" channel for the PDP. The following methodology will be used to ensure that the PDP does not adversely impact the delivery of Bed Sediment Supply to the assessment channel.

Step 1: Determine whether the Portion of the Project Site is a Significant Source of Bed Sediment Supply to the Channel Receiving Runoff

A triad approach will be completed to determine whether the project site is a Significant Source of Bed Sediment Supply to the channel receiving runoff and includes the following components:

A. Site soil assessment, including an analysis and comparison of the Bed Sediment in the receiving channel and the onsite channel;

B. Determination of the capability of the channels on the project site to deliver the site Bed Sediment (if present) to the receiving channel; and

C. Present and potential future condition of the receiving channel.

Prior to performing a site-specific triad assessment, the User should refer to the macro-scale findings of the HRU/GLU Analysis performed as part of the SMR Hydromodification Susceptibility Study (APPENDIX D). The HRU/GLU Analysis will provide the designer with critical geomorphic information for the subwatershed where the PDP is located, including the impacts of existing imperviousness on the hydrologic cycle and the potential for sediment production.

A. Site soil assessment, including an analysis and comparison of the Bed Sediment in the channel receiving runoff and the onsite channels

A geotechnical and sieve analysis is the first piece of information to be used in a triad approach to determine if the project site is a Significant Source of Bed Sediment Supply to the assessment channel. An investigation must be completed of the assessment channel to complete a sieve analysis of the Bed Sediment. Two samples will be taken of the assessment channel using the "reach" approach (TS13A, 2007). Samples in each of the two locations should be taken using the surface and subsurface bulk sample technique (TS13A, 2007) for a total of four samples. Pebble counts may be required for some channels.

A similar sampling assessment should be conducted on the project site. First-order and greater channels that may be impacted by the PDP (drainage area changed, stabilized, lined or replaced with underground conduits) will be analyzed in each subwatershed. First-order channels are identified as the unbranched channels that drain from headwater areas and develop in the uppermost topographic depressions, where two or more contour crenulations (notches or

indentations) align and point upslope (NEH, 2007). First-order channels may, in fact, be field ditches, gullies, or ephemeral gullies (NEH, 2007). One channel per subwatershed that may be impacted on the project site must be assessed. A subwatershed is defined as tributary to a single discharge point at the project site boundary.

The sieve analysis should report the coarsest 90% (by weight) of the sediment for comparison between the site and the assessment channel. The User should render an opinion if the Bed Sediment found on the site is of similar gradation to the Bed Sediment found in the receiving channel. The opinion will be based on the following information:

- Sieve analysis results
- Soil erodibility (K) factor
- Topographic relief of the project area
- Lithology of the soils on the project site

The User should rate the similarity of onsite Bed Sediment and Bed Sediment collected in the receiving channel as high, medium, or low. The rating should be consistent with Figures 4 through 6 of the Hydromodification Susceptibility Report and Mapping: SMR (See APPENDIX D). This site soil assessment serves as the first piece of information for the triad approach.

B. Determination of the capability of the onsite channels to deliver Bed Sediment Supply (if present) to the channel receiving runoff from the project site.

The second piece of information is to qualitatively assess the sediment delivery potential of the channels on the project site to deliver the Bed Sediment Supply to the channel receiving runoff from the project site, or the Bed Sediment delivery potential or ratio. There are few documented procedures to estimate the Bed Sediment delivery ratio (see: Williams, J. R., 1977: Sediment delivery ratios determined with sediment and runoff models. IAHS Publication (122): 168-179, as an example); it is affected by a number of factors, including the sediment source, proximity to the receiving channel, onsite channel density, project sub-watershed area, slope, length, land use and land cover, and rainfall intensity. The User will qualitatively assess the Bed Sediment delivery potential and rate the potential as high, medium, or low.

C. Present and potential future condition of the channel receiving runoff from the project site.

The final piece of information is the present and potential future condition of the channel receiving runoff from the project site. The User should assess the receiving channel for the following:

- Bank stability - Receiving channels with unstable banks may be more sensitive to changes in Bed Sediment Load.

- Degree of incision - Receiving channels with moderate to high incision may be more sensitive to changes in Bed Sediment Load.
- Bed Sediment gradation - Receiving channels with more coarse Bed Sediment (such as gravel) are better able to buffer change in Bed Sediment Load as compared to beds with finer gradation of Bed Sediment (sand).
- Transport vs. supply limited channels. Receiving channels that are transport limited may be better able to buffer changes in Bed Sediment Load as compared to channels that are supply limited.

The User will qualitatively assess the channel receiving runoff from the project site using the gathered observations and rate the potential for adverse response based on a change in Bed Sediment Load as high, medium, or low.

In addition to the findings of the macro-scale HRU/GLU Analysis, the User should use the triad assessment approach, weighting each of the components based on professional judgment to determine if the project site provides a Significant Source of Bed Sediment Supply to the receiving channel, and the impact the PDP would have on the receiving channel. The final assessment and recommendation must be documented in the HMP portion of the WQMP.

The recommendation may be any of the following:

- Site is a Significant Source of Bed Sediment Supply – all channels on the project site must be preserved or by-passed within the site plan.
- Site is a source of Bed Sediment Supply – some of the channels on the project site must be preserved (with identified channels noted).
- Site is not a Significant Source of Bed Sediment Supply.

The final recommendation will be guided by the triad assessment. Projects with predominantly "high" values for each of the three assessment areas would indicate preservation of channels on the project site. Sites with predominantly "medium" values may warrant preservation of some of the channels on the project site, and sites with generally "low" values would not require site design considerations for Bed Sediment Load.

The User should also assess if the receiving channel has been altered either for alignment, cross section, or longitudinal grade, or has degraded to the extent that an in-channel restoration or rehabilitation project would be required to restore the functions and values of the channel bed. In such cases, the User should discuss options for participating in an in-channel project in lieu of onsite design features to preserve the Bed Sediment Supply.

Step 2: Avoid Areas Identified As Significant Sources of Bed Sediment Supply in the Site Design

If the analysis in Step 1 indicates that some or all of the channels on the project site must be preserved as a source of Bed Sediment Supply to the receiving channel, the site plan should be

developed to avoid impacting the identified channels. The User will designate channels on the project site that should be avoided to preserve the discharge of Bed Sediment Supply from the site. The User may consider the factors discussed above when determining whether a specific channel on the project site is a Significant Source of Bed Sediment Supply and should be preserved.

Step 3: Site-Specific Alternative Compliance Measures

If it is infeasible to avoid channels on the project site that are Significant Sources of Bed Sediment Supply in the design of the site plan, the drainage(s) may be by-passed to maintain the Bed Sediment Supply to the receiving channel. The User will need to prepare specific designs to achieve this objective.

2.3.ii Alternative Compliance Option

An Alternative Compliance Option may only be pursued if the replacement of Bed Sediment Supply is deemed infeasible by the Copermittee with jurisdiction over the project site, or if the project site design requires significant alteration of onsite channels. The infeasibility of the different Sediment Supply BMPs stated in the general approach may only be demonstrated and documented by the User. The User may also demonstrate the expected feasibility of the Alternative Compliance Option.

In such an eventuality, Users may propose an Alternative Compliance Option for Bed Sediment management from a PDP based on numerical modeling. This option would generally include a long-term monitoring program, with potential corrective measures to be identified and implemented as needed in response to findings from the monitoring program. The use of an Alternative Compliance Option derives from Lane's interrelationship that conceptualizes the balance between hydrologic and geomorphic processes for alluvial channels.

For example, the User may recommend an annual replenishment of Bed Sediment Load downstream of the project site based on an estimation of the amount of reduction of Bed Sediment Supply from the project site as a result of development.

The general steps to estimate the average annual replacement of Bed Sediment Load are:

1. Identify the sources of Total Sediment Supply based on a geotechnical review of the site. Areas that are not a Significant Source of Bed Sediment Supply may be omitted from the analysis.
2. Estimate the base erosion rate of areas identified as sources of Total Sediment Supply. This estimate should be completed using the Modified Universal Soil Loss Equation (MUSLE) and a 2-year runoff return period.
3. Approximate the sediment delivery ratio of sources. This can be done using published values for the area or estimated values based on best professional judgment.
4. Evaluate the Bed Sediment proportion of sources and calculate the yield rate. The Bed Sediment proportion of the sources should be determined by comparing the sieve analysis

in the channel with that in the identified supply areas on the project site. The yield is computed by multiplying the total yield, by the Bed Sediment proportion and the sediment delivery ratio.

5. Identity sources of Bed Sediment Supply to be eliminated after development. This is performed based on a review of the site plan.
6. Calculate and compare the total pre- and post-development Bed Sediment Supply yield to estimate the average annual amount of Bed Sediment that should be replenished to the channel.

Alternatively, the User may propose adjusting the flow duration curve to maintain pre-project conditions in the receiving channel with the expected change in Bed Sediment Supply discharge from the project site. The erosion potential (total sediment transported in the proposed condition vs. the baseline) should be modeled and used to adjust the flow duration curve to ensure a condition that does not vary more than 10% from the natural condition. Bledsoe (2002) introduced the index of stream erosion potential (Ep), which compares the erosive power of pre- and post-development streamflows. This index allows comparison of sediment-transport relationships to ensure that an erosion potential that is comparable to pre-development conditions is achieved. Changes in Total Sediment Supply after development are accounted for by changing the target Ep from 1.0 (proposed is the same as pre-project) in proportion to the change in Bed Sediment Supply (post-development/pre-development), calculated using the six steps above. This option may not be practical when changes in Bed Sediment Supply are relatively large (greater than 50%). The User should determine, using best professional judgment, if the alternative modeling approach is applicable.

The alternative modeling approach must include the following:

1. Continuous hydrologic simulation for the project baseline condition and proposed condition over the range of flow values up to the pre-project 10-year event;
2. Sediment transport model of the receiving channel for the PDP baseline condition and proposed condition;
3. Analysis of the change in Bed Sediment Supply from the PDP baseline condition to the proposed condition;
4. Explanation of method used to control the discharge from the PDP to account for changes in the delivered Bed Sediment Supply; and
5. Summary report.

Channel systems and fluvial processes react to changes in the watershed as to progressively evolve to a dynamic equilibrium. However, the SMR is geomorphically highly dynamic due to natural conditions including topography, vegetative cover and soils, and may only achieve dynamic equilibrium in geologic time (i.e., many thousands of years). The alternative Hydrologic Performance Standard for this option consists of evaluating the changes in both Bed Sediment Supply and hydrologic changes caused by a PDP. The User must demonstrate through a channel stability impact assessment that the changes to both the amount of Bed Sediment Load being transported and the amount of sediment supplied to the receiving channel will maintain the

general trends of aggradation and degradation in the different impacted channel reaches, which are representative of the pre-development geormorphologic state of a channel. Typical channel sediment continuity analysis procedures may be performed using moveable bed fluvial models such as HEC-6t or equivalent.

Receiving channel monitoring may be required for the project site to verify that the PDP does not result in long-term changes to the receiving channel. The User should make a recommendation if long-term monitoring is required, for concurrence by the Copermittee with jurisdiction over the project site. Some of the considerations in assessing the need for a long-term monitoring program are:

1. Total area of the watershed at the PDP discharge point vs. the PDP area;
2. Condition and type of receiving channel;
3. Magnitude of change in Bed Sediment Supply to the receiving channel;
4. Relief of the land on the project site;
5. Number of channels (density) potentially delivering Bed Sediment Supply to the receiving channel, and the delivery ratio; and
6. Soil characteristics on the project site.

Site-specific modeling is discussed further in APPENDIX H .

2.4 Mechanisms to Assess and Address Cumulative Impacts

The Copermittees have developed the SMR HMP Monitoring Program, which defines both a Hydromodification monitoring approach and a mechanism for assessing and addressing cumulative impacts from PDPs within a watershed on channel morphology, as required by provisions F.1.h. (1)(m) and F.1.h. (1)(n) of the 2010 SMR MS4 Permit. The mechanism includes an evaluation of changes over time to physical features of receiving channels which are located downstream of urbanized areas. The findings of the initial monitoring efforts will be considered during assessment of priority water quality conditions in the SMR.

3.0 HMP Requirements for Projects

Per 2010 SMR MS4 Permit Provision F.1.h(1)(d), this chapter identifies where in the SMR and under what circumstances do the HMP Performance Standards apply to PDPs. The HMP identifies the coverage areas that are exempted from Hydromodification requirements based on Permit Provisions, the state of the Hydromodification science, the practicality of implementation of Hydrologic Control BMPs, environmental benefits of the implementation of Hydrologic Control BMPs, and approved Hydromodification exemptions for other jurisdictions in California.

Users may refer to the HMP Decision Matrix presented in **Section 3.1** to determine if Hydrologic Control and/or Sediment Supply BMPs are required. When required, the HMP Decision Matrix will direct the User to the adequate sections of this HMP describing the Hydrologic Control and Sediment Supply BMPs to be implemented based on the project type and size.

3.1 HMP Applicability Requirements

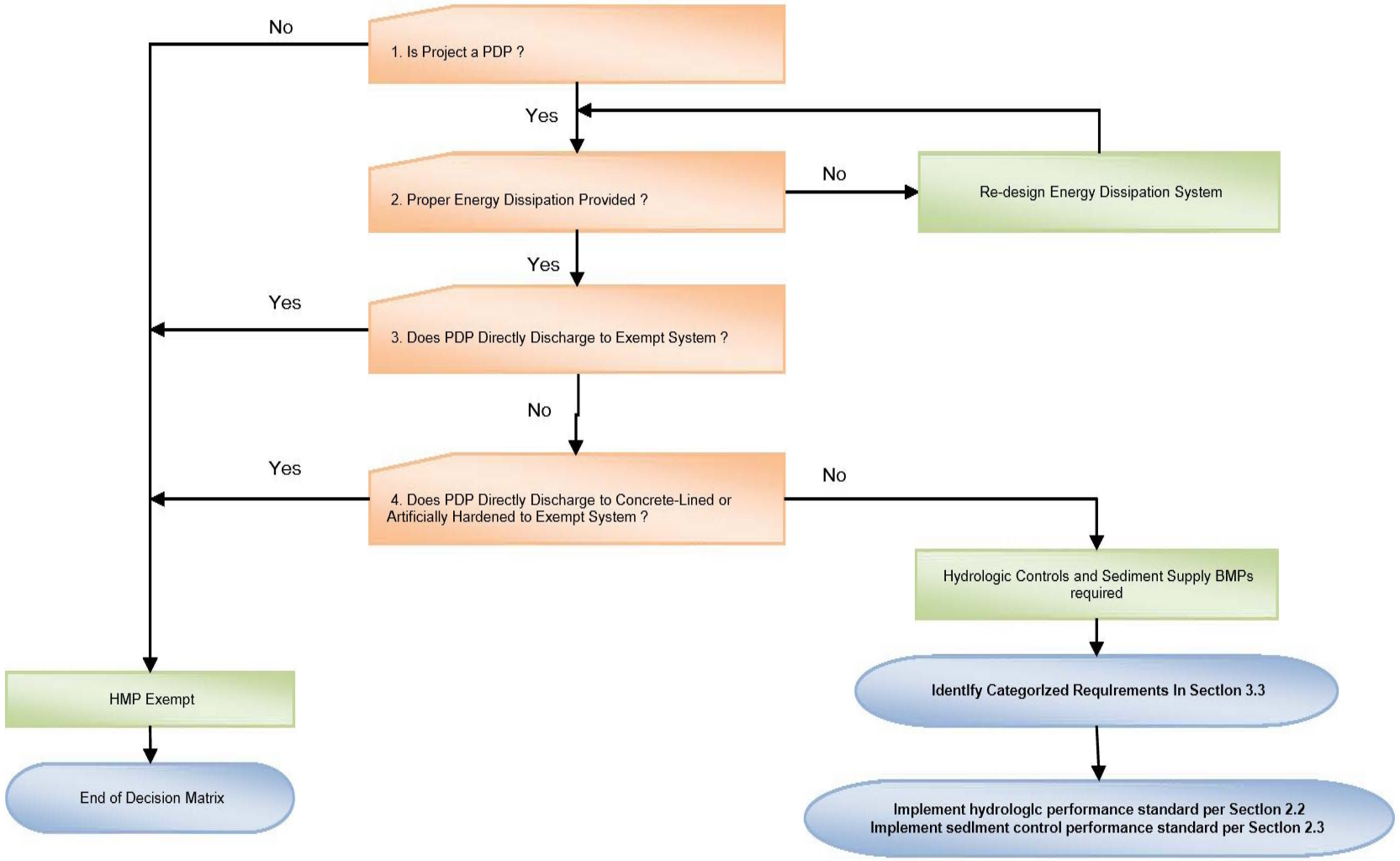
3.1.i HMP Decision Matrix

To determine if a proposed project must implement Hydrologic Control BMPs, refer to the HMP Decision Matrix in **Figure 6.**

The HMP Decision Matrix can be used for all projects. PDP categories are based on the size and type. Their associated requirements are defined in **Section 3.3**.

It should be noted that all PDPs are subject to the 2010 SMR MS4 Permit's LID and water quality treatment requirements even if Hydrologic Control BMPs are not required.

Figure 6 - SMR HMP Decision Matrix



- **Figure 6**, Node 1 – Hydrologic Control BMPs are only required if the proposed project is a PDP, as defined per 2010 SMR MS4 Permit Section F.1.d.
- **Figure 6**, Node 2 – Properly designed energy dissipation systems are required for all PDP outfalls to unlined channels. Such systems should be designed in accordance with the District Standard Drawings and the 1982 Los Angeles County Flood Control District Hydraulic Design Manual or approved alternative to ensure downstream channel protection from concentrated outfalls (identified in **Section 3.1.ii)**.
- **Figure 6**, Node 3 – Exemptions may be granted for PDPs discharging runoff directly to an exempt receiving water, such as Vail Lake or Skinner Lake, or to an exempt channel discharging directly into a large river channel (identified in **Table 3**).
- **Figure 6**, Node 4 – For PDPs discharging runoff directly to a concrete-lined or artificially hardened MS4 facility that has the capacity to convey the 10-year ultimate condition discharge that extends to exempt receiving waters detailed in Node 3, exemptions from HMP Performance Standards may be granted. Such concrete-lined or artificially hardened MS4 facilities that have the capacity to convey the 10-year ultimate condition discharge, include storm drain and channel reaches that have been identified as not-susceptible to Hydromodification (see SMR Hydromodification Susceptibility Study in **Appendix C**).
- **Figure** provides an overview of the SMR, and identifies potentially exempt areas per the requirements of the 2010 SMR MS4 Permit and non-exempt areas.
- **Figure 8** and **Figure 9** zoom geographically into the Temecula area and the Temecula Creek area downstream of Vail Lake, respectively.

3.1.ii Requirement for Proper Energy Dissipation System(s)

As identified in the HMP Decision Matrix in **Figure 6**, properly designed energy dissipation systems are required for all PDP outfalls to unlined channels. The provision is consistent with the District's Standard Design Manual and the 1982 Los Angeles County Flood Control District Hydraulic Design Manual or approved alternative to ensure downstream channel protection from concentrated outfalls.

For reference purposes, the 1982 Los Angeles County Flood Control District Hydraulic Design Manual identifies that (page B-12):

"When a storm drain outlets into a natural channel, an outlet structure shall be provided, which prevents erosion and property damage. Velocity of the flow at the outlet should agree as closely as possible with the existing channel velocity. Fencing and a protection barrier shall be provided…

(1) … When the discharge velocity is high, or supercritical, the designer shall, in addition, consider bank protection in the vicinity of the outlet and an energy dissipation structure."

In order to encroach upon a Copermittee MS4 facility and construct an energy dissipation system, an Encroachment Permit must be obtained during the design phase. The User may contact the

District's Operations and Maintenance Division or the Copermittee's Public Works Department, as appropriate, for up-to-date criteria as to location and type of location to be used prior to initiating any design of outlet structure. For a majority of projects seeking encroachment to a MS4 facility, the initial location and type of outlet structures and energy dissipation systems will typically be assessed during the planning phase, specifically during the Environmental Review and Document phase.

Figure 7 - SMR Channel Susceptibility and Exemption Coverage

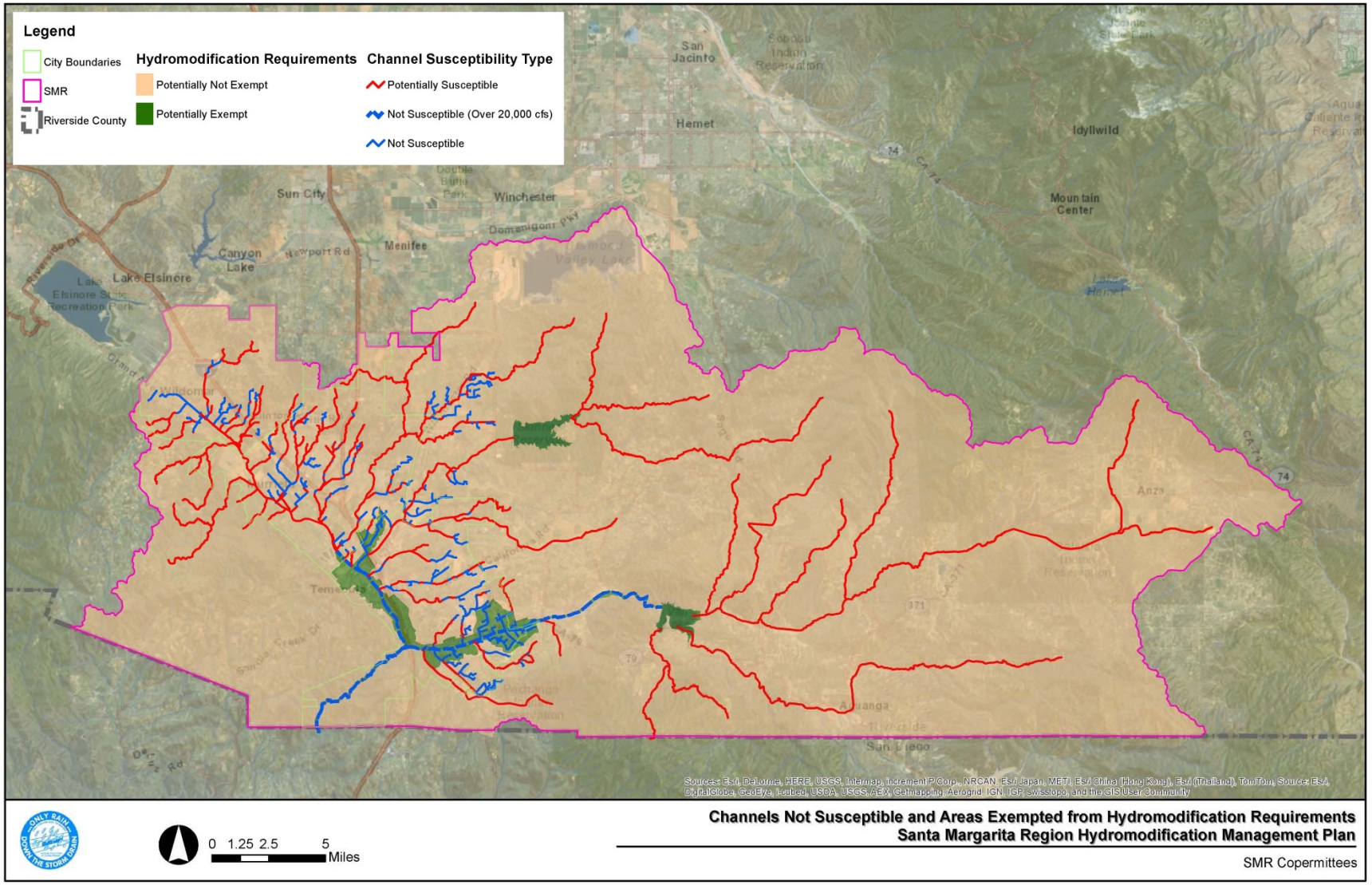


Figure 8 - SMR Channel Susceptibility and Exemption Coverage – Temecula Area

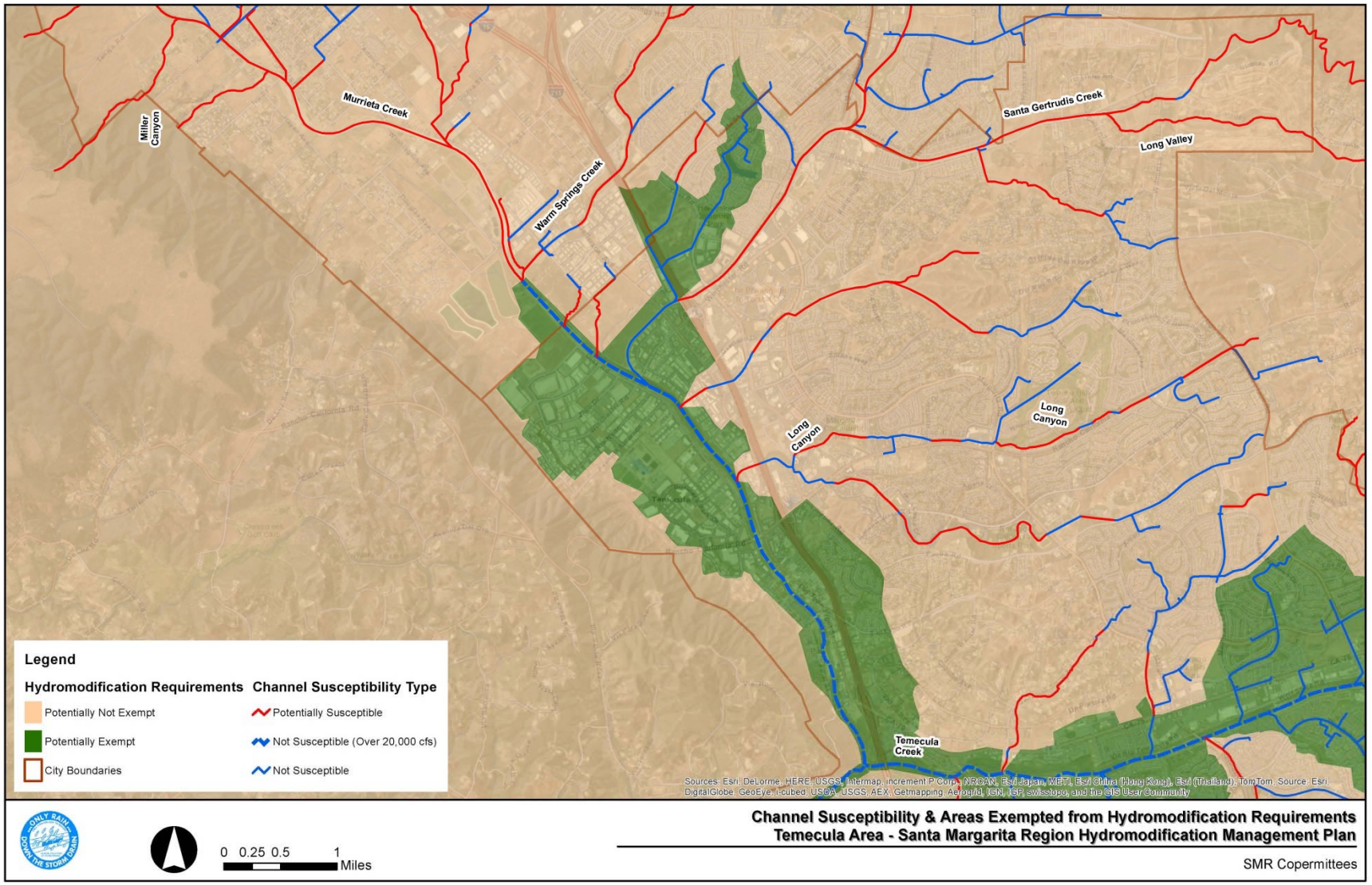
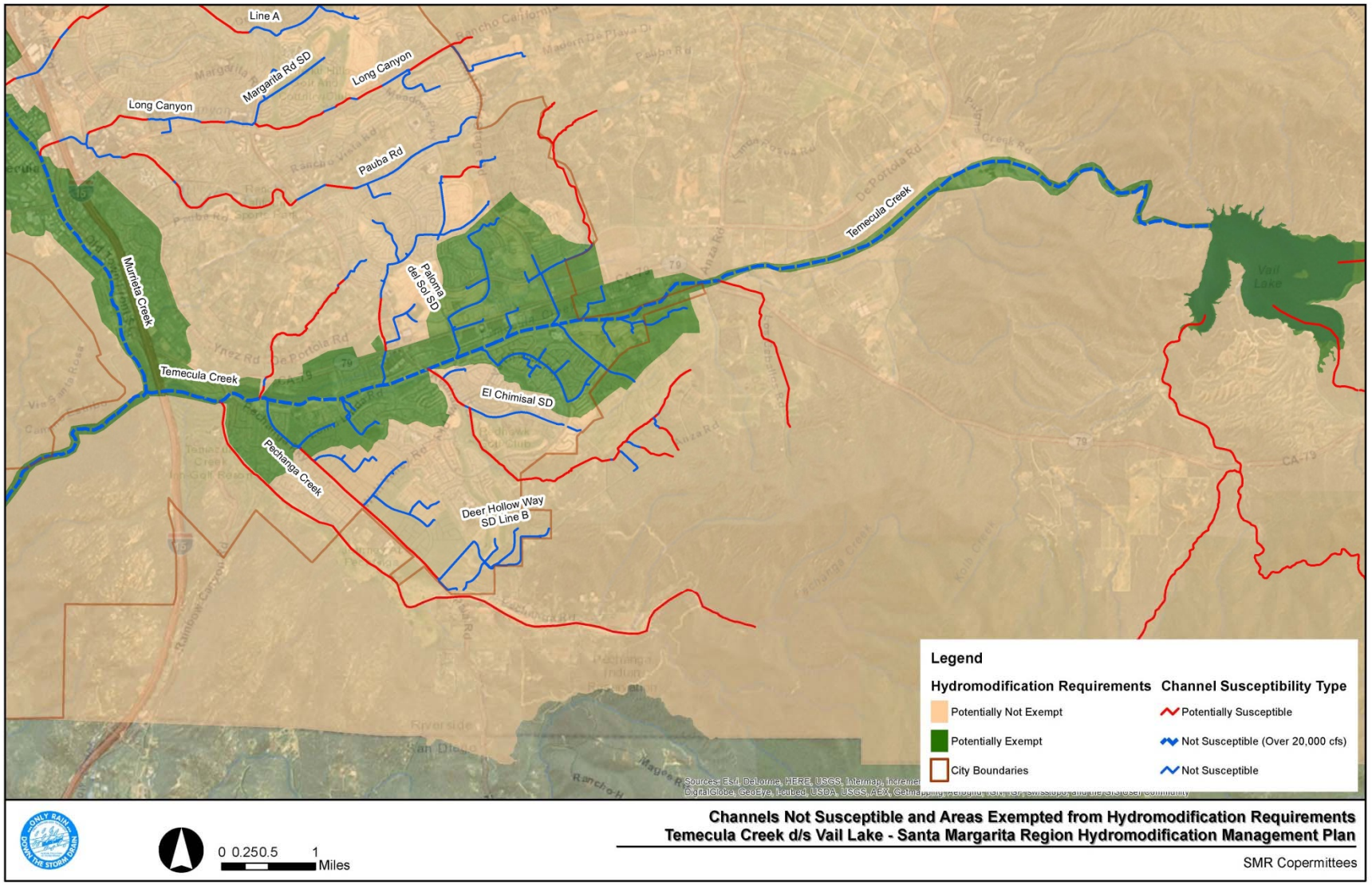


Figure 9 - SMR Channel Susceptibility and Exemption Coverage – Temecula Creek Area



3.2 HMP Exemptions

PDPs may be exempt from HMP Performance Standards based on specific channel or watershed conditions or already approved design guidelines.

3.2.i Concrete-Lined & Artificially Hardened Channel Exempt Areas

The channel exempt areas include those areas that discharge to concrete-lined or artificially hardened channels sections. This includes, as identified in Section F.1.h.(4) of the Permit:

- PDPs that discharge runoff into underground storm drains discharging directly to water storage reservoirs and lakes; or
- PDPs that discharge runoff into MS4 facilities whose bed and bank are concrete lined all the way from the point of discharge to water reservoirs and lakes; or
- PDPs that discharge runoff into other areas identified in the HMP as acceptable to not need to meet the requirements of Section F.1.h by the San Diego Water Board Executive Officer.

Concrete-lined or artificially hardened MS4 facilities that are identified as Engineered, Fully Hardened and Maintained (EFHM) in the SMR Hydromodification Susceptibility Study (see APPENDIX D) are exempt from the HMP Performance Standards. The exemption does not apply to PDPs that discharge to Engineered, Partially Hardened and Maintained (EPHM) and Engineered, Earthen and Maintained (EEM) channels. To confirm the exemption, the succession of existing concrete-lined or artificially hardened MS4 facilities must be continuous from the discharge point to an exempt receiving water, such as a reservoir or a large river. PDPs may evaluate local drainage systems that were not included in the SMR Hydromodification Susceptibility Report for exemption applicability. The User must ensure that the MS4 facilities have been designed to convey the 10-year ultimate condition peak discharge.

The 10-year flow should be calculated based upon the 10-year high confidence synthetic rainfall hydrograph, as detailed in the 1978 RCFCWCD Hydrology Manual. As an alternative, the 10-year ultimate peak discharge may also be determined based on continuous simulation and the results of the SMRHM.

Pursuant to 2010 SMR MS4 Permit Provision F.1.h(1)(a), the SMR was screened to identify and classify susceptible and non-susceptible channels. The screening analysis consisted of verifying the type of material and susceptibility of the GIS-delineated District drainage facilities using as-built plans and aerial photography. For questionable segments, the analysis was complemented by a field visit. Findings are summarized in the Hydromodification Susceptibility Documentation Report and Mapping (see APPENDIX D).

Major MS4 facilities that are exempt from HMP Performance Standards are presented in **Table 3** for reference only. The PDP may use the exemption maps, including Figures 6 through 11 of this

HMP and Map 2: HCOC Applicability Map from the Hydromodification Susceptibility Documentation Report and Mapping: SMR (see APPENDIX D), for planning purposes and must determine if the PDP would discharge runoff into a continuous succession of existing concrete-lined or artificially hardenedMS4 facilities that have the capacity to convey the 10-year ultimate condition discharge all the way to an exempt reservoir or other exempt waterbody. The table contains the name of the channel, as well as the associated downstream and upstream limits. The upstream limit being reported corresponds to the nearest cross street. The resulting map from this effort is presented in **Figure** . The map shows drainage areas that are potentially exempt from HMP Performance Standards.

Table 3 - Channels Exempt from Hydromodification Performance Standards

Channel	Downstream Limit	Upstream Limit
Murrieta Creek	Confluence with Warm Spring Creek	600 feet downstream of Elm Street
Storm Drain RCFC5429	Santa Gertrudis Creek Lateral A,B	Lock Haven Center
Santa Gertrudis Creek Line I	Santa Gertrudis Creek Lateral A,B	End of Line I
Santa Gertrudis Creek Lateral A,B	Murrieta Creek Channel	Confluence with Storm Drain RCFC4057
Wolf Valley Creek Channel	Temecula Creek	Loma Linda Road
Wolf Valley – Loma Linda Road Storm Drain	Wolf Valley Creek Channel	None – all tributaries are exempt
Via Del Coronado Storm Drain	Temecula Creek	None – all tributaries are exempt
Line V / VV of Temecula Creek	Temecula Creek	Upstream of tunneling structure under CA-79
Apis Road Storm Drain	Temecula Creek	None – all tributaries are exempt
Wolf Valley Loop / Margarita Road Storm Drain	Temecula Creek	None – all tributaries are exempt
Mahlon Vail Circle Storm Drain	Temecula Creek	None – all tributaries are exempt
DePortola Road Storm Drain	Temecula Creek	Butterfield Stage Park
Butterfield Stage Road / Macho Road Storm Drain	Temecula Creek	None – all tributaries are exempt
Temecula Creek Road Storm Drain	Temecula Creek	Highway 79
Chaote Street Storm Drain	Temecula Creek	None – all tributaries are exempt
Nighthawk Pass Storm Drain	Temecula Creek	None – all tributaries are exempt
Temecula Creek	Confluence with Santa Margarita River	Outflow of Vail Lake

Table 4 provides a summary of the two exempt reservoirs in the SMR, as identified in the Hydromodification Susceptibility Study. Discharges from PDPs to large reservoirs or lakes can be exempt from HMP Performance Standards since stormwater inflow velocities are naturally managed by the significant tailwater condition in the reservoir. HMP Performance Standard exemptions would only be granted for PDPs discharging runoff directly to the exempt reservoirs or into concrete-lined or artificially hardened MS4 facilities designed convey the 10-year ultimate condition discharging into a lake or reservoir. To qualify for the exemption, the outlet elevation of the MS4 facility must be within (or below) the normal operating water surface elevations of the reservoir and properly designed energy dissipation must be provided.

Table 4 - Reservoirs in the Santa Margarita Region

Reservoir	Watershed
Vail Lake	Temecula Creek

Skinner Lake	Tucalota Creek
Diamond Valley Reservoir	

Figure 10 below displays areas that are potentially exempt for the entire SMR based on the criteria outlined above, where the areas in green are potentially exempt as they discharge to engineered MS4 facilities all the way to exempt receiving waters (large river, water storage reservoirs). **Figure 11** provides the User with an exemption map of higher definition in the Temecula area. **Figure 12** provides the User with an exemption map of higher definition for Temecula Creek downstream of Vail Lake.

Figure 10 - SMR Exemption Area

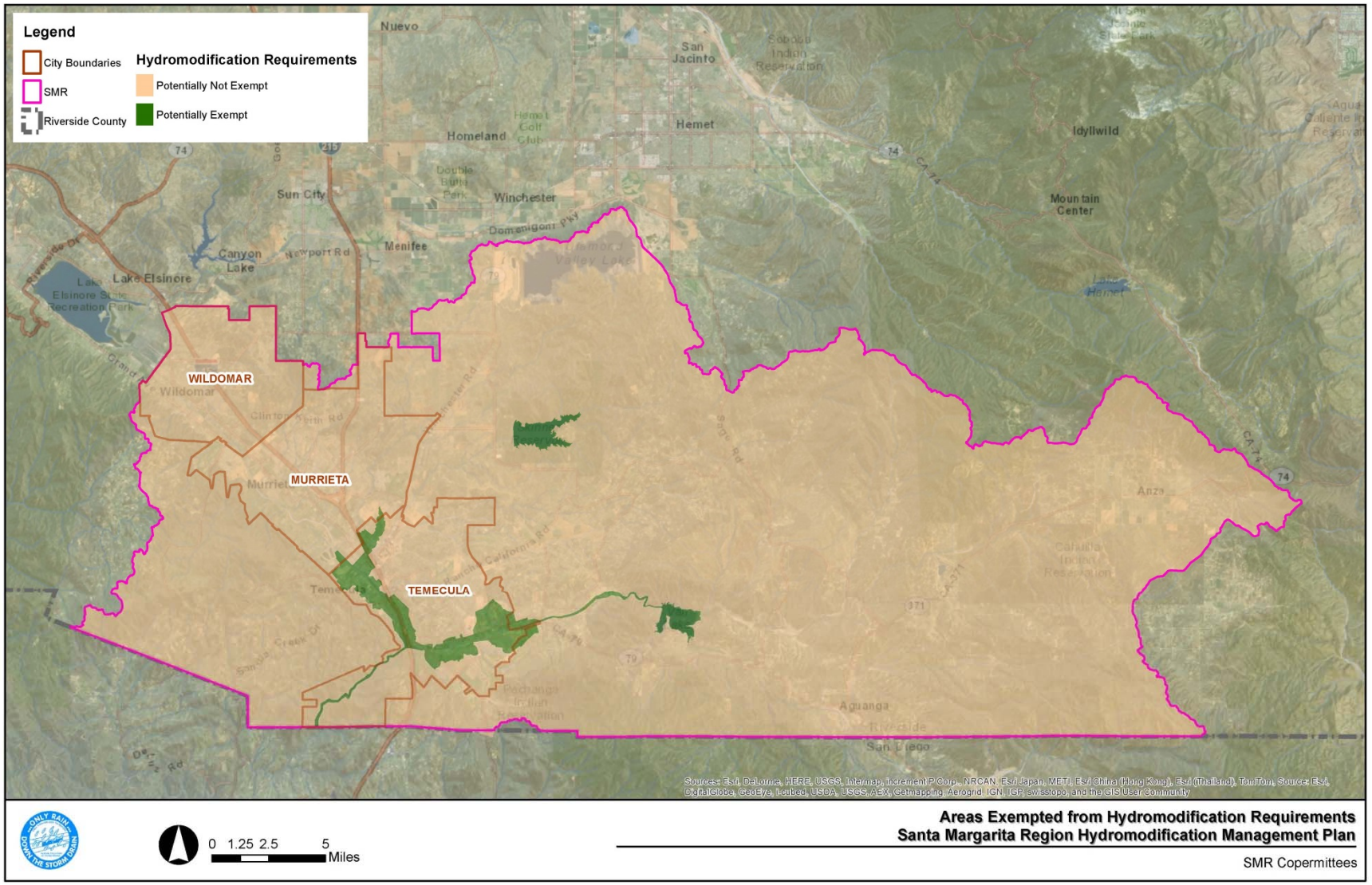


Figure 11 - SMR Exemption Area – Temecula Area

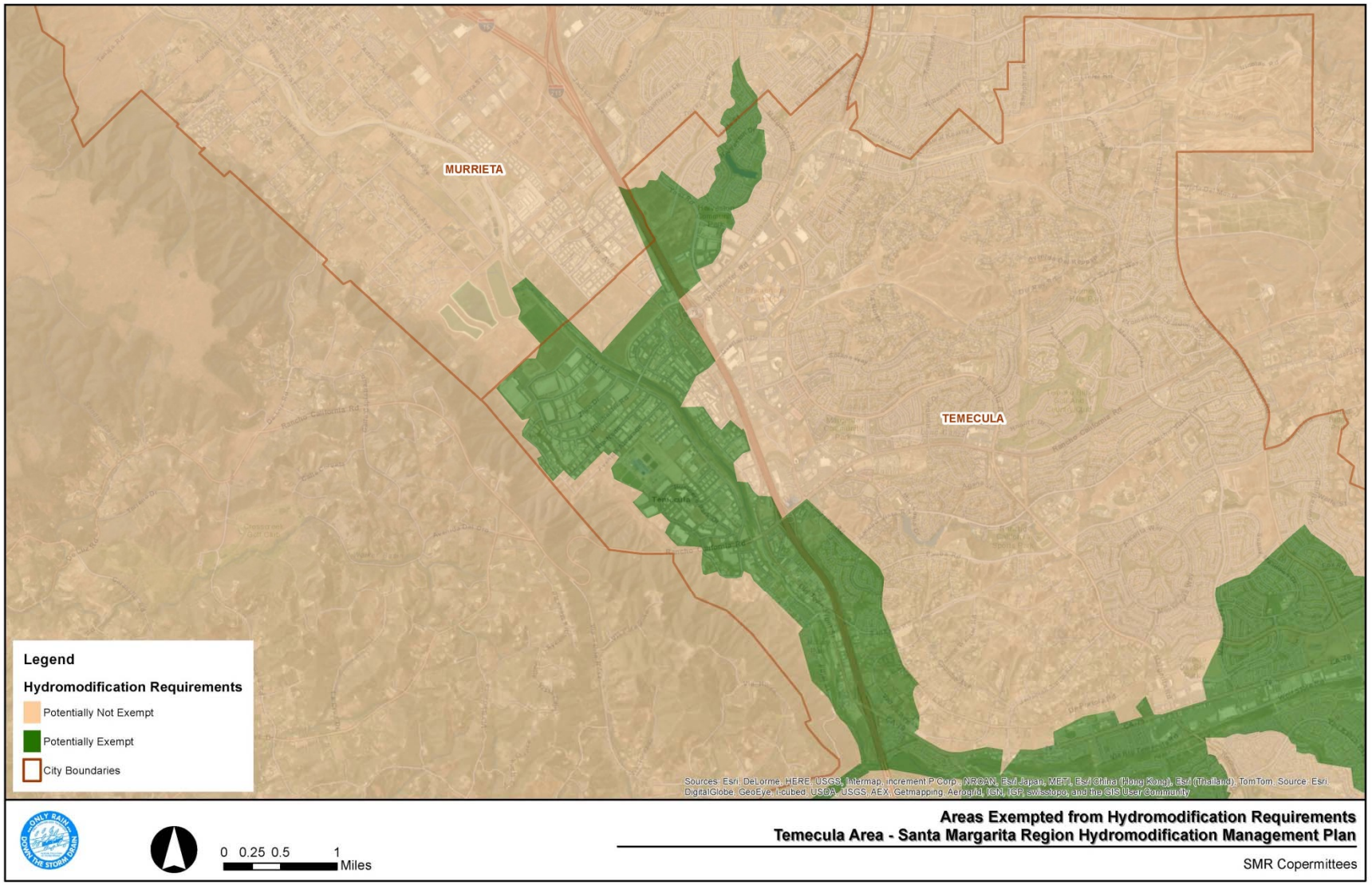
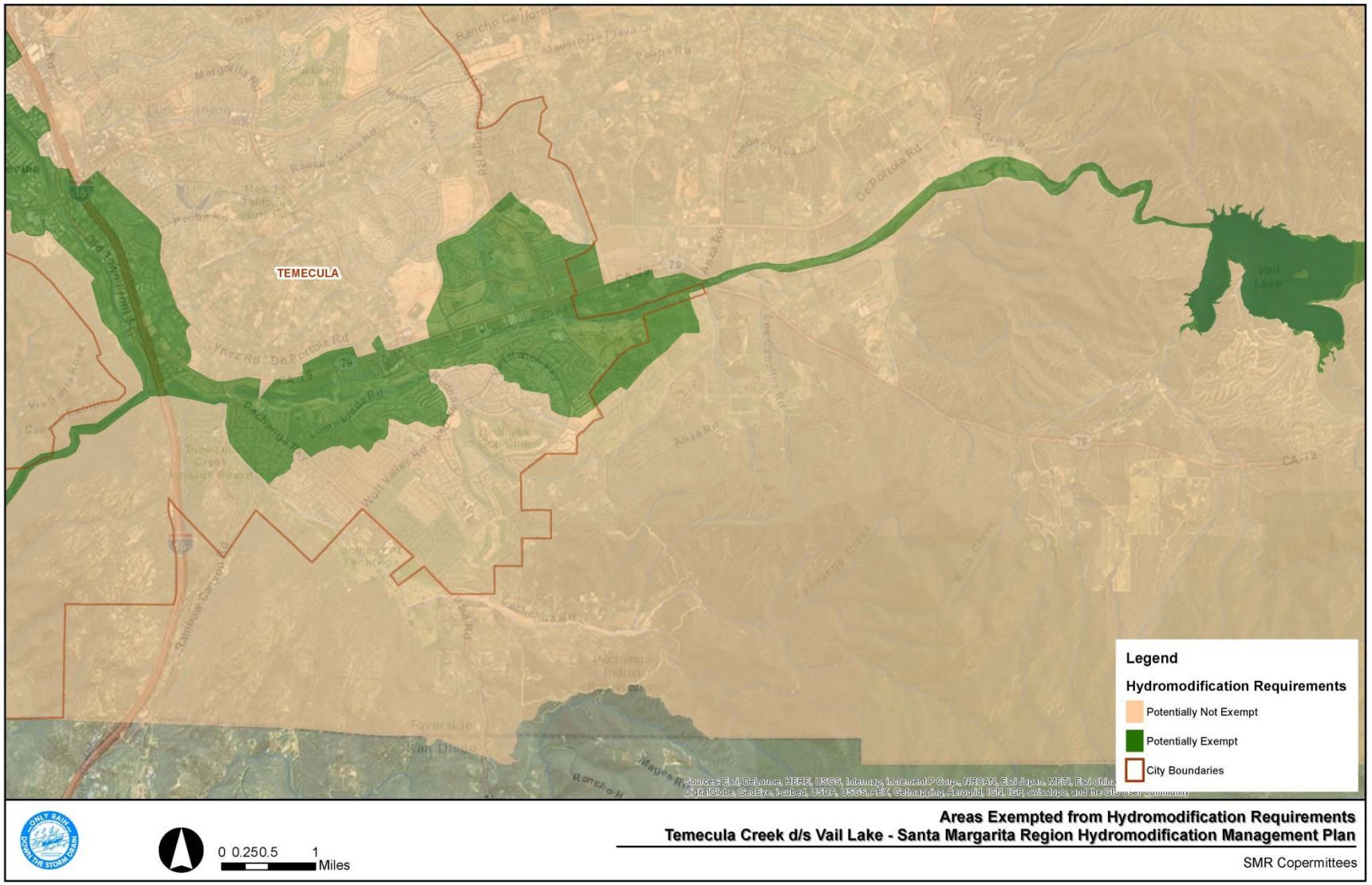


Figure 12 - SMR Exemption Area – Temecula Creek downstream of Vail Lake



3.2.ii Exemption for Large River Reaches

Effects of cumulative watershed impacts are minimal in channel reaches of large depositional rivers. These large rivers typically have very wide floodplain areas when in the natural condition or are stabilized when in the engineered condition, and are of low gradient.

The results of a flow duration curve analysis that was performed for the San Diego River are presented in the San Diego County HMP. This analysis demonstrated that the effects of cumulative watershed impacts are minimal in those reaches for which the contributing drainage area exceeds 100 square miles and with a 100-year design flow in excess of 20,000 cfs. Development and redevelopment projects that discharge either directly or via an engineered and regularly maintained MS4 facility designed to convey the 10-year ultimate condition into such large river channels are hence exempt from the SMR HMP requirements, provided that properly sized energy dissipation is implemented at the outfall location. As identified in the SMR Hydromodification Susceptibility Study (See APPENDIX D), all exempt river reaches, which are presented in **Table 5** have a drainage area larger than 100 square miles and a 100-year design flow higher than 20,000 cfs. **Table 5** also provides the corresponding upstream and downstream limits to define the exempted reach.

Table 5 - Exempt Channel Reaches in the Santa Margarita Region

River	Downstream Limit	Upstream Limit
Murrieta Creek	Confluence with Santa Margarita River	Above Warm Springs Creek
Temecula Creek	Confluence with Santa Margarita River	Outlet of Vail Lake
Santa Margarita River	Pacific Ocean	At Origin

3.3 PDP Requirements

A proposed PDP that is not located in an exemption zone (see **Figure** , **Figure** , or **Figure**) must meet the HMP Performance Standards defined in **Section 2.1**, following the guidelines described in this section. The User may refer to **Figure** , **Figure** , and **Figure** to identify a potential exemption from Hydromodification requirements. To confirm the eligibility to an exemption from Hydromodification requirements, if any, the User must identify in the Preliminary WQMP:

- The list of successive MS4 facilities and Receiving Waters that the project site is tributary to, from the point of discharge of the project site to an exempt Receiving Water. Exempt Receiving Waters are identified in **Section 3.2**.
- For each listed MS4 facility or Receiving Water, if bed and banks are artificially hardened or concrete-lined.

The exemption from Hydromodification requirements will be considered by the Copermittee having jurisdiction over the project site, if all MS4 facilities and Receiving Waters to an exempt Receiving Water, are concrete-lined and/or artificially hardened.

The User may associate the size and type of the PDP to one of the following Categories and meet all the HMP Performance Standards outlined for that category:

- Category 1 – New Development Projects exceeding one acre or Redevelopment Projects over one acre
- Category 2 – Small-sized projects less than one acre yet defined as a PDP and Copermittee roadway projects

Proposed PDPs face different levels of spatial, environmental, financial, technical, and permitting constraints based on their size and type. As such, the 2010 SMR MS4 Permit was translated into HMP Performance Standards that are specific and adapted to each Category. The definition of each Category was principally derived from the elements of the 2010 SMR MS4 Permit, as well as from a review of the other HMPs (Santa Clara, Alameda, Sacramento, San Diego, and South Orange County). Most individual single-family residential projects will be exempt from the HMP Performance Standards.

The following subsections describe the HMP Performance Standards specific to each Category.

3.3.i Category 1 – PDPs over One Acre

Category 1 PDPs will be subject to a number of spatial, environmental, financial, technical, and permitting constraints.

Hydrologic Control and Sediment Supply BMPs to ensure compliance with the HMP Performance Standards are described in **Section 2.1**. Using this approach, management of both flow and duration is achieved through onsite Hydrologic Control BMPs or implementation of hydrologic controls through a regional or sub-regional BMP that accepts discharges from the project, but is located outside of the project boundaries, and sediment loss is addressed through Sediment Supply BMPs.

If allowed by the Copermittee with jurisdiction over the project site, a PDP that is greater than 100 acres or a PDP in a common development plan that exceeds 100 acres may implement Comprehensive Regional BMPs. Comprehensive Regional BMPs must address the incremental impacts of the PDP on the receiving channels from a regional perspective. The User must delineate the subwatersheds that include entirely the project site to demonstrate compliance with the water quality, hydrologic, and fluvial geomorphologic objectives from a regional perspective. The following objectives must be addressed in implementing Comprehensive Regional BMPs:

- Water Quality Objectives, LID site principles, LID BMPs to capture or biotreat the Design Capture Volume (DCV), and HMP Performance Standards in consistency with the requirements set forth in the SMR WQMP;
- Copermittee and regional hydrologic objectives to manage increases in runoff peak discharges and increases in runoff volumes for the 10-year and 100-year frequency storm events, in consistency with the drainage requirements set forth by the Copermittee having jurisdiction over the project;

- Fluvial geomorphologic objectives to manage the adverse impacts of the PDPs over the existing aggradation/degradation of the receiving channel, and the existing stability and erosion of the receiving channels for the 10-year and 100-year frequency storm events, in consistency with the drainage requirements set forth by the Copermittee having jurisdiction over the project.

A PDP may benefit from the implementation of Comprehensive Regional BMPs instead of separate Hydrologic Control BMPs to address NPDES and Local Drainage requirements through the reduction of the overall footprint of Hydrologic Control BMPs, the simplification of the required MS4 facilities, the streamlined maintenance of facilities for optimal operability, and the potential to create multi-use facilities.

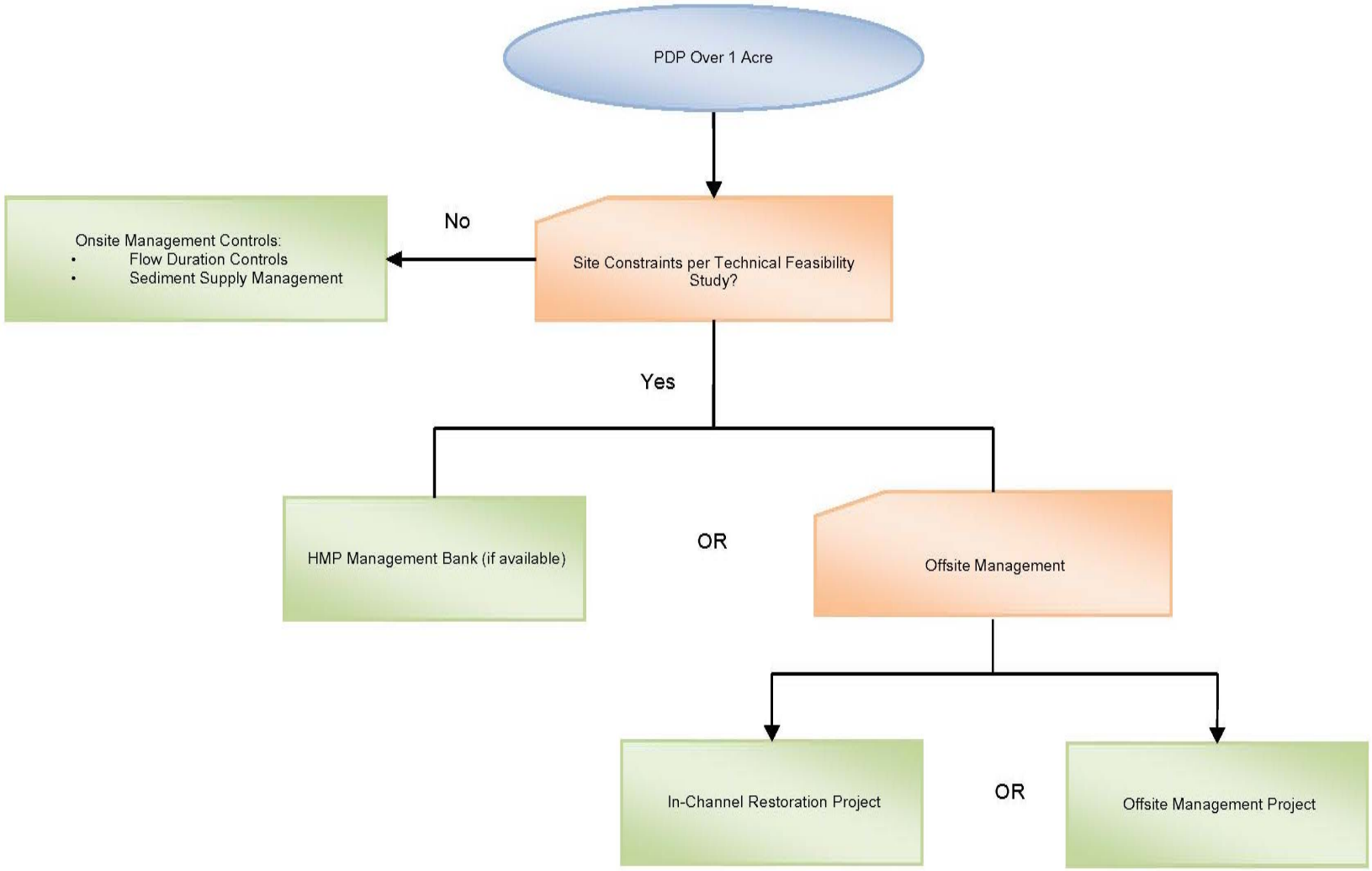
Comprehensive Regional BMPs may be onsite or offsite Hydrologic Control BMPs implemented to address regional water quality, hydrologic, and fluvial geomorphologic objectives consistent with the framework of a regional technical study. Comprehensive Regional BMPs will typically be larger detention facilities with a water quality component that manages the DCV, a Hydromodification component including the design of additional storage and adequate outlet structure to manage the range of geomorphically significant flows (10% of Q2 to Q10, or consistent with the guidelines provided in APPENDIX I), and a drainage mitigation component including the design of additional storage and adequate outlet structure to manage increases in runoff peak discharges, runoff volumes, receiving channel aggradation/degradation, channel erosion & channel stability.

The User must develop a regional technical study to demonstrate that the HMP Performance Standards are met for the sub-watersheds that include entirely the project site, through the implementation of Comprehensive Regional BMPs. The regional technical study must be submitted along with the Project-Specific WQMP. The User may consider the following approaches:

- For the Hydrologic Performance Standard, the User may follow Step 1 in **Section 2.2.iv**. If a HMP Management Bank is available, the PDP can pursue this option. The PDP can also pursue the in-channel restoration or rehabilitation option (Option 1 – Step 2b) identified in **Section 2.2.iv**.
- For the Sediment Control Performance Standard, the User may perform the three-step approach as described in **Section 2.3.i**. The alternative compliance will consist of modifying the hydrologic regime of onsite runoff to compensate for sediment loss, while meeting the established Hydrologic Performance Standard.

The Alternative Compliance Options to meet both the Hydrologic Control and Sediment Control Performance Standards are intrinsically related. A flow chart indicating which HMP Performance Standards should be pursued and implemented for a Category 1 project is shown in **Figure 13**

Figure 13 - Hydromodification Performance Standards for PDPs Over One Acre



3.3.ii Category 2 –PDPs less than one acre & Copermittee Roadway Projects

Category 2 PDPs are those projects disturbing an area less than one acre but defined as a PDP. Category 2 PDPs may include the following projects, as characterized by 2010 SMR MS4 Permit Provision F.1.d.(1) and Provision F.1.d.(2):

- New Development Projects that are smaller than one acre that create 10,000 square feet or more of impervious surfaces (collectively over the entire project site) including commercial, industrial, residential, mixed-use, and public projects. This category includes New Development Projects on public or private land which fall under the planning and building authority of the Copermittees.
- Projects to construct automotive repair shops, defined as a facility that is categorized in any one of the following Standard Industrial Classification (SIC) codes: 5013, 5014, 5541, 7532-7534, or 7536-7539.
- Projects to construct restaurants defined as a facility that sells prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption (SIC code 5812), where the land area for development is greater than 5,000 square feet. Restaurant projects where land development is less than 5,000 square feet must meet all WQMP requirements except for Structural Treatment BMP and numeric sizing criteria requirement F.1.d.(6) and Hydromodification requirement F.1.h.
- All hillside development projects greater than 5,000 square feet but less than one acre. This category is defined as any development which creates 5,000 square feet of impervious surface which is located in an area with known erosive soil conditions, where the development will grade on any natural slope that is 25% or greater.
- All development projects less than one acre that are located within or directly adjacent to or discharging directly to an ESA (where discharges from the development or redevelopment will enter receiving waters within the ESA), which either creates 2,500 square feet of impervious surface on a proposed project site or increases the area of imperviousness of a proposed project site to 10% or more of its naturally occurring condition. "Directly adjacent" means situated within 200 feet of the ESA. "Discharging directly to" means outflow from a drainage channel that is composed entirely of flows from the subject development or redevelopment site, and not commingled with flows from adjacent lands.
- Impervious parking lots 5,000 square feet or more and potentially exposed to runoff. Only parking lots that are less than one acre are included into Tier 3. Parking lots are defined as a land area or facility for the temporary parking or storage of motor vehicles used personally, for business, or for commerce.
- Retail Gasoline Outlets (RGOs) - This category includes RGOs that meet the following criteria: (a) 5,000 square feet or more or (b) a projected Average Daily Traffic of 100 or more vehicles per day. RGO projects that are less than one acre are included into Tier 3.

- Those Redevelopment projects less than one acre that create, add, or replace at least 5,000 square feet of impervious surfaces on an already developed site and the existing development and/or the redevelopment project falls under the project categories or locations listed in 2010 SMR MS4 Permit Provision F.1.d.(2). Where redevelopment results in an increase of less than 50% of the impervious surfaces of a previously existing development, and the existing development was not subject to WQMP requirements, the numeric sizing criteria discussed in 2010 SMR MS4 Permit Provision F.1.d.(6) applies only to the addition or replacement, and not to the entire development. Where redevelopment results in an increase of more than 50% of the impervious surfaces of a previously existing development, the numeric sizing criteria applies to the entire development.

In addition, Copermittee Roadway Projects are included in Category 2. Copermittee Roadway Projects are linear New Development or Redevelopment projects to be completed within a limited right-of-way. Category 2 includes also the following roadway projects, as defined per Permit Provisions F.1.d.(1) and F.1.d.(2):

- Streets, roads, highways, and freeways. This category includes any paved surface that is 5,000 square feet or greater used for the transportation of automobiles, trucks, motorcycles, and other vehicles. To the extent that the Copermittees develop revised standard roadway design and post-construction BMP guidance that comply with the provisions of Section F.1 of the Order, then public works projects that implement the revised standard roadway sections do not have to develop a WQMP.
- Roadway Redevelopment Projects that create, add, or replace at least 5,000 square feet of impervious surfaces. Where a roadway Redevelopment Project results in an increase of less than 50% of the impervious surface within the limits of the project, and the existing development was not subject to WQMP requirements, the numeric sizing criteria discussed in Permit Provision F.1.d.(6) applies only to the addition or replacement, and not to the entire development. Where the roadway Redevelopment Project results in an increase of more than 50% of the impervious surface within the limits of the project, the numeric sizing criteria applies to the entire project.

Attachment C of the 2010 SMR MS4 Permit identifies that:

> "Redevelopment does not include trenching and resurfacing associated with utility work; resurfacing existing roadways; new sidewalk construction, pedestrian ramps, or bike lane on existing roads; and routine replacement of damaged pavement, such as pothole repair."

The majority of Category 2 projects are completed within a limited amount of space, making it unlikely the User will be able to implement onsite Hydrologic Control and Sediment Supply BMPs. The following approaches are available:

- Implementing Hydrologic Control BMPs either within the project boundaries or through a regional or sub-regional BMP that accepts discharges from the project, but is located outside of the project boundaries and Sediment Supply BMPs to ensure compliance with

the HMP Performance Standards identified in **Section 2.1**. Using this approach, management of both flow and duration is achieved through Hydrologic Control BMPs.

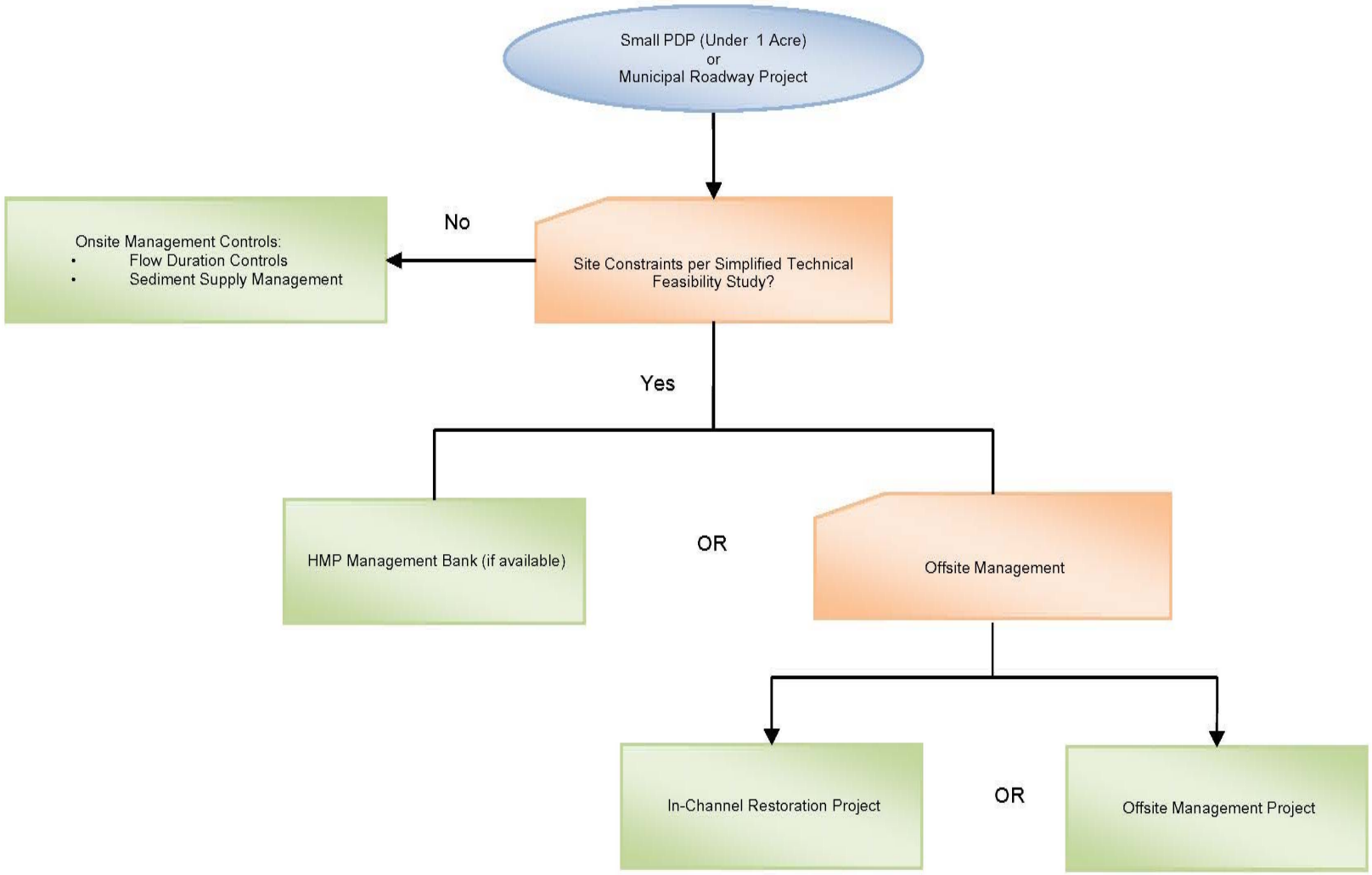
- If onsite Hydrologic Control BMPs are not technically feasible due to site constraints, a simplified technical feasibility study must be developed to explain why the HMP Performance Standards cannot be met onsite. The simplified technical feasibility study must include:

    - the soil conditions of the PDP site;
    - a demonstration of the lack of available space for onsite Hydrologic Control BMPs;
    - an explanation of prohibitive costs to implement onsite Hydrologic Control BMPs; and
    - a written opinion from a California Registered Geotechnical Engineer, who will identify the infeasibility due to geotechnical concerns.

- Once the simplified technical feasibility study is accepted by the Copermittee with jurisdiction over the project site, the User may pursue payment into the HMP Management Bank, if one exists and is available to the PDP. If not, the User must pursue either an offsite Hydrologic Control BMP project or an in-channel restoration or rehabilitation project detailed in Option 1 – Step 2b in **Section 2.2.iv**. The offsite management project or in-channel restoration will meet the hydrologic performance standard.

A flow chart indicating which HMP performance standard should be considered for a Category 2 PDP is shown in **Figure 14**.

Figure 14 - Hydromodification Performance Standards for Small Size PDPs



4.0 HMP and Model WQMP Integration

Within the SMR WQMP, the HMP Performance Standards are incorporated into Section 3.6 – Meet Hydromodification Requirements. The section also identifies HMP Performance Standards for Category 1 and 2 PDPs, as well as the methodology and steps that Users must follow to achieve compliance with these Performance Standards. The alternatives for compliance with HMP Performance Standards – Off-Site Management and 3.6.3.b) – HMP Management Bank, and Section 3.6.4 – Meet the Sediment Supply Performance Standard, respectively will also be integrated into Sections 3.6.3.a) of the WQMP.

Guidance regarding the Hydrologic Control BMP technical feasibility study has also been integrated with the LID feasibility analysis as part of Section D of the SMR WQMP Template. Section D of the SMR WQMP Template addresses evaluation of onsite conditions that may require implementation of offsite Hydrologic Control BMPs. The Copermittees will use the SMR WQMP, WQMP Template, and LID BMP Design Handbook to incorporate the HMP Performance Standards into their development approval processes via their WQMPs and ordinances.

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APPENDIX A - User Quick Start Sheet

The quick start summary lists the following steps that a User should follow for their PDP to meet the HMP Performance Standards:

1. The first step consists of verifying if the project is exempt from HMP Performance Standards. Exemption occurs:

    - If the project is not classified as a PDP per the 2010 SMR MS4 Permit Provision F.1.d.;
    - If the proposed project discharges runoff directly to an exempt Receiving Water such as an exempt river reach, or an exempt reservoir. Or, if the proposed project discharges to an engineered MS4 facility with the capacity to convey the 10-year ultimate condition that extends to the an exempt river reach or reservoir (See **Section 3.2.i**);
    - If the project discharges to a large river per the definition provided in **Section 3.2.iii;** or
    - If the project discharges to stable Receiving Waters per the results of a channel stability analysis (See **Section** Error! Reference source not found.).

2. If not exempt from HMP Performance Standards, the User should identify the Performance Standards that apply to the PDP Category of the proposed project. For specific Category Performance Standards, the User may refer to the HMP Decision Matrix referenced in **Section 3.1**and requirements listed in **Section 3.3**. These direct the User to implement, when required, Hydrologic Control and Sediment Supply BMPs following the approach listed in **Section 2.0**:

    a. Hydrologic Control BMPs

Figure 13 summarizes the options that a User may pursue to achieve Hydrologic Control Performance Standards. Prioritization of Hydrologic Control BMPs, as well as the applicability of each type of Hydrologic Control BMPs, is defined in **Figure 13**. Onsite Hydrologic Control BMPs are to be designed based on the SMRHM. Alternatively, the User may develop their own numerical criteria but should support the findings with continuous simulation models. Technical infeasibility of a type of Hydrologic Control BMP should be documented. Specifics are provided in **Section 2.2**.

Figure 13 - SMR HMP Options for Hydrologic Control BMPs

Type of Hydrologic Control BMP	Onsite	Regional	Offsite (management or in-channel restoration)	Management Bank (if available)	Green Street Project or equivalent
Large (>100 ac)	Yes	Yes	n/a	n/a	n/a
Medium (1 ac ≤A≤100 ac)	Yes - #1	n/a	Yes - #2a	Yes - #2b	n/a
Small (<1 ac)	Yes - #1	n/a	Yes - #2a	Yes - #2b	n/a
Public roadway	n/a	n/a	Yes	n/a	Yes

b. Sediment Supply BMPs

The User may follow a three-step process to ensure maintenance of the pre-project sediment supply to the channel:

1. Determine whether the site is a significant source of Bed Sediment Load to the receiving channel.
2. Avoid areas of significant Bed Sediment Load supply in the site design.
3. Replace areas of significant Bed Sediment Load supply that are eliminated through urban development.

If the three-step process is deemed infeasible, an alternative compliance option allows the User to model the site conditions and the receiving channel and provide additional management in site runoff to compensate for the reduction (or addition) of Bed Sediment Load. Specifics are detailed in **Section 2.3.ii**.

1. The User should integrate Hydrologic Control and Sediment Supply BMPs into the project site design, and define the design specifics in the preliminary project-specific WQMP that should be submitted to the Copermittee with jurisdiction over the project site. The Copermittee may approve the proposed design upon identification of compliance with the HMP Performance Standards.

APPENDIX B - Copermittee HMP Development Process

The District was the lead in the Copermittee development of the HMP. The Copermittees participated financially and through participation in HMP workshops. The workshops were scheduled over the course of the project at times corresponded with key decision points in the development of the HMP. Participants in the HMP workshops provided valuable input on the development of the HMP.

The Copermittees will continue to meet to discuss and resolve issues that may arise during HMP implementation. Participants in the HMP development process will also assist in refining and reinforcing methodologies, criteria, and standards established in the HMP.

The group of participants in the SMR HMP development process has met four times since October 2012. **Table 6** shows meeting dates, locations, and agenda items. In addition to the formal meetings, the Copermittees coordinated via email to review and discuss technical documents, deliberate on specific HMP related topics, and concur on issues.

Table 6 - SMR HMP Copermittee Meetings

Date	Location	Agenda
October 29, 2012	District, Riverside	SMR HMP Outline and Approach Presentation of the San Diego Hydrology Model Tool
December 2012	City Hall, Murrieta	Presentation and discussion of the first Draft SMR HMP Presentation and discussion of the HMP Evaluation Program Schematic
March 2013	City Hall, Temecula	Presentation and discussion of the second Draft SMR HMP Presentation and discussion of the Draft HMP Evaluation Program
April 2013	District, Riverside	SMRHM Training Workshop
May 2013	City Hall, Temecula	Presentation and discussion of the Final SMR HMP Presentation of the Final HMP Evaluation Program
June 2014	District, Riverside	Compliance document training

A Draft SMR HMP was submitted to the SDRWQCB in June 2013 and a proposed final HMP that addressed the SDRWQCBs comments was submitted on March 10, 2014. The final HMP was submitted on July 11, 2014 to address the additional SDRWQCBs comments received on April 8, 2014 and incorporate the Final SMR HMP requirements into the SMR WQMP. In addition, the Copermittees used the revised SMR WQMP to incorporate the HMP requirements into their development approval processes through their WQMPs and municipal ordinances.

As required by Permit Provision F.1.h(5)(a), the draft document was posted on the District's website in January 2013 (http://rcflood.org/NPDES/SantaMargaritaWS.aspx) for public review and comment. The Final Draft SMR HMP was also posted on the District's website for a second round of public review and comment.

APPENDIX C - State of the Hydromodification Science: A Literature Review

Pursuant to 2010 SMR MS4 Permit Provision F.1.h(1)(g), this appendix provides the results of a literature review conducted as a basis for the development of the HMP.

Hydromodification in the context of this HMP refers to changes in the magnitude and frequency of channel flows due to urbanization and the resulting impacts on the receiving channels in terms of erosion, sedimentation, and degradation of in-channel habitat. The processes involved in aggradation and degradation are complex, but may be affected by an alteration of the hydrologic regime of a watershed due to increases in impervious surfaces, more efficient MS4 facilities, and a change in historic sediment supply sources, among other factors. The study of Hydromodification is an evolving field, and regulations to manage the impacts of Hydromodification must be grounded in the latest science available.

HMPs seek ways to manage Hydromodificaton that may result from urban development by establishing requirements for controlling runoff from New Development and Redevelopment projects. In order to establish appropriate requirements for New Development and Redevelopment, it is important to understand 1) how land use changes alter stormwater runoff; and 2) how these changes can impact receiving channels. These and other issues central to HMPs adopted in California have been addressed in numerous journal articles, books, and reports. This literature review builds upon previous literature reviews developed for the South Orange County HMP and the San Diego County HMP, including recent studies or information relevant to Southern California.

C.1. Hydromodification Management Concepts

There are many different approaches to managing Hydromodification impacts from urban development, and most HMPs provide multiple options for achieving and documenting compliance with National Pollutant Discharge Elimination System (NPDES) MS4 permit requirements. In general, hydrograph management approaches focus on managing runoff from a developed area to not increase instability in a channel, and in-channel solutions focus on managing the receiving channel to accept an altered flow regime without becoming unstable. This section briefly summarizes various approaches for HMP compliance.

C.1.1. Stability of Alluvial Channels

Southern California channels typically combine steep slopes and erodible materials with a predominance of sand and gravel substrates, which may be assimilated to alluvial channels (SCCWRP, 2011). An exchange of material between the inflowing sediment load and the bed and banks of the channel is established, thus creating a constant adjustment of the channel's width, depth, slope, and planform in response to changes in water or sediment discharge (NEH, 2007). A channel planform is defined as the horizontal alignment of a channel as observed from a point

perpendicular to the Earth's surface (USDA, 2007). Natural alluvial channels constantly form their geometry by moving boundary material to react to changes in precipitation and the rate of tectonic uplift. Lane's interrelationship (1955) conceptualizes this balance between hydrologic and geomorphic processes for alluvial channels:

$$Q_s \times D_{50} \propto Q_w \times S$$

Where:

Q_s = Sediment discharge

D_{50} = Median sediment size

Q_w = Flow

S = Channel Slope

As seen by Lane's interrelationship, if any of the four variables is altered, one or more of the remaining variables must change.

Due to natural and/or man-made conditions, such as construction of Vail Lake and Skinner Reservoir, a majority of channels within the SMR are dynamically adjusting to a new geomorphic equilibrium corresponding to the altered hydrology and sediment transport regimes. The tributary areas to both Vail Lake and Skinner Reservoir consist primarily of mountainous highlands, with narrow, deeply incised drainages whose rate of incision is naturally dependent on precipitation and the rate of tectonic uplift. In addition, the construction of Vail Dam and Skinner Reservoir and historical urbanization within the SMR have progressively altered the hydrology and sediment transport regimes in the downstream channels. Approximately two-thirds of the Upper Santa Margarita River Watershed is controlled by these dams, which conserve virtually all of the runoff for municipal, industrial and agricultural use. Recent observations of the downstream channels show that the latter are still geomorphically adjusting to the altered hydrology and sediment transport regimes. Downstream of the constructed dams, the reduction in frequency and magnitude of discharges into Temecula Creek and Tulacota Creek has resulted in a significant reduction of the cumulative work performed in those downstream channels (See Section C.2.1.), which may result into increased aggradation of Temecula Creek, Tulacota Creek, and their respective downstream reaches. In essence, the SMR is a dynamic system that is still converging towards a geomorphic equilibrium.

In addition to Vail Lake and Skinner Reservoir, the Permittees have constructed a significant storm drain infrastructure to control storm water discharges from urbanized areas and provide an adequate level of protection against flooding hazards in urbanized communities. Currently, two-thirds of the SMR are controlled by controlled-release points, or flood control basins that effectively reduce the magnitude and frequency of incoming storm water discharges. In areas tributary to those controlled-release points, increases in runoff discharge, magnitude, and frequency associated with future urbanization are managed to ensure the long-term stability of downstream channels, thus resulting in aggradation in those downstream channels.

For those channels that are not influenced by dams and controlled-release points, urban development in the upstream reaches will usually result in increased runoff, causing an

incremental reduction in channel slope (S) through downcutting or increased channel meander to the existing dynamic adjustment due to the construction of Vail Dam and Skinner Reservoir. Urban development may also result in incremental change in sediment discharge (Qs). Bed sediment load is derived from the channel bed and banks. If channels are altered by urban development in such a way as to reduce or increase sediment discharge, instability may occur.

Only a portion of the total sediment load in a channel is important for channel stability. Total channel sediment load may be classified by size or transport mechanism. The wash load commonly refers to the portion of the total sediment load that remains continuously in suspension (based on particle size). The wash load has a nominal impact on channel stability. Bed sediment load refers to the material that moves along the channel bed via Saltation, and is continuously in contact or exchange with the channel bed. Bed sediment load is the critical portion of total sediment discharge for channel stability.

C.1.2.Hydrologic Management Measures

Facilities that detain or infiltrate runoff to manage development impacts are the focus of most HMP implementation guidance. They work by either reducing the volume of runoff (infiltration facilities) or holding water and releasing it below the critical flow (Qc) (detention facilities). These facilities, also referred to as Hydrologic Control BMPs, can range from regional detention basins designed solely for flow control, to bioretention facilities that serve a number of functions. A number of Hydrologic Control BMPs, including swales, bioretention, flow-through planters, and extended detention basins have been developed to manage stormwater quality, and several resources describe the design of stormwater quality BMPs (CASQA 2003; Richman et al. 2004). In many cases, these facilities can be designed to also meet Hydrologic Performance Standards.

Many HMPs also provide guidance for applying LID approaches to site design and land use planning to preserve the hydrologic cycle of a watershed and manage Hydromodification impacts. These plans typically include decentralized stormwater management systems and protection of natural drainage features, such as wetlands and channel corridors. Runoff is typically directed toward infiltration-based stormwater BMPs that slow and treat runoff. Hydrologic Control BMPs differ from those used to meet Water Quality Objectives in that they focus more on generating a flow duration curve that matches or reduces the undeveloped flow duration curve than on removing potential Pollutants, although these two functions can be combined into one facility. Various methods exist for sizing Hydrologic Control BMPs.

- **Hydrograph Matching** uses an outflow hydrograph for a particular site that matches closely with the pre-project hydrograph for a design storm. This method is most traditionally used to design flood-detention facilities to manage for a particular storm recurrence interval (e.g., the 100-year storm). Although hydrograph matching can be employed for multiple storm recurrence intervals, this method generally does not take into account the smaller, more frequent storms that are identified by the actual state of the science as performing a majority of the erosive work on channels and is therefore not widely accepted for HMP compliance nor recommended for use as a part of this HMP.

- **Volume Control** matches the pre-project and post-construction runoff volume for a project site. Any increase in runoff volume is either infiltrated onsite, or discharged to

another location where channels will not be impacted. The magnitude of peak flows and Time of Concentration is not controlled, so while this method ensures there is no increase in total volume of runoff, it can result in higher erosive forces during storms.

- **Flow Duration Control** matches or reduces both the duration and magnitude of a specified range of storms. The entire hydrologic record is taken into account, and pre-project and post-construction runoff magnitudes and volumes are matched as closely as possible. Excess runoff is either infiltrated onsite or discharged below Qcp (Geomorphically critical flow – 10% of the 2-year flow).

The Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVUPPP) HMP reviewed each of these methods and concluded that a Flow Duration Control approach was the most effective in controlling erosive flows. Two examples were evaluated using this approach, one on the Thompson Creek subwatershed in Santa Clara Valley and one on the Gobernadora Creek watershed in Orange County. The evaluation approach used continuous simulation modeling to generate flow duration curves, and then designed a test Hydrologic Control BMP to match pre-project durations and flows.

In addition to the SCVURPP HMP, the flow duration control approach has been applied by the Alameda Countywide Clean Water Program, San Mateo County Water Pollution Prevention Plan, the Fairfield-Suisun Urban Runoff Management Program, Contra Costa Clean Water Program, San Diego County, and South Orange County. Among these agencies, different approaches have emerged on how to demonstrate that proposed Hydrologic Control BMPs meet flow duration control guidelines. Both methods employ continuous simulation to match or reduce flow durations, but differences exist in how continuous simulation is used (site-specific simulation vs. unit area simulation). Differences also exist in the focus of the two approaches (regional detention facilities vs. onsite LID facilities). Both approaches were evaluated by the different RWQCBs and deemed valid (Butcher 2007).

Other existing HMPs have defined an approach to design and implement hydrologic control BMPs, including Counties of the Bay Area and Contra Costa County.

BAHM Approach

The Bay Area Hydrology Model (BAHM) is a continuous simulation rainfall runoff hydrology model developed for ACCWP, SMCWPPP, and SCVURPP. It was developed from the Western Washington Hydrology Model, which focuses primarily on meeting Hydromodification Management Performance Standards using stormwater detention ponds alone or combined with LID facilities (Butcher 2007). The Western Washington Hydrology Model is based on the Hydrologic Simulation Program – FORTRAN (HSPF) modeling platform, developed by the USEPA, and uses HSPF parameters in modeling watersheds.

Users who want to size a Hydrologic Control BMP select the location of their project site from a map of the Bay Area and BAHM correlates the project location to the nearest rainfall gauge and applies an adjustment factor to the hourly rainfall for the nearest gauge, to produce a weighted hourly rainfall at the project site. The User then enters parameters for the proposed project site describing soil types, slope, and land uses. BAHM then runs the continuous rainfall-runoff

simulation for both the pre-project and the post-construction conditions of the project site. Output is provided in the form of flow duration curves that compare the magnitude and timing of storms between the pre-project and the post-construction modeling runs.

If an increase in flow durations is predicted, the User can select and size Hydrologic Control BMPs from a list of modeling elements. An automatic sizing subroutine is available for sizing detention basins and outlet orifices that matches the flow duration curves between the pre-project scenario and a post-construction management scenario. Manual sizing is necessary for other Hydrologic Control BMPs included in the program, such as storage vaults, bioretention areas, and infiltration trenches. The program is designed so that, once a Hydrologic Control BMP is selected and sized, the modeling run can be transferred to the Copermittee with jurisdiction over the project site for approval. The Copermittee model reviewer can launch the program and verify modeling parameters and sizing techniques.

A HMP tool was also developed to support Users with the San Diego County HMP. The San Diego Hydrology Model (SDHM) derives from the BAHM, and integrates parameters that are specific to San Diego County. Similarly, the South Orange Hydrology Model (SOHM) was developed for the purposes of the South Orange County NPDES Permit.

A similar approach will be used for the SMR HMP. The Western Washington Continuous Simulation Hydrology Model (WWHM) has been modified to include local rainfall and loss rate information, in addition to preferred local BMP selection to provide Users a user-friendly tool to develop a Hydromodification management strategy. The SMRHM allows the user to match or reduce the flow duration curve for the selected range of flows using locally preferred BMPs.

Contra Costa Clean Water Program (CCCWP) Approach

The CCCWP developed a protocol for selecting and sizing Hydrologic Control BMPs, which are referred to as Integrated Management Practices (IMPs) in their guidebook. Instead of a User running a site-specific continuous simulation to size Hydrologic Control BMPs, the CCCWP provides sizing factors for designing site level IMPs. Sizing factors are based on the soil type of the project site and are adjusted for Mean Annual Precipitation. Sizing factors are provided for bioretention facilities, flow-through planters, dry wells and a combination cistern and bioretention facility.

Sizing factors were developed through continuous simulation HSPF modeling runs for a variety of development scenarios. Flow durations were developed for a range of soil types, vegetation and land use types, and rainfall patterns for development areas in Contra Costa County. Then, based on a unit area (one acre) of impervious surface, flow durations were modeled using several IMP designs. These IMPs were then sized to achieve flow control for the range of storms required, (from 10% of the 2-year storm up to the 10-year storm). These sizing factors were then transferred to a spreadsheet form for use by Users.

The primary difference between the CCCWP approach and the BAHM approach is the level of modeling required. The CCCWP approach is simplified for the User in that both Hydromodification and water quality management is incorporated into the IMP sizing factors. The BAHM allows for more flexibility in that regional BMPs may be used to meet

Hydromodification Performance Standards, and if desired, water quality, in addition to site level approaches. The 2010 SMR MS4 Permit allows for offsite management of Hydromodification, if the onsite infeasibility of Hydrologic Control BMPs has been demonstrated. Therefore, an approach that uses continuous simulation to assess regional or neighborhood level BMP implementation is preferred for this HMP.

C.1.3. Sediment Management Measures

Urban development can reduce the mass of Bed Sediment transported through the elimination of alluvial channel sections. This occurs in site development when first-order and particularly larger channels are lined or placed into underground conduits. First-order channels are identified as the unbranched channels that drain from headwater areas and develop in the uppermost topographic depressions, where two or more contour crenulations (notches or indentations) align and point upslope (NEH, 2007). First-order channels may, in fact, be field ditches, gullies, or ephemeral gullies (NEH, 2007).

There are two general approaches for managing the Bed Sediment Load relative to urbanization and channel stability. The first approach attempts to correct for the change in Bed Sediment Load material load by increasing or decreasing the discharge rate as appropriate to generally maintain the balance between hydrologic and geomorphic processes as conceptualized in Lane's interrelationship. While theoretically a sound approach, this option requires a significant amount of detailed information that is difficult to obtain and requires good calibration of sediment models.

Sediment transport models are non-linear and relatively sensitive to the rate of sediment supply and particle size distribution. This HMP does not recommend any specific sediment transport equation or model as the selection of such a model should be based on channel and watershed specific information, and the amount and quality of available data. Examples of sediment transport equations the designer may consider include: Duboys Formula, Meyer-Peter Formula, Einstein Bed Load Function, Modified Einstein Procedure, Colby's Method, Engelund and Hansen Method, Ackers and White Method. There are several models that use these transport formulas to predict long-term sediment transport. General guidance for site-specific analysis is provided in APPENDIX H

The second approach to maintaining sediment supply is physically based, relying on a field assessment of site locations that may supply Bed Sediment Load to the receiving channel, and protecting those sources during the site planning and development process. With this approach, the User will only provide engineered solutions for flow management. Protection of site Bed Sediment Load sources is the preferred approach since it is physically based and potentially less prone to error. Guidelines for field assessment of Bed Sediment Load sources are provided with the sediment control management approach, which is described in **Section 2.3**.

C.1.4. In-Channel Stabilization Solutions

In-Channel solutions focus on managing the channel corridor to provide stability, modifying the channel to accept an altered flow regime. In cases where development is proposed in a watershed with an impacted channel it may be beneficial to focus on rehabilitating the channel to match the new independent variables of channel cross section, sediment discharge, flow discharge and channel slope rather than retrofitting the watershed or only controlling a percentage of the runoff with onsite controls. This type of approach can restore channel functions, beneficial uses, and values at a much more rapid pace, especially in locations that cannot physically be returned to their natural state due to changes in channel alignment and restrictions on the channel cross section due to adjacent development. In addition, in some cases where a master planned watershed development plan is being implemented it may be more feasible to design a new channel to be stable under the proposed watershed land use rather than to construct distributed onsite facilities.

In-channel stabilization and restoration solutions are available as alternative compliance as a part of the SMR HMP. In-channel restoration projects are available if onsite Hydrologic Control BMPs are not feasible and it has been determined that the receiving water that the project discharges to has impacts due to Hydromodification. Tiered benefits (benthic communities, morphology) of such in-channel restoration projects must offset the hydrologic and sediment changes induced by the associated PDP(s).

A number of methods exist for managing channels to accept altered flow regimes and higher shear forces. These have been covered in detail in a number of sources available to watershed groups and public agencies. A few helpful sources include Riley 1998, Watson and Annable 2003, and FISRWG 1998.

C.1.5. Channel Susceptibility – Domain of Analysis

Southern California Coastal Water Research Project (SCCWRP) has developed a series of screening tools that evaluate the susceptibility of a channel to Hydromodification impacts (SCCWRP, 2010). These screening tools allow a User to rate the susceptibility of the evaluated channel to erosion for a variety of geomorphic scenarios including alluvial fans, broad valley bottoms, incised headwaters, etc.

The development of HMPs in most Southern California counties is correlated to the ultimate findings of SCCWRP studies on Hydromodification (SCCWRP, 2008 through 2011). It is generally acknowledged that SCCWRPs formulation of regional standards for Hydromodification management may serve as a baseline for development of HMP Performance Standards for specific regions in Southern California.

When evaluating the channel susceptibility though the SCCWRP screening tools, a domain of analysis is defined. This domain of analysis corresponds to the reach lengths upstream and downstream from a project from which Hydromodification assessment is required. The domain of analysis determination includes an assessment of the incremental flow accumulations downstream of the site, identification of grade control points in the downstream channel, and quantification of downstream tributary influences. The SMR program elected not to perform the

extensive susceptibility mapping required to correlate channel reaches with variable low flow discharge thresholds, since the return on investment for this type of analysis appears to be very low.

The effects of Hydromodification may propagate for significant distances downstream (and sometimes upstream) from a point of impact such as a MS4 outfall. Accordingly, the domain of analysis serves as a representative buffer domain across which the susceptibility of a channel should be evaluated. This representative domain spans multiple channel types/settings, and is defined as follows in this HMP (SCCWRP, 2010):

Proceed downstream until reaching the closest of the following:

- at least one reach downstream of the first grade-control point (but preferably the second downstream grade-control location)
- tidal backwater/lentic waterbody
- equal order tributary (Strahler 1952)
- a two-fold increase in drainage area

OR demonstrate sufficient flow attenuation through existing hydrologic modeling.

Proceed upstream to extend the domain for a distance equal to 20 channel widths or to grade control in good condition – whichever comes first. Within that reach, identify hard points that could check headward migration, evidence that head cutting is active or could propagate unchecked upstream

Within the analysis domain there may be several reaches that should be assessed independently based on either length or change in physical characteristics. In more urban settings, segments may be logically divided by road crossings (Chin and Gregory, 2005), which may offer grade control, cause discontinuities in the conveyance of water or sediment, etc.

The domain of analysis is discussed here since it may be relevant for use in site-specific analysis as discussed in APPENDIX H . It is not used in this HMP as a discriminator for HMP applicability to a specific project.

C.2. Flow Duration Control Approach

C.2.1. Effects of Urban Development and Critical Flow

The effects of urban developments on channel response have been the focus of many studies (see Paul and Meyer, 2001 for a review), and the widely accepted consensus is that increases in impervious surfaces associated with urbanizing land uses can cause channel degradation. Urban development generally leads to a change in the amount and timing of runoff in a watershed, which may increase erosive forces on channel bank and bed material and can cause large-scale channel enlargement, general scour, channel bank failure, loss of aquatic habitat, and degradation of water quality.

Channel erosion is a complex process subject to a variety of influences. Channel erosion is non-linear (Philips 2003), meaning the response of channels is not directly proportional to changes in land use and flow regimes. Small changes or temporary disturbances in a watershed may lead to unrecoverable channel instability (Kirkby 1995). These disturbances may give rise to feedback systems whereby small instabilities can be propagated into larger and larger instabilities (Thomas 2001).

A number of studies have sought to correlate the amount of urban development in a watershed and channel instability (Bledsoe 2001; Booth 1990, 1991; Both and Jackson 1997; MacRae 1992; 1993; 1996; Coleman et al. 2005). Evidence from these studies suggests that below a certain threshold of watershed imperviousness, channels maintain stability. This threshold or imperviousness transition zone appears to be around seven to 10% watershed urbanization for perennial channels (Schueler 1998 and Booth 1997), but may begin at a lower level for intermittent channels such as those found in Southern California. Studies done in Santa Fe, New Mexico (Leopold and Dunne 1978) suggest that changes occur at 4% impervious area of the watershed.

Initial studies by Coleman et al. (2005) suggest that a response in the channel may begin to occur at two to 3% watershed imperviousness for intermittent channels in Southern California. It is important to understand that use of impermeable cover alone is a poor predictor of channel erosion due to differences in stormwater detention and infiltration within regions.

In highly urbanized watersheds returning a channel to a natural condition is infeasible due to existing development in the watershed. In these scenarios the focus should be on in-channel restoration to restore the beneficial uses of the Receiving Water.

Though it is well established that watershed urbanization causes channel degradation, a detailed understanding of how development alters runoff and how this altered runoff in turn causes erosion is still being developed.

The ability to transport sediment is proportional to the amount of flow in the channel: as flow increases, the amount of sediment moved within a channel also increases. The ability of a channel to transport sediment is termed stream power, which integrated over time is work. Leopold (1964) introduced the concept of effective work, whereby the flow-frequency relationship of a channel is multiplied by sediment transport rate. This gives a mass-frequency relationship for erosion rates in a channel. Flows on the lower end of the relationship (e.g., two-year flows) may transport less material, but occur more frequently than higher flows, thereby having a greater overall effect on the work within the channel. Conversely, higher magnitude events, while transporting more material, occur infrequently causing less effective work. Leopold found that the maximum point on the effective work curve occurred around the 1-to 2-year frequency range. This maximum point is commonly referred to as the dominant discharge. It corresponds roughly to a bankfull event (a flow that fills the active portion of the channel up to a well-defined break in the bank slope).
The constructions of Vail Lake, Skinner Reservoir, and Diamond Valley Reservoir have effectively created man-made sumps capturing the majority of incoming storm water flows from Temecula Creek, Wilson Creek, Kolb Creek, and Tucalota Creek. At these reservoirs, stormwater may only overtop the spillway(s) and be discharged into the downstream channels during higher magnitude events (10-year and higher magnitude events). Since the completion of the dams, the

reduction in frequency and magnitude of discharges into Temecula Creek and Tulacota Creek has resulted in a significant reduction of the cumulative work performed in those downstream channels.

Urban development tends to have the greatest relative impact on flows that are frequent and small, and which tend to generate less-than-bankfull flows. Change is greatest in these events because prior to urban development, infiltration would have absorbed much or all of the potential runoff, but following urban development, a high percent of the rainfall runs off. Thus, events that might have generated little or no flow in a non-urbanized watershed can contribute flow in urban settings. These smaller less-than-bankfull events have been found to cause a significant proportion of the work in urban channels (MacRae 1993) due to their high frequency, and can lead to channel instability. Less frequent, larger magnitude flows (e.g., flows greater than Q10) are less strongly affected by urban development because during such infrequent storm events, the ground rapidly becomes saturated, and acts (for purposes of runoff generation) in a similar manner as impervious surfaces.

Due to the increase in impervious surfaces and fewer opportunities for infiltration of stormwater, urban development creates a higher runoff rate and more runoff volume than an un-urbanized watershed. Opportunities for infiltration of excess stormwater exist in urbanized areas, but many times are infeasible due to cost, technical barriers or land use constraints. Therefore, some of the excess stormwater must be discharged to a receiving channel. In order to achieve a comparable Ep to a pre-developed condition, this excess runoff volume must be discharged at a rate at which insignificant effective channel work is done.

The Bed Sediment Load moves through transmission of shear stress from the flow of water on the channel bed. An increase in the hydraulic radius (measure of channel flow efficiency through a ratio of the channel's cross sectional area of the flow to its wetted perimeter) corresponds to an increase in shear stress. In order to initiate movement of Bed Sediment Load, however, a shear stress threshold must be exceeded. This is commonly referred to as Critical Shear Stress, and is dependent on sediment and channel characteristics. For a given point on a channel where the bed composition and cross-section is known, the Critical Shear Stress can be related to a flow. The flow that corresponds to the Critical Shear Stress is known as the critical flow, or Qc. For a given cross-section, flows that are below the value for Qc do not initiate Bed Sediment Load movement, while flows above this value do initiate Bed Sediment Load movement.

C.2.2. Geomorphically-Significant Flows in Existing HMPs

SCVURPPP expressed Qc as a percentage of the two-year flow in order to develop a common metric across watersheds of different size, and allow for easy application of HMP performance standards. For the two watersheds studied in detail in the SCVURPPP study, a similar relationship was found where Qc corresponded to 10% of the two-year flow. Several methodologies were used to determine both the two-year flows and the ten-year flows across the evaluated watersheds. The two-year flow was computed based on either the rational method, as described in the Santa Clara Valley Hydrology Procedures, or the Cunnane ranking schema applied to "all event frequency" curves. The ten-year flow was computed based on the Log Pearson type III distribution applied to annual flow frequency curves. This became the basis for

the lower range of geomorphically significant flows under the SCVURPPP HMP and is referred to as Qcp to indicate that it is a percentage of flow. That program also adopted the 10-year flow as the upper end of the range of flows to control with the justification that increases in channel work above the 10-year flow were small for urbanized areas.

A similar study was conducted for the Fairfield-Suisun Urban Runoff Management Program (FSURMP) on two watersheds in Fairfield, California following a geomorphic assessment. That study found Qcp to be 20%t of the pre-development two-year flow. The differences in the two values may be attributable to differences in watershed characteristics in Santa Clara County and Fairfield, the number of channels studied, the methodology used to compute the two-year flow, and the precision of the modeling tools. Channels in Fairfield were found to have a more densely vegetated riparian corridor and may have a higher resistance to increases in shear stresses (FSURMP). Values for Qcp appear to be similar among neighboring watersheds, but there appears to be a range of appropriate Qcp values. The characteristics of individual biomes (climatically and geographically defined areas of ecologically similar climatic conditions, such as communities of plants, animals, and soil organisms, often referred to as ecosystems) should be taken into account when developing a Qcp. For example, Western Washington State, which has more densely vegetated riparian zones than either Fairfield or Santa Clara County, has adopted a Qcp of 50% of the 2-year flow.

The Santa Clara HMP focused on using detention basins for Hydromodification management and emphasized the lower flow control limit for site runoff. Extended detention Hydrologic Control BMP basins can be constructed with multi-stage outlets to manage both the duration and magnitude of flows within a prescribed range. To avoid the erosive effects of extended low flows, the maximum rate (depth) at which runoff is discharged is set below the erosive threshold. Per the Santa Clara HMP, the lower flow control limit was defined as the flow rate that generates critical shear stress on the channel bed and banks. Both Santa Clara and Alameda Counties correlated the lower flow control limit to a value equal to 10% of the 2-year runoff event.

The Contra Costa HMP emphasized the importance of using LID methods to meet Hydromodification Performance Standards. LID approaches to Hydrologic Performance Standards rely on site design and distributed LID BMPs to control the frequency and duration of flows, and to manage hydrograph modification impacts. By minimizing directly connected impervious areas and promoting infiltration, LID approaches mimic natural hydrologic conditions to counteract the hydrologic impacts of development. LID systems are sized to achieve flow control for the range of storms required (from 10% of the 2-year storm up to the 10-year storm).

The San Diego County HMP defined an adaptive lower flow threshold based on the channel susceptibility rating (high, medium, or low). Receiving channels in San Diego County were individually classified by their susceptibility to channel erosion impacts using a critical flow calculator and a channel screening tool developed by SCCWRP. This classification produced three lower flow thresholds which are 0.1Q2, 0.3Q2, and 0.5Q2. The upper range of the management flow was considered the pre-project 10-year storm event.

To date, seven approved HMPs have been published. These include HMPs for SCVURPPP (2005), the CCCWP (2005), the FSURMP (2005), the Alameda Countywide Clean Water Program

(ACCCMP 2005), the San Mateo Countywide Stormwater Pollution Prevention Program (SMCWPPP [formerly STOPPP] 2005), the San Diego County HMP (2009), and the South Orange County HMP (2012). In addition, a number of HMPs were implemented while agencies developed their final plans. Interim HMPs are not detailed in this report because these plans have adopted findings from the above listed HMPs. A summary of flow control standards adopted in each of the approved HMPs in California and western Washington is given in **Table 7**.

Table 7 - Summary of Flow Control Standards – Approved HMPs

Permitting Agency	Q_{cp}	Largest Managed Flow
Alameda County	10% of the 2-year flow (0.1Q2)	10-year flow (Q10)
Contra Costa County	10% of the 2-year flow (0.1Q2)	10-year flow (Q10)
Fairfield-Suisun Urban Runoff Management Program	20% of the 2-year flow (0.2Q2)	10-year flow (Q10)
San Diego County	10, 30, or 50 % of the 2-year flow (0.1Q2, 0.3Q2, or 0.5Q2)	10-year flow (Q10)
San Mateo County	10% of the 2-year flow (0.1Q2)	10-year flow (Q10)
Santa Clara County	10% of the 2-year flow (0.1Q2)	10-year flow (Q10)
South Orange County	10% of the 2-year flow (0.1Q2)	10-year flow (Q10)
Western Washington State	50% of the 2-year flow (0.5Q2)	50-year flow (Q50)

C.2.3. Applicable Flow Thresholds for the SMR

HMPs that have been developed in the San Francisco Bay Area, Northern California (Contra Costa, Santa Clara, and Alameda Counties and the Sacramento area), in Southern California (San Diego, South Orange Counties) vary with regard to the emphasis placed on lower flow control thresholds as compared to other approaches, such as distributed LID methods. The SMR HMP was developed using the lower flow control threshold approach. There is consensus in that both the frequency and duration of flows must be controlled using continuous simulation hydrologic modeling (rather than the standard design storm approach used for flood control design) to manage for potential development impacts. At this point, it is generally accepted that events more frequent than the 10-year flow are the most critical for Hydromodification management, since flows within this range of return period (up to the 10-year event) have been documented to perform the most work on the channel bed and banks. However, the range of analysis could potentially change in the future if new studies provide sufficient evidence warranting a modification.

Rates of sediment production from Southern California rivers depend upon bedrock geology, rates of tectonic uplift, land use, and precipitation (Warrick et al., 2003). The California Geological Survey agency identifies 13 unique geomorphic zones based on geology, faults, topographic relief, and climate (California Department of Conservation, 2002). The SMR is located within the Peninsular Ranges geomorphic zone, whose geology is characterized by the granitic rocks intruding the older metamorphic rocks. South Orange County and San Diego County are also located within the same geomorphic zone, thus exhibits similar macro-scale geomorphic trends to those in the SMR.

The approaches developed for the San Diego County HMP and the South Orange County HMP were approved by the SDRWQCB and selected as the base approach for the SMR HMP. However, the South Orange County program elected not to perform the extensive susceptibility mapping required to correlate channel reaches with variable low flow discharge thresholds. The implementation of HMPs in Northern California, and in San Diego County has shown that numerically larger low flow thresholds generally have very limited applicability in practice. Accordingly, a base low flow threshold (0.1Q2) was selected for this HMP. The selection of the low flow threshold (0.1Q2) was based on other approved HMPs in California with similar hydrologic and geologic conditions. The low flow threshold (0.1Q2) is the most conservative of the potential range identified in the San Diego HMP. Nonetheless, the User may compute a site-specific low flow threshold at their option, following a methodology developed by the User. An example of such a procedure is described in the San Diego County HMP.

If the User opts for developing a site-specific criterion, the selected lower flow threshold should correspond to the critical channel flow that produces the critical shear stress that initiates channel Bed Sediment movement or that erodes the toe of channel banks. For a channel segment that is lined but not exempt by this HMP, the low flow threshold must be computed assuming the lining has been removed.

C.3. Classification and Geomorphic Stability of Channels

Numerous channel stability assessment methods have been proposed to help distinguish which channels are most at risk from hydrograph modification impacts and/or define where HMP Performance Standards should apply. Assessment strategies range from purely empirical approaches to channel evolution models to energy-based models (see Simon et al., 2007 for a critical evaluation). Channel stability assessment methods are useful in assessing the impact of urban development or control programs over time. Their value lies in showing trends as changes in a watershed occur, rather than classifying the reach of a discrete channel section at a given point in time.

C.3.1. Empirical approaches and Models

A recent study by Bledsoe et al. (2008) for SCCWRP describes nine types of classification and mapping systems with an emphasis on assessing channel susceptibility in Southern California. The summary below is taken from that study. Bledsoe also provides a summary of the implications of these classification and mapping systems to the development of Hydromodification tools for Southern California. The article provides a detailed breakdown of guidelines for developing Hydromodification tools given the advantages and disadvantages of each system previously assessed.

General Stability Assessment Procedures

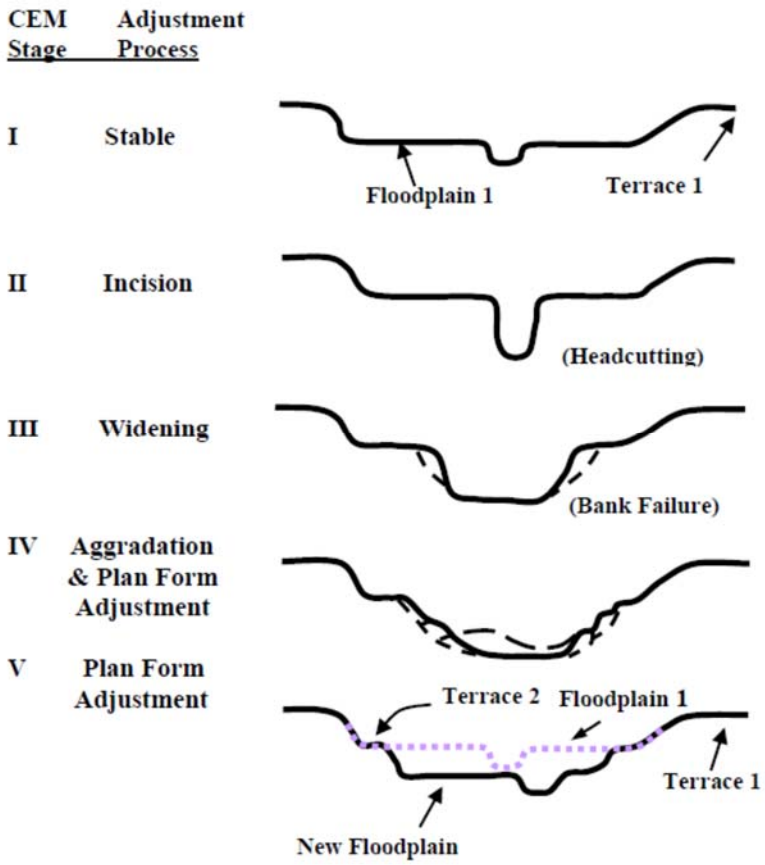
By assessing an array of qualitative and quantitative parameters of channels and floodplains, several investigators have developed qualitative assessment systems for channel and river networks. These assessment methods have been incorporated into models used to analyze

channel evolution and stability. Many parameters used to establish methodologies such as the Rosgen approach are extendable to a qualitative assessment of channel response in Californian river networks. Field investigations in Southern California have shown that grade control can be the most important factor in assessing the severity of channel response to Hydromodification. Qualitative methodologies have proven extendable to many regions, and they use many parameters that may provide valuable information for similar assessments in California.

Channel Evolution Models of Incising Channels

The Channel Evolution Model (CEM) developed by Schumm et al. (1984) posits five stages of incised channel instability organized by increasing degrees of instability severity, followed by a final stage of quasi-equilibrium. Work has been done to quantify channel parameters, such as sediment load and specific stream power, through each phase of the CEM. A dimensionless stability diagram was developed by Watson et al. (2002) to represent thresholds in hydraulic and bank stability. This conceptual diagram can be useful for engineering planning and design purposes in channel restoration projects requiring an understanding of the potential for shifts in bank stability.

Figure 15 - Five Stages of the Channel Evolution Model (CEM)



Channel Evolution models Combining Vertical and Lateral Adjustment Trajectories (Schumm et al. 1984)

Originally, CEMs focused primarily on incised channels with geotechnically, rather than fluvially, driven bank failure. Several CEMs have been proposed that incorporate channel responses to erosion and sediment transport into the original framework for channel instability. In these new systems, an emphasis is placed on geomorphic adjustments and stability phases that consider both fluvial and geomorphic factors. The state of Vermont has developed a system of stability classification that suggests channel susceptibility is primarily a function of the existing Rosgen channel type and the current channel condition referenced to a range of variability. This system places more weight on entrenchment (vertical erosion of a channel that occurs faster than the channel can widen, resulting in a more confined channel) and slope than differentiation between bed types.

Equilibrium Models of Supply vs. Transport-capacity / Qualitative Response

The qualitative response model builds on an understanding of the dynamic relationship between the erosive forces of flow and slope relative to the resistive forces of grain size and sediment supply to describe channel responses to adjustments in these parameters. In this system, qualitative schematics provide predictions for channel response to positive or negative fluctuations in physical channel characteristics and Bed Sediment. Refinements to such frameworks have been made to account for channel susceptibility relative to existing capacity and riparian vegetation among other influential characteristics.

Hierarchical Approaches to Mapping Using Aerial Photographs / GIS

It has become an increasingly common practice to characterize channel networks as hierarchical systems. This practice has presented the value in collecting channel and floodplain attributes on a regional scale. Multiple studies have exploited geographical information systems (GIS) to assess hydrogeomorphic behavior at a basin scale. Important valley scale indices such as valley slope, confinement, entrenchment, riparian vegetation influences, and overbank deposits can provide information for river networks in California. Many agencies are developing protocols for geomorphic assessment using GIS and other database associated mapping methodologies. These tools may be useful as they are further developed in a monitoring program, but are not viable at a scale useful for reach-by-reach channel analysis.

The approach taken by this HMP to monitor its effectiveness is embedded in a derivative of the channel classification approach defined by Rosgen (1996). The author distinguishes three different levels of channel classification including: 1) Level I that generally describes channel relief, landform, and valley morphology; 2) Level II that describes the morphology of a channel and associates the later to a channel type based on channel form and Bed Sediment composition. Field measurements of entrenchment, width-to-depth ratio, sinuosity, slope, and representative sampling of channel material may be suitable; and 3) Level III that assesses channel condition and departure. A channel that is geomorphically stable per Rosgen's definition is characterized by two elements: 1) Dimension, pattern, and profile of a channel are maintained over time; and 2) the transport capacity of a watershed's flows and detritus is maintained. As such, physical and biological functions of a geomorphologically stable channel remain at an optimum.

C.3.2. Channel Classification System

Planform Classifications and Predictors

Alluvial channels form a continuum of channel types whose lateral variability is primarily governed by three factors: flow magnitude, bank erodibility, and relative sediment supply. Though many natural channels conform to a gradual continuum between straight and intermediate, meandering, and braided patterns, abrupt transitions in lateral variability imply the existence of geomorphic thresholds where sudden change can occur. The conceptual framework for geomorphic thresholds has proven integral to the study of the effects of disturbance on river and channel patterns. Many empirical and theoretical thresholds have been proposed relating channel power, sediment supply and channel gradient to the transition between braiding and meandering channels. Accounting for the effects of Bed Sediment particle size has been shown to provide a vital modification to the traditional approach of defining a discharge slope combination as the threshold between meandering and braided channel patterns. The many braided planforms in Southern California indicate the need to refine and calibrate established thresholds to river networks of interest. However, at this time there is not a well-accepted model to predict how Hydromodification affects channel planform.

Energy-Based Classifications

The link between channel degradation and urbanization has been studied; however, impervious area is not the solitary factor influencing channel response. Studies have shown that the ratio between specific channel power and median Bed Sediment size D50b, where b is approximately 0.4 to 0.5 for both sand-and gravel-bed channels, can be used as a valuable predictor of channel form. Stream power, which is linearly related to the total discharge, is the most comprehensive descriptor of hydraulic conditions and sedimentation processes in channels. Several studies have been performed relating channel stability to a combination of parameters such as discharge, median Bed Sediment size, and bed slope, as an analog for stream power.

A recent study by Bledsoe et al. (2008) for SCCWRP describes nine types of classification and mapping systems with an emphasis on assessing channel susceptibility in Southern California. The summary below is taken from that study. Bledsoe also provides a summary of the implications of these classification and mapping systems to the development of Hydromodification tools for Southern California. The article provides a detailed breakdown of guidelines for developing Hydromodification tools given the advantages and disadvantages of each system previously assessed.

Sand vs. Gravel Behavior / Threshold vs. Live-Bed Contrasts

It is well recognized that the fluvial-geomorphic behavior varies greatly between sand and gravel/cobble systems. Live bed channels (of which sand channels are good examples) are systems where sediment moves at low flows, and where sediment is frequently in motion. Threshold channels, such as gravel channels, by contrast, require considerable flow to initiate Bed Sediment Load movement. Live bed channels are more sensitive to increases in flow and decreases in sediment supply than threshold channels. Scientific consensus shows that sand bed

channels lacking vertical control show greater sensitivity to changes in flow and sediment transport regimes than do their gravel/cobble counterparts. Factors such as slope, and sedimentation regimes are known to have greater impact on sand bed channels. This can be an important issue for stormwater systems receiving runoff from watersheds composed primarily of channels with sandy substrate. The transition between sand and gravel bed behavior can be rapid, enabling the use of geographic mapping methods to prioritize channel segments according to their susceptibility to the effects of Hydromodification.

Bank Instability Classifications

Early investigations provided the groundwork for bank instability classifications by analyzing shear, beam, and tensile failure mechanisms. The dimensionless stability approach developed by Watson characterized bank stability as a function of hydraulic and geotechnical stability. Rosgen (1996) proposed the widely applied Bank Erosion Hazard Index (BEHI) as a qualitative approach based on the general stability assessment procedures outlined above. Other classification systems, like the CEM, determine bank instability according to channel characteristics that control hydrogeomorphic behavior.

As required per 2010 SMR MS4 Permit Provision F.1.h(1)(a), a Hydromodification Susceptibility Study has been performed as part of this HMP effort to identify and map channel segments that may be vulnerable to Hydromodification and cause a Hydrologic Condition of Concern (HCOC). The study located in APPENDIX D helps Users determine whether or not a project will drain to a potentially susceptible channel segment.

APPENDIX D - Hydromodification Susceptibility Documentation Report and Mapping: Santa Margarita Region

Restoration and Rehabilitation Opportunities in the Santa Margarita Region (refer to Appendix D)

APPENDIX E - HSPF Pervious Land Parameters for SMRHM

Pervious Land Hydrology (PWATER) Parameters

The HSPF hydrology parameters of PWATER are divided into four sections, titled PARM1-4. PARM1 is a series of checks to outline any monthly variability versus constant parameter values within the simulated algorithm; whereas, PARM2 and 3 are a series of climate, geology, topography, and vegetation parameters that require numerical values to be input.

PARM2 involves the basic geometry of the overland flow, the impact of groundwater recession, potential snow impact due to forest cover and the expected infiltration and soil moisture storage. The main parameters of groundwater recession are KVARY and AGWRC. The infiltration and soil moisture storage parameters are INFILT and LZSN.

PARM3 involves the impact of climate temperature during active snow conditions, a wide range of evaporation parameters due to the variability of the onsite soil and existing vegetation and subsurface losses due to groundwater recharge or the existing geology. The main evaporation parameters are INFEXP, INFILD, BASETP, and AGWETP. The parameter for subsurface loss is DEEPFR, which accounts for one of only three major losses from the PWATER water balance (i.e., in addition to evaporation, and lateral and channel outflows).

PARM4 involves the flow and hydrograph characteristics, the expectation of rain interception due to the inherent moisture storage capacity from existing vegetation, land use and/or near surface soil conditions and evaporation due to the root zone of the soil profile. The main interception parameters are CEPSC and UZSN. The parameter for evaporation as a primary function of vegetation is LZETP.

PARM2

KVARY – A groundwater recession flow parameter used to describe non-linear groundwater recession rate (per inches) (initialize with reported values, then calibrate as needed). KVARY is usually one of the last PWATER parameters to be adjusted; it is used when the observed groundwater recession demonstrates a seasonal variability with a faster recession (i.e., higher slope and lower AGWRC values) during wet periods, and the opposite during dry periods. Value ranges are shown in Table A-4. Values that are representative of the conditions in South Orange County have been selected for the SOCHM. Plotting daily flows with a logarithmic scale helps to elucidate the slope of the flow recession.

AGWRC – A groundwater recession rate, or ratio of current groundwater discharge to that from 24 hours earlier (when KVARY is zero) (per day) (estimate, then calibrate).

The overall watershed recession rate is a complex function of watershed conditions, including climate, topography, soils, and land use. Hydrograph separation techniques can be used to estimate the recession rate from observed daily flow data (such as plotting on a logarithmic scale).

INFILT – Index to mean soil infiltration rate (in/hr); (estimate, then calibrate). In HSPF, INFILT is the parameter that effectively controls the overall division of the available moisture from precipitation (after interception) into surface runoff. Since INFILT is not a maximum rate nor an infiltration capacity term, its values are normally much less than published infiltration rates, percolation rates (from soil percolation tests), or permeability rates from the literature. INFILT is primarily a function of soil characteristics, and value ranges have been related to the Soil Conservation Source (SCS) hydrologic soil groups (Donigian and Davis, 1978, p.61, variable INFIL) as follows (**Table 8**):

Table 8 - SCS Hydrologic Soil Group Characteristics

SCS Hydrologic Soil Group	INFILT Estimate		Runoff Potential
	(in/hr)	(mm/hr)	
A	0.4 – 1.0	10.0 – 25.0	Low
B	0.1 – 0.4	2.5 – 10.0	Moderate
C	0.05 – 0.1	1.25 – 2.5	Moderate to High
D	0.01 – 0.05	0.25 – 1.25	High

An alternate estimation method that has not been validated is derived from the premise that the combination of infiltration and interflow in HSPF represents the infiltration commonly modeled in the literature (e.g., Viessman et al., 1989, Chapter 4). With this assumption, the value of 2.0*INFILT*INTFW should approximate the average measured soil infiltration rate at saturation, or mean permeability.

LZSN – Lower zone nominal soil moisture storage (inches). LZSN is related to both precipitation patterns and soil characteristics in the region. Viessman, et al, 1989, provide initial estimates for LZSN in the Stanford Watershed Model (SWM-IV, predecessor model to HSPF) as one-quarter of the mean annual rainfall plus four inches for arid and semiarid regions, or one-eighth annual mean rainfall plus four inches for coastal, humid, or subhumid climates.

PARM3

INFEXP – Exponent that determines how much a deviation from nominal lower zone storage affects the infiltration rate (HSPF Manual, p. 60).

Variations of the Stanford approach have used a POWER variable for this parameter; various values of POWER are included in Donigian and Davis (1978, p. 58). However, the vast majority of HSPF applications have used the default value of 2.0 for this exponent.

INFILD – Ratio of maximum and mean soil infiltration capacities. In the Stanford approach, this parameter has always been set to 2.0, so that the maximum infiltration rate is twice the mean (i.e., input) value; when HSPF was developed, the INFILD parameter was included to allow investigation of this assumption. However, there has been very little research to support using a value other than 2.0.

DEEPFR - The fraction of infiltrating water which is lost to deep aquifers (i.e., inactive groundwater), with the remaining fraction (i.e., 1-DEEPFR) assigned to active groundwater storage that contributes baseflow to the channel.

It is also used to represent any other losses that may not be measured at the flow gauge used for calibration, such as flow around or under the gauge site. Watershed areas at high elevations, or in the upland portion of the watershed, are likely to lose more water to deep groundwater (i.e., groundwater that does not discharge within the area of the watershed), than areas at lower elevations or closer to the gauge.

BASETP – ET by riparian vegetation as active groundwater enters the channel bed; specified as a fraction of potential ET, which is fulfilled only as outflow exists.

If significant riparian vegetation is present in the watershed then non-zero values of BASETP are typically applied. If riparian vegetation is significant, a generic BASETP value of 0.2 is typically representative of the evapotranspiration conditions in the San Juan Hydrologic Unit. This value was established in conjunction with a satisfactory annual water balance.

AGWETP – Fraction of model segment (i.e., pervious land segment) that is subject to direct evaporation from groundwater storage, e.g., wetlands or marsh areas, where the groundwater surface is at or near the land surface, or in areas with phreatophytic vegetation drawing directly from groundwater. This is represented in the model as the fraction of remaining potential ET (i.e., after base ET, interception ET, and upper zone ET are satisfied), that can be met from active groundwater storage.

A value of 0.05 has been selected for inclusion into the SOCHM. This value was adjusted and calibrated in the Aliso Creek watershed HSPF model (Orange County) based on adjustment of the low flow simulation, and ultimately the annual water balance.

PARM4

CEPSC – Amount of rainfall, in inches, which is retained by vegetation, that never reaches the land surface, and is eventually evaporated (estimate, then calibrate). Typical guidance for CEPSC for selected land surfaces is provided in Donigian and Davis (1978, p. 54, variable EPXM) (**Table 9**).

Table 9 - CEPSC for Selected Land Surfaces

Land Cover	Maximum Interception (in)
Grassland	0.10
Cropland	0.10 – 0.25
Forest Cover, light	0.15
Forest Cover, heavy	0.20

LZETP – Index to lower zone evapotranspiration (unitless). LZETP is a coefficient to define the ET opportunity; it affects evapotranspiration from the lower zone, which represents the primary soil moisture storage and root zone of the soil profile. LZETP behaves much like a "crop coefficient" with values mostly in the range of 0.2 to 0.7; as such, it is primarily a function of vegetation. Typical and possible value ranges are shown in **Table 11**, and the following ranges for different vegetation are expected for the "maximum" value during the year (**Table 10**):

Table 10 - LZETP Value Ranges

Land Cover Type	Input Coefficient
Forest	0.6 – 0.8
Grassland 0.4	0.4 - 0.6
Row Crops 0.5	0.5 – 0.7
Barren 0.1	0.1 – 0.4
Wetlands 0.6	0.6 – 0.9

Table 11 - Typical permanent channel cross-section with benchmark locations and points of measurement – Rosgen (1996)

HSPF HYDROLOGY PARAMETERS AND VALUE RANGES

			RANGE OF VALUES					
NAME	DEFINITION	UNITS	TYPICAL		POSSIBLE		FUNCTION OF ...	COMMENT
			MIN	MAX	MIN	MAX		
PWAT - PARM2								
FOREST	Fraction forest cover	none	0.0	0.50	0.0	0.95	Forest cover	Only impact when SNOW is active
LZSN	Lower Zone Nominal Soil Moisture Storage	inches	3.0	8.0	2.0	15.0	Soils, climate	**Calibration**
INFILT	Index to Infiltration Capacity	in/hr	0.01	0.25	0.001	0.50	Soils, land use	**Calibration**, divides surface and subsurface flow
LSUR	Length of overland flow	feet	200	500	100	700	Topography	Estimate from high resolution topo maps or GIS
SLSUR	Slope of overland flow plane	ft/ft	0.01	0.15	0.001	0.30	Topography	Estimate from high resolution topo maps or GIS
KVARY	Variable groundwater recession	1/inches	0.0	3.0	0.0	5.0	Baseflow recession variation	Used when recession rate varies with GW levels
AGWRC	Base groundwater recession	none	0.92	0.99	0.85	0.999	Baseflow recession	**Calibration**
PWAT - PARM3								
PETMAX	Temp below which ET is reduced	deg. F	35.0	45.0	32.0	48.0	Climate, vegetation	Reduces ET near freezing, when SNOW is active
PETMIN	Temp below which ET is set to zero	deg. F	30.0	35.0	30.0	40.0	Climate, vegetation	Reduces ET near freezing, when SNOW is active
INFEXP	Exponent in infiltration equation	none	2.0	2.0	1.0	3.0	Soils variability	Usually default to 2.0
INFILD	Ratio of max/mean infiltration capacities	none	2.0	2.0	1.0	3.0	Soils variability	Usually default to 2.0
DEEPFR	Fraction of GW inflow to deep recharge	none	0.0	0.20	0.0	0.50	Geology, GW recharge	Accounts for subsurface losses
BASETP	Fraction of remaining ET from baseflow	none	0.0	0.05	0.0	0.20	Riparian vegetation	Direct ET from riparian vegetation
AGWETP	Fraction of remaining ET from active GW	none	0.0	0.05	0.0	0.20	Marsh/wetlands extent	Direct ET from shallow GW
PWAT - PARM4								
CEPSC	Interception storage capacity	inches	0.03	0.20	0.01	0.40	Vegetation type/density, land use	Monthly values usually used
UZSN	Upper zone nominal soil moisture storage	inches	0.10	1.0	0.05	2.0	Surface soil conditions, land use	Accounts for near surface retention
NSUR	Manning's n (roughness) for overland flow	none	0.15	0.35	0.05	0.50	Surface conditions, residue, etc.	Monthly values often used for croplands
INTFW	Interflow inflow parameter	none	1.0	3.0	1.0	10.0	Soils, topography, land use	**Calibration**, based on hydrograph separation
IRC	Interflow recession parameter	none	0.5	0.7	0.3	0.85	Soils, topography, land use	Often start with a value of 0.7, and then adjust
LZETP	Lower zone ET parameter	none	0.2	0.7	0.1	0.9	Vegetation type/density, root depth	**Calibration**

Source: USEPA BASINS Technical Note 6

Model assumptions for channel reach infiltration rates were derived through calibration based on data collected within the reaches of Aliso Creek (11 stations) and Rose Creek (6 stations). In the model, infiltration rates vary by soil type. Channel infiltration was calibrated by adjusting a single infiltration value, which was varied for each soil type by factors established from literature ranges (USEPA 2000) of infiltration rates specific to each soil type. The final resulting infiltration rates were 1.368 in/hr (Soil Group A), 0.698 in/hr (Soil Group B), 0.209 in/hr (Soil Group C) and 0.084 in/hr (Soil Group D). The infiltration rates for Soil Groups B, C, and D are within the infiltration range given in literature (Wanielisata et al. 1997). The result for Soil Group A is below the range given in Wanielisata et al. (1997).

APPENDIX F - Channel Classification Procedure

Channel stability over time may be assessed by monitoring the channel for five factors: 1) aggradation; 2) degradation; 3) shifting of particle sizes of channel bed sediment; 4) changing the rate of lateral extension through accelerated bank erosion; and 5) morphological changes following the Channel Evolution Model (Simon et al., 1992). It is recommended that annual assessments of channel stability at cross sections at each monitoring site be carried out at the same time of the year, at the end of the spring season, thus maximizing the chances to monitor similar weather patterns.

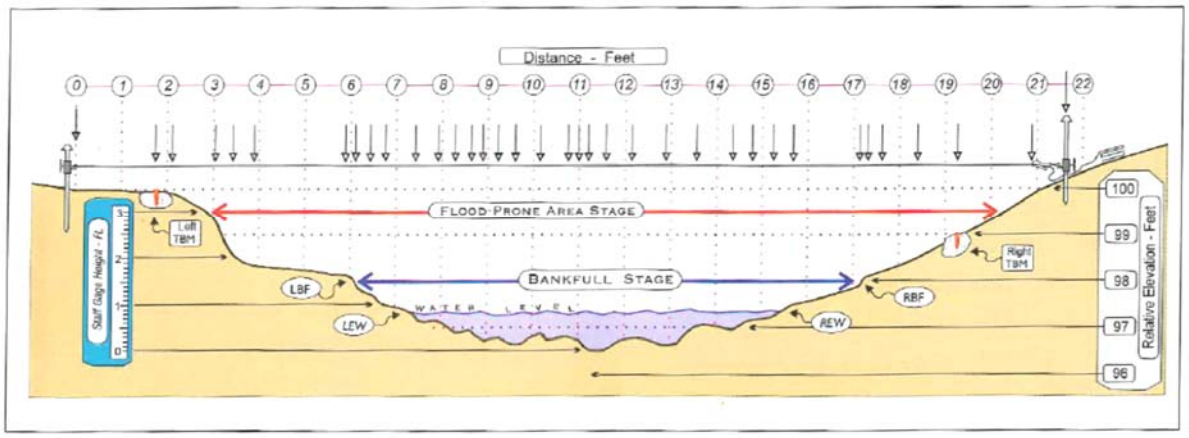
Evaluation of vertical or bed stability will serve as the reference method to understand geomorphological changes of a channel over time. Vertical or bed stability will be evaluated at each of the identified cross sections; this field method will identify a potential aggradation or degradation, if any, of the channel. Rate, magnitude, and direction of vertical change, if any, will be quantified.

Vertical or bed stability

Rosgen (1996) has documented a couple of methods for assessing aggradation or degradation over time, including one, known as the "Monumented Cross-sections Method", a derivative of which is utilized by this HMP Monitoring Program. This method requires installation of a permanent monument consisting of a 10-inch stove bolt set up in a pad of concrete to record coordinates and reference elevations to establish site cross sections. However, in order to avoid permanent impacts to private property, modern surveying techniques, including GPS devices, are also available to record cross section locations, and a permanent monument may not be necessary. Field measurements and bank angles may also be used to establish cross sections.

During each cross section survey, a leveled tape line or alternative measuring technique may be used. Figure 16 depicts the intercept of the rod with the leveled tape line.

Figure 16 - Typical permanent channel cross section with benchmark locations and points of measurement – Rosgen (1996)



The following guidance is provided where a level tape is used:

- Locate the permanent benchmark, if applicable, on both sides of the channel (or, if on one side, a bearing for the transect is needed)
- Stretch the tape very tight with spring clamp and tape level
- Locate tape at same elevation as reference bolt on benchmark
- Read distance and elevation reading of rod intercept with tape
- Measure major features, such as:
    - Left benchmark (LBM)
    - Left terrace/floodplain (LT, LFP)
    - Left bankfull (LBF)
    - Left bank (LB)
    - Left edge of water (LEW)
    - Various bed features, bars, etc.
    - Thalweg (TW)
    - Inner berm features (IB)
    - Right edge of water (REW)
    - Right bank (RB)
    - Right bankfull (RBF)
    - Right terrace/floodplain (RT, RFP)
    - Right benchmark (RBM)

Measurements will include the floodplain, terraces, and channel adjacent slopes. Other surveying procedures such as auto or laser levels and total station surveys may be adapted from the described "measuring tape and elevation rod" method. If technically feasible, any exceptional event associated with a level higher than the bankfull level will to be marked and indicated on the cross section. The cross section will be plotted for each measurement and compared to previous cross sections to evaluate bed stability. Finally, the longitudinal slope will be assessed based on measurements taken at two consecutive cross sections.

Each channel segment being surveyed will initially be classified per the simplified Rosgen system of channel classification (Rosgen, 1996). Classification will be possible upon identification of the following parameters: flood-prone width, bankfull width, bankfull depth, and longitudinal slope. **Figure 17** shows the different types of channels per Rosgen channel classification (Rosgen, 1996). During each subsequent year, surveyed channel segments will be compared to the six-stage Channel Evolution Model defined by Simon, as well as the previous year's cross section data, to correlate any potential impacts of urbanization to a change of channel geomorphology (Simon et al., 1992). A channel segment will be considered stable over time if features of the channel segment (such as dimension, pattern, and profile) are maintained, and the channel system neither aggrades nor degrades.

Figure 17 - Simplified Rosgen Channel Classification (Rosgen, 1996)

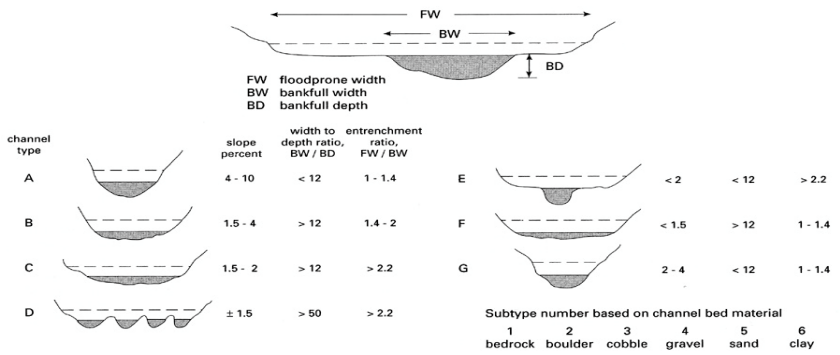


Figure 1.12 The Rosgen system of channel classification.

APPENDIX G - Santa Margarita Region Hydrology Model Guidance Manual

- The *Santa Margarita Region Hydrology Model* program can be downloaded for free on the Riverside County Flood Control and Water Conservation District's NPDES/Municipal Stormwater Management Program website.

http://www.rcflood.org/NPDES/Default.aspx

APPENDIX H - Conducting a Site-Specific Hydromodification Analysis

A User may choose to develop a site-specific Hydromodification susceptibility analysis in lieu of using the continuous simulation tool provided by the SMR HMP. The site-specific analysis must be developed to demonstrate that the project will not adversely impact the receiving channel through either changes in the receiving channel hydrograph, or changes in Bed Sediment Load supply to the channel.

The following items are not intended to be an approach to complete the analysis, rather, they are provided for information as suggestions for the engineering analysis. Each project will have unique conditions and will require a customized approach for analysis. A site-specific analysis may or may not be ultimately approved by the Copermittee with jurisdiction over the project site. It is the responsibility of the User to assess the potential for an analysis to successfully demonstrate that the project is consistent with the guidelines of this HMP.

1. It is recommended that the User develop a study approach and outline, and review it with the Copermittee with jurisdiction over the project site prior to beginning the full study.
2. The study must demonstrate that the project is consistent with the requirements of the 2010 SMR MS4 Permit and this HMP.
3. Site-specific information to characterize Bed Sediment gradation, flow and rainfall data, and watershed hydrologic parameters will be required. Continuous simulation is required.
4. An objective of the study may be to determine if the loss of Bed Sediment Load from the project-site to the receiving channel can be partially or fully managed by additional management of the runoff discharge from the project-site.
5. Sediment transport modeling has inherent uncertainty. The Copermittee with jurisdiction over the project site may not approve a site-specific analysis if it is apparent that the change in conditions that will be modeled are about the same magnitude as the model uncertainty.

The selected lower flow threshold should correspond to the critical channel flow that produces the Critical Shear Stress that initiates channel Bed Sediment Load movement or that erodes the toe of channel banks of a comparable soft-bottom channel.

The method of analysis, including the specific modeling program, the sediment transport function, the reach of the receiving water to be modeled, the method of determining Bed Sediment discharge in the receiving channel, the method of determining Bed Sediment discharge from the project-site, the period of record for continuous simulation and other parameters are left to the discretion of the User. The study report should document and justify the approach, selected models and methods, data requirements, analysis method and results for review.

APPENDIX I - Identification of a Site-Specific Low Flow Threshold

If allowed by the Copermittee with jurisdiction over the project site, Users have the option to use a site-specific low flow threshold for individual projects instead of 10% of the 2-year peak flow specified in the HMP.

A User may assess the viability of pursuing a site-specific low flow threshold based on the results of a planning-level analysis that is presented in this Appendix. The planning-level analysis consists of a critical flow sensitivity assessment, which provides the User with a general indication that a site-specific low flow threshold may be appropriate, but is not sufficient to quantify the threshold. The stepwise approach is consistent with that developed for the San Diego County HMP (2011).

The demonstration of an applicable low flow threshold must be performed based on field geomorphic evaluation, non-uniform hydraulic modeling, and sediment continuity modeling. This Appendix provides general concepts on these topics. A person knowledgeable in sediment processes should be consulted if the User desires to take the next step and establish a site-specific low flow threshold.

A. For Planning Purposes Only: Simplified Stepwise Approach

For initial planning purposes, the User may run the desktop-level analysis using the proposed empirical equations and assess the viability of pursuing a site-specific low flow threshold. To establish viability of a site-specific threshold, the User may perform and document the findings of each of the following six steps.

The simplified stepwise approach is only provided as an attempt to assist the User with a simplified method. The uncertainty associated with each of the variables of the simplified approach can potentially falsely influence the results. It is the User's responsibility to analyze the results and the geomorphic environment of the downstream channel before attempting to pursue a site-specific low flow threshold.

Step A-1: Identify the Typical Range of Rainfall Conditions for the HMP Area

The purpose of Step 1 is to identify the mean annual precipitation at the project site based on existing records from a nearby precipitation station. The mean annual precipitation serves as an input to characterize the dominant discharge for the receiving channel. Based on 70+ years of District SMR rainfall records, the mean annual precipitation ranges from 11.6 to 20.6 inches in the SMR. The User should identify on **Figure 3** of the main document, the meteorological zone where the project site is located, and subsequently refer to **Table 12** to select the associated mean annual precipitation.

Table 12 - SMR Mean Annual Precipitation per Meteorological Zone

Meteorological Zone	Mean Annual Precipitation (in inches)
Eastern Slopes	14.7
Temecula Valley	15.8
Western Plateau	20.6
Wildomar / North Murrieta	11.6

Step A-2: Identify a Range of Typical Receiving Channel Dimensions for Each Watershed Area

Empirical relationships have been developed to express channel dimensions (width, depth, and to a lesser extent, gradient) as a function of the dominant discharge. For undeveloped channels in semi-arid parts of the U.S. such as in the SMR, dominant discharge can be approximated by the 5-year discharge flow.

Step A-2.a – The dominant discharge, Qbf, assumed to be approximately equivalent to the 5-year peak discharge (Q5), may be estimated using the USGS regional regression for undeveloped watersheds in the South Coast Region (Waananen and Crippen, 1977). This equation calculates Q5 (cfs) as a function of watershed area (sq. mi.) as determined in Step 2, and mean annual precipitation (MAP, in/yr) as determined in Step 1. The relationship is:

$$Q_5(cfs) = 0.4 \cdot [Watershed\ Area\ (sq.mi)]^{0.77} \cdot [Mean\ Annual\ Precipitation\ (inches)]^{1.69}$$

Step A-2.b –Identification of the width and the depth of each channel reach: The User may iteratively identify the type of channel as defined in **Table 13** that most corresponds to each individual channel reach that is selected within the domain of analysis (defined in APPENDIX C). In addition to the channel type, **Table 13** identifies the source and the empirical channel geometry relationships. Empirical relationships were developed based on channel geometry and hydrology in Southern California.

Table 13 - Empirical relationships for Channel Dimensions

Channel Type	Source	Empirical Channel Geometry Relationships
Undeveloped channels in Southern California – narrow, deep, and steep dimensions	Coleman et al., 2005	$Width(ft) = 0.6012 \cdot Q_{bf}^{0.6875}$ $Depth(ft) = 0.3854 \cdot Q_{bf}^{0.3652}$ Q_{bf} in cfs
Gravel channels – wide, shallow, flat braided dimensions	Parker et al., 2007	$Width(m) = 4.63 \cdot \frac{Q_{bf}^{2/5}}{9.81^{1/5}} \cdot \left[\frac{Q_{bf} \cdot d_{50}^2}{\sqrt{9.81 \cdot d_{50}}}\right]^{0.0667}$ $Depth(m) = 0.382 \cdot \frac{Q_{bf}^{2/5}}{9.81^{1/5}}$ Q_{bf} in the bankfull discharge in m^3/s d_{50} is the diameter of median channel material in m
Medium width, depth, and gradient channels	Hey and Thorne, 1986	$Width(m) = 2.73 \cdot Q_{bf}^{0.5}$ $Depth(m) = 0.22 \cdot Width^{0.37} \cdot d_{50}^{-0.11}$ Q_{bf} in the bankfull discharge in m^3/s d_{50} is the diameter of median channel material in m

Step A-3.c – Compute a channel slope using Manning's equation such that the wetted cross-sectional area at bankfull depth conveys the dominant discharge. Manning's equation is expressed as:

$$Q = 1.486 \cdot \frac{A \cdot R^{0.67} \cdot \sqrt{s}}{n}$$

Where:

- Q = Flowrate (cfs)
- A = Cross-Section Flow Area (ft2)
- R = Hydraulic Radius (ft) = A / P
- P = Wetted Perimeter (ft)
- s = Energy Gradient Assumed Equal to Longitudinal Slope (ft/ft)
- n = Manning Roughness (unitless)

For planning purposes, the User can assume a Manning Roughness value of 0.025, corresponding to a non-vegetated, straight channel of small slope, after aging whose Bed Sediment is composed

of colloidal alluvial silt (ASCE No.77, 1992). However, it is suggested that the User determine the retardance coefficient from
Table 14. This reflects the small, ephemeral receiving channels which are prevalent in Southern California. A different Manning Roughness value may be used only if it has been previously approved by the Copermittee with jurisdiction over the project site. A sensitivity analysis performed in the San Diego HMP found that the retardance coefficient had little effect on the estimated critical shear flow rate.

Table 14 - Critical Shear Stress per Sediment Type (Source: ASCE No.77, 1992)

Material	n	Clear Water		Water Transporting Colloidal Silts	
		V (fps)	τ (lb/ft2)	V (fps)	τ (lb/ft2)
Fine sand, colloidal	0.020	1.50	0.027	2.50	0.075
Sand loam, noncolloidal	0.020	1.75	0.037	2.50	0.075
Silt loam, noncolloidal	0.020	2.00	0.048	3.00	0.11
Alluvial silts, noncolloidal	0.020	2.00	0.048	3.50	0.15
Ordinary firm loam	0.020	2.50	0.075	3.50	0.15
Volcanic ash	0.020	2.50	0.075	3.50	0.15
Stiff clay, very colloidal	0.025	3.75	0.26	5.00	0.46
Alluvial silts, colloidal	0.025	3.75	0.26	5.00	0.46
Shales and hardpans	0.025	6.00	0.67	6.00	0.67
Fine gravel	0.020	2.50	0.075	5.00	0.32
Graded loam to cobbles when noncolloidal	0.030	3.75	0.38	5.00	0.66
Graded silts to cobbles when colloidal	0.030	4.00	0.43	5.50	0.80
Coarse gravel, noncolloidal	0.025	4.00	0.30	6.00	0.67
Cobbles and shingles	0.035	5.00	0.91	5.50	1.10

Step A-3: Identify a Range of Typical Channel Material for Receiving Channels

The User should identify the weakest predominant type of Bed Sediment in each section of the receiving channel within the domain of analysis. A simple identification from aerial imagery, available photography, or existing technical documentation is deemed sufficient for planning purposes, or a field review or a geotechnical investigation can be used. The User should

subsequently identify the critical shear stress associated with each type of predominant Bed Sediment using Error! Reference source not found.
Table 14 presents a nonexhaustive list of critical shear stresses for typical channel materials and covers the range of Critical Shear Stresses to be encountered in the SMR.
Table 14 may be used for planning purposes only.

Appropriate references for Critical Shear Stress values are provided in ASCE No.77 (1992) and Fischenich (2001). To account for the effects of vegetation density and channel irregularities, the applied shear stress can be partitioned into form and bed/bank roughness components, and the lowest value of d50 be used for calculations. Other references include the procedure for application of allowable velocity to determine the Critical Shear Stress or equivalent allowable velocity associated with a specific type of Bed Sediment. Design of Open Channels, TR-25 (USDA, 1977) will guide the User through the allowable velocity approach, which relates allowable velocity to sediment concentration, grain diameter of the non-cohesive boundary material, and plasticity index and soil characteristics for cohesive boundary material. Another effective reference is the National Engineering Handbook Part 654, Chapter 8, which contains the Shields diagram and describes the allowable shear stress approach (NEH, 2007).

Step A-4: Identify the Flow Rate at Which Boundary Shear Stress Exceeds Critical Shear Stress for the Channel and Material

The tractive force theory was initially described in Shield's diagram (1936) and further translated into an equation by the Bureau of Reclamation (1987). The tractive force theory establishes that Bed Sediment Load is being displaced when the shear stress applied on the boundary of a particle of Bed Sediment exceeds the critical shear stress associated with that particle. The average boundary shear stress on a particle of Bed Sediment may be expressed as:

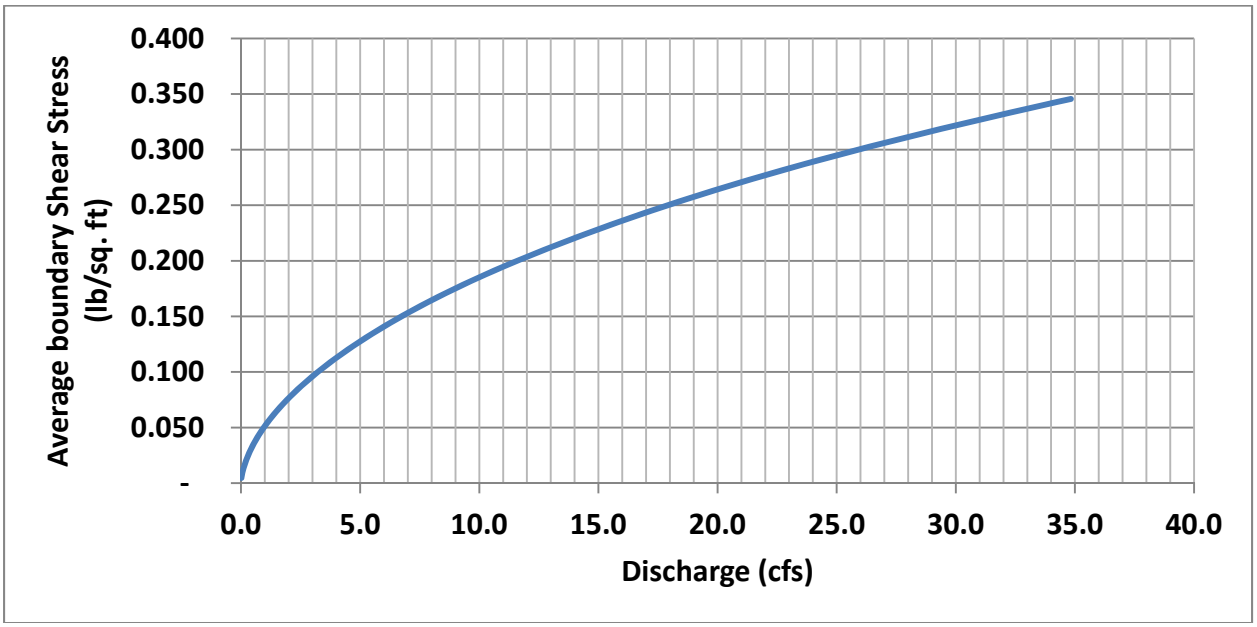
$$\tau = \gamma \cdot R \cdot s$$

Where:

- τ = Effective Shear Stress of d_{50} from sieve analysis (lb/ft2)
- γ = Unit Weight of Water (62.4 lb/ft3)
- R= Hydraulic Radius (ft) as determined in Step 2
- s = Longitudinal slope (ft/ft) as determined in Step 2.c

Using Manning's equation for the established channel cross-section, roughness, and gradient, the flow depth is iterated to produce a shear stress rating curve for each of the channel section selected within the domain of analysis. A shear stress rating curve correlates the average boundary shear stress to a discharge, which can be as high as the dominant discharge in this exercise. For the purpose of the exercise, an example shear stress rating curve is shown in **Figure 8**. The example shear stress rating curve was developed with the following parameters: s= 0.005 ft/ft; n= 0.035; side slope = 1H: 1W; bankfull depth = 1.51 feet; bankfull width = 7.91 feet.

Figure 18 - Example Shear Stress Rating Curve



Based on the Critical Shear Stress identified in Step 4, the User should identify on each shear stress rating curve, Qcrit, or the flow rate at which boundary shear stress equals critical shear stress.

Step A-5: Express Critical Flow As A Function of Q2

The User may use the USGS regional regression of the 2-year peak discharge for the South Coast Region (Waananen and Crippen, 1977) to determine the 2-year peak discharge in each channel reach selected within the domain of analysis. The regression equation is expressed, as follows:

$$Q_2(\text{cfs}) = 0.14 \cdot [\text{Watershed Area (sq. mi)}]^{0.72} \cdot [\text{Mean Annual Precipitation (inches)}]^{1.62}$$

The critical flow (Qcrit) is expressed as a function of Q2 to remain consistent with the standardized relationship stated in existing HMPs throughout California.

Step A-6: Identify the Most Conservative Low Flow Threshold

In a final step, the User should summarize in a tabular format the findings of the stepwise approach applied to each section of channel. An example of such tabular representation is showcased in **Table 15**, in which critical flow rates are grouped by type of channel material.

Table 15 - Summary Table of Critical Flow Rates per Section of Channel

Drainage Management Area	Trib Area	Mean Annual Precip	5-year Flowrate	2-year Flowrate	Critical Flowrate	Low Flow Threshold	Bankfull Width	Bankfull Depth
	A	MAP	Q5	Q2	Qcrit	Qcrit/Q2	W	D
	sq mi	in/yr	cfs	cfs	cfs	% of Q2	ft	ft
τ_{crit} = 0.025 lb/ft2, sand bed (low end)								
Section A1	1	15.8	42.5	12.2	0.296	**2.4%**	7.91	1.51
τ_{crit} = 0.05 lb/ft2, sand bed (high end)								
Section A2	1	15.8	42.5	12.2	0.947	**7.7%**	7.91	1.51
τ_{crit} = 0.12 lb/ft2, gravel								
Section A3	1	15.8	42.5	12.2	4.452	**36.4%**	7.91	1.51

In the above example, for Section A1, the ratio between the critical flow and the 2-year peak flow is computed as: (0.296 cfs) / (12.2 cfs) = 0.024 = 2.4%.

From the summary table, the User should identify the most conservative low flow threshold among all downstream sections. For instance, in the presented example, the User should select 2.4% Q2 as the site-specific low flow threshold. In this instance, a site-specific low flow threshold would not be advantageous for the project.

B. For Consideration and Approval by the Copermittee with jurisdiction over the project site: Full-Scale Geomorphic Assessment

For consideration and approval of a site-specific low flow threshold by the Copermittee with jurisdiction over the project site, demonstration must be established based on field geomorphic evaluation, nonuniform hydraulic modeling, and sediment continuity modeling. A person familiar with sediment transport should be consulted if the User was to establish a site-specific low flow threshold.

The field geomorphic assessment, to be performed within the domain of analysis, should identify the geometry of each selected cross-section and characterize the associated Bed Sediment Load. The geomorphic evaluation requires surveying the cross-section and longitudinal profile geometry of the active channel, estimating the hydraulic roughness of the channel, and evaluating the critical shear stress (pounds per square foot) of the most sensitive bed and bank material. For non-cohesive material, a Wolman pebble count or sieve analysis is used to obtain a grain size distribution, which can be converted to Critical Shear Stress using an empirical relationship or reference tables in the literature. For cohesive material, an in-situ jet test or reference tables are used. For banks reinforced with vegetation, reference tables are generally used.

The site-specific hydrologic and hydraulic evaluation should determine the 2-year peak discharge Q2 based on a flow gage record in the receiving channel or a continuous hydrologic model, if available. In computing Q2, the original condition of the watershed tributary to the channel, before development, should be considered. This provides a means of apportioning the critical flow in a channel to individual projects (on a pro-rata area basis) that discharge to that channel,

such that cumulative discharges do not exceed the critical flow (Qcrit) in the channel of concern. This flow apportionment must be provided as a part of the analysis by the User.

The User must demonstrate through a channel stability impact assessment that the changes to both the amount of Bed Sediment transported and the amount of Bed Sediment supplied to the channel, will maintain the general trends of aggradation and degradation in the impacted channel reaches, which are representative of the dynamic equilibrium of a channel.

APPENDIX J – Flow Control Threshold Analysis Report (Appendix A of 2011 San Diego HMP)

APPENDIX K – SMR HMP Monitoring Program

April 2016

Hydromodification Management Plan Monitoring Program

In Compliance with Order No. R9-2010-0016, this HMP Monitoring Program has been developed by the Riverside County Co-Permittees.

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I. Introduction

This Santa Margarita Region (SMR) Hydromodification Management Plan (HMP) has been established to manage increases in runoff discharge rates and durations from applicable Priority Development Projects (PDPs); the overall goal of the SMR HMP is to ensure that geomorphic stability within SMR channels will not be compromised as a result of receiving runoff discharges from PDPs. The level of understanding of the variables influencing the geomorphologic changes in channels receiving urban runoff may be deduced through monitoring. As such, this SMR HMP Monitoring Program defines a Hydromodification monitoring approach, as required by Provision F.1.h.(1)(m) of San Diego Regional Board Water Quality Control Board (SDRWQCB) Order No. R9-2010-0016 (2010 Permit); Provision F.1.h.(1)(m) requires that the SMR HMP:

> Include a description of monitoring and other program evaluations to be conducted to assess the effectiveness of implementation of the HMP. Monitoring and other program evaluations must include an evaluation of changes to physical (e.g., cross section, slope, discharge rate, vegetation, pervious/impervious area) and biological (e.g., habitat quality, benthic flora and fauna, IBI scores) conditions of receiving water channels as areas with Priority Development Projects are constructed (i.e. pre- and post-project), as appropriate.

The goals of the SMR HMP Monitoring Program are to:

- Gather data which can assist in assessing susceptibility and characterizing the physical conditions of surface waters to Hydromodification in the upper SMR Watershed Management Area (WMA);
- Gather data which may be used in future monitoring and development of the SMR WMA Water Quality Improvement Plan (WQIP), required under SDRWQCB Order No. R9-2013-0001, as amended by R9-2015-001 and R9-2015-0100 (Regional Permit);
- Assess whether monitored surface waters are impacted by Hydromodification; where impacts may be identified, those surface waters will be considered during assessment of priority water quality conditions in the SMR WMA WQIP; and
- Provide gathered information to existing stream rehabilitation efforts in the upper SMR.

The SMR HMP Monitoring Program proposes to achieve these goals by conducting monitoring at two sites within the SMR WMA, through Fiscal Year 2018-2019; additional sites throughout the SMR WMA will also be monitored through a collaborative effort with the Southern California Monitoring Coalition (SMC) to account for both temporal and spatial variability. The gathered data will also be used to supplement an ongoing effort spearheaded by the Meadowview Community Association and the U.S. Fish and Wildlife Service (USFWS) to rehabilitate a reach of Meadowview Stream, which is located in the northern portion of the city of Temecula.

This HMP Monitoring Program also includes a mechanism for assessing and addressing cumulative Hydromodification impacts from development projects within the SMR, as required by 2010 Permit Provision F.1.h(1)(n). After assessment and survey data is gathered from each site, it will be utilized to track site geomorphic evolution, and assess what type of impacts may have occurred; if necessary, those impacts can then be addressed within the context of the SMR WMA's identified highest priority water quality conditions.

II. Background

In accordance with 2010 Permit Provision F.1.h(5)(a), the SMR Co-Permittees submitted a public-reviewed draft SMR HMP, with SMR HMP Monitoring Program Plan, to the SDRWQCB on June 30, 2013; comments were received from the SDRWQCB, and a revised draft SMR HMP was re-submitted in March 2014, pursuant to 2010 Permit Provision F.1.h(5)(b). The SDRWQCB found the revised draft SMR HMP to be conditionally adequate, and prescribed an effective date for the final SMR HMP: July 11, 2014. This effective date provided a unique situation for the SMR HMP Monitoring Program in the following ways:

- The effective date of the SMR HMP was less than one and a half years before the expiration date of the 2010 Permit. Provision F.1.h(1)(m) of the 2010 Permit prescribes that the SMR HMP Monitoring Program must, "assess the effectiveness of implementation of the HMP". Similarly, Provision F.1.h(1)(l) requires development of a protocol to evaluate potential impacts which may be observed from Priority Development Projects (PDPs) which have implemented the hydrologic performance standard of the SMR HMP. However, by the end of Fiscal Year 2014-2015, there were no PDPs conditioned to implement the hydrologic andor sediment supply standards of the SMR HMP which had been constructed in the SMR WMA, and it was anticipated that more time may pass before a significant number of hydrologic and sediment control BMPs could be constructed and assessed within the SMR for monitoring purposes.
- By May 8, 2013, the SDRWQCB had developed and adopted the Regional Permit, and had notified the SMR Co-Permittees that upon expiration of their 2010 Permit, they would be enrolled into the Regional Permit. The Regional Permit allows the SMR Co-Permittees to focus their efforts on identified highest water quality priorities in the SMR WMA, and to develop management measures, goals and schedules in the SMR WQIP to address those priorities. The Regional Permit also requires that Co-Permittees monitor for Hydromodification and other impacts, with the purpose of assessing the effectiveness of measures implemented in key watershed areas to address the WMAs identified highest priority water quality conditions. This is in contrast to the 2010 Permit, which requires Hydromodification monitoring at selected individual sites located downstream from PDPs, to assess whether the science behind the hydrologic and sediment performance standards is operating as intended. Monitoring driven by management actions at particular locations (i.e., a local scale) will always benefit from information gathered from one or more regional-scale reference sites that can characterize natural or background variability (SCCWRP, 2012). Therefore, the effectiveness of future measures implemented under the SMR WQIP can only be properly assessed if background conditions regarding Hydromodification of SMR WMA streams are monitored and assessed prior to implementation of those measures.
- In December 2014, representatives from the Meadowview Community Association (Association) contacted the Riverside County Flood Control and Water Conservation District regarding a reach of the Meadowview stream which is located on Association property within the city of Temecula, and displays substantial mass wasting of the stream banks. Observed impacts include damage to infrastructure (an adjacent road partially collapsed during a recent storm event), and possible threats to public safety (eroding stream banks appear to be encroaching upon open trails used by pedestrians, cyclists and equestrians). The Association and the USFWS are currently working on a plan to

implement environmentally sustainable solutions to restore and stabilize the stream's banks. The Co-Permittees wish to support the proposed project by contributing data, reports and any other helpful information gathered under this SMR HMP Monitoring Program to project stakeholders. Beginning July 2015, coordination with the Association, project stakeholders and applicable federal agencies was underway, and a license agreement to gain access to the site for monitoring was executed in November 2015.

Given this unique situation of the Co-Permittees' need to revise the 2014 SMR HMP Evaluation Program and the need to obtain data to assist with the requirements of the Regional Permit, the Co-Permittees saw an opportunity to modify the Hydromodification Monitoring Program to accomplish both efforts, and meet the monitoring program goals noted above. The program concept was presented to SDRWQCB staff, and preliminarily agreed upon on July 15, 2015.

III. Monitoring Measures

Monitoring measures aim at identifying potential susceptibility of monitored stream reaches to Hydromodification and then tracking their geomorphology over time. The Co-Permittees will collect the following Hydromodification monitoring observations and measurements at the two monitoring locations described in Section IV.D., below:

1) Channel conditions, including:
   a) Channel dimensions
   b) Hydrologic and geomorphic conditions
   c) Presence and condition of vegetation and habitat
2) Location of discharge points
3) Photo documentation of existing erosion, with location (i.e., latitude and longitude coordinates) where photos were taken
4) Measurement or estimate of dimensions of any existing channel bed or bank eroded areas, including length, width, and depth of any incisions
5) Known or suspected cause(s) of existing downstream erosion impact, including flow, soil, slope, and vegetation conditions, as well as upstream land uses and contributing new and existing development

A. Field Methods

Stream Susceptibility

The "Hydromodification Screening Tools: Field Manual for Assessing Channel Susceptibility" developed by SCCWRP (Technical Report 606, 2010) will be utilized as appropriate to make the observations and measurements described above. In support of the Hydromodification monitoring observations and measurements noted above, two data types will be calculated through GIS analysis and collected during field efforts:

1) Landscape GIS Metrics
   a) Contributing drainage area above the point of interest
   b) Mean annual area-weighted precipitation
   c) Geomorphic confinement: valley bottom width at site
   d) Valley slope at site
   e) Upstream land use coverage

2) Site-Specific Field Metrics
   a) Bank angle
   b) Bank height
   c) Stream gradient
   d) Substrate particle size (if necessary)
   e) Vertical susceptibility
   f) Lateral susceptibility

A stream reach at each location will be delineated. Once the stream reach to be assessed has been determined, the risk potential for mass wasting (erosion) will be measured. At representative transects, the left and right bank angles and bank heights will be measured using a stadia rod and

gravity-driven protractor. If necessary, the stream substrate particle size (pebble count) will be measured and a median particle size will be determined. Vertical and lateral susceptibility to bank wasting will then be assessed. Vertical susceptibility will first be assessed by recording the status of three streambed parameters: composition of the stream substrate, armoring potential (i.e., bed consolidation), and grade control presence and effectiveness. Lateral susceptibility will then be assessed through a decision tree using a combination of vertical susceptibility rating, bank stability threshold, and valley width index to determine the lateral susceptibility.

Stream Geomorphology

In addition to assessing susceptibility, geomorphology of each monitored site will be tracked over time; a channel survey at each sites' selected cross sectional transects will be conducted annually. The channel survey will consist of collecting topographic and bathymetric measurements along each cross section to characterize morphology and longitudinal slope of the channel segment. Four parameters will be surveyed: 1) the floodprone width; 2) the bankfull width; 3) the bankfull depth; and 4) the longitudinal slope. Initially, each surveyed channel segment will be classified per the simplified Rosgen system of channel classification (Rosgen, 1996), as detailed in Figure 1. During each subsequent year, surveyed channel segments will be compared to the six-stage Channel Evolution Model defined by Simon, as well as the previous year's cross section data, to correlate any potential impacts of urbanization to a change of channel geomorphology (Simon et al., 1992). The six-stage Channel Evolution Model and steps for assessing geomorphology of each monitored site are described in more detail in Section IV.A. below.

Figure 1: Simplified Rosgen Channel Classification

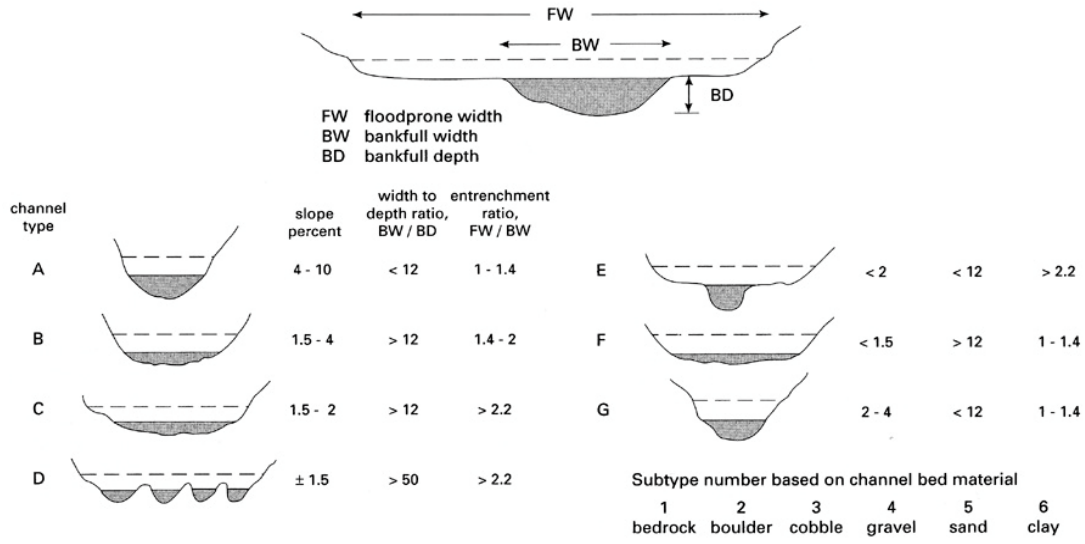


Figure 1.12 The Rosgen system of channel classification.

(Rosgen, 1996)

Stream Bioassessment

Biological communities can provide a direct representation of the health of flowing channel segments; however, the SMR is a predominantly non-perennial region, where flows in the vast majority of streams are characterized as 'episodic'. Conversely, 2010 Permit Provision F.1.h(1)(m) requires that the SMR HMP Monitoring Program "include an evaluation of changes to…..biological (e.g., habitat quality benthic flora and fauna, IBI scores) conditions of receiving water channels as areas with Priority Development Projects are constructed, as appropriate."

As part of the State of California's Surface Water Ambient Monitoring Program (SWAMP) Bioassessment program, the Southern California Index of Biotic Integrity (SoCal IBI) and the California Stream Condition Index (CSCI) scoring systems, amongst a handful of other SWAMP Standard Operating Procedures, have been evaluated for their applicability in perennial and non-perennial streams. Current research suggests that these tools provide a good indication of the benthic macroinvertebrate (BMI) health in perennial streams and for a sub-set of non-perennial streams. Non-perennial streams exhibit a wide spectrum of hydrologic conditions from flowing the majority of the year, to flowing for only a short duration after storm events. Current research by SCCWRP and the SDRWQCB is investigating the extent of applicability of the scoring tools in non-perennial stream systems. However, currently there is no SWAMP approved scoring method for assessing streams on the ephemeral end of the non-perennial stream spectrum, rather only experimental metrics have been discussed or employed in the past few years by a handful of technical workgroups or interested parties whose goal remains to develop the tools to assess California's ephemeral or 'episodic' streams.

Therefore, while monitoring methods described in this SMR HMP Monitoring Plan can be used in assessing physical habitat characteristics (i.e., substrate composition, canopy cover, flow, channel alteration) because a viable biological assessment procedure does not yet exist for episodic streams, it will not include biological assessments at this time.

B. Spatial and Temporal Variability

The single most important factor affecting the temporal variability inherent to measuring channel aggradation and degradation is variable inter-annual rainfall frequency and intensity. Droughts in California can last years, with little to no rainfall occurring in southern California. During El Niño years, anomalously high storm frequencies and intensities can result in sudden geomorphic changes. Rainfall intensity also varies intra-annually.

Physical habitat metrics and cross sectional transects of a representative set of channel segments is important to capture the range of watershed conditions of the SMR. Other important factors that reflect channel responses to Hydromodification include channel grade, watershed area, and channel sinuosity. In addition to channel and watershed features, location within the watershed is an important consideration.

The two selected monitoring stations (described in Section IV.D. below) are distributed within the SMR WMA to provide for representative geographic variability.

C. Monitoring at Additional Sites

In accordance with Section E.7 of Attachment E of the 2010 Permit, the SMR Co-Permittees partner with other southern California MS4 Co-Permittees in the development and implementation of the southern California regional stream survey, through the SMC. The SMC's current workplan (see: SCCWRP Technical Report 849 - http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/849_SMCWorkplan2015.pdf) describes the program for the years 2015 through 2019, and includes addition of an enhanced physical habitat assessment with Hydromodification module; this added method to assess susceptibility of southern California streams to Hydromodification is consistent with the methodology being utilized by this SMR HMP Monitoring Program.

Over the five-year term of SMC's survey, both condition sites and trend sites will be monitored annually throughout southern California. Within the SMR, one trend site has been selected which is located on Sandia Canyon Creek, adjacent to De Luz Road in unincorporated Riverside County; this is a site which will initially be assessed for susceptibility to Hydromodification impacts (i.e., physical habitat assessment with Hydromodification module, the same methodology utilized by this SMR HMP Monitoring Program), and will again be monitored each year throughout the five-year period of the SMC study. Additionally, SMC will monitor one condition site each year within the SMR WMA, with site locations being distributed throughout the upper SMR, and varying from year to year.

The SMR Co-Permittees will utilize data gathered during the first three years of the SMC survey to supplement the findings and final report of this SMR HMP Monitoring Program.

IV. Data Analysis and Reporting

The SMR HMP Monitoring Program extends through Fiscal Year 2018-2019; this period of time is necessary to implement monitoring, analyze data from selected sites and the SMC survey, and to account for spatial and temporal variability of the conditions in the SMR. Implementation of the SMR HMP Monitoring Program will be discussed in the Transitional SMR Annual Reports, pursuant to Regional Permit Provision F.3.b(2). Analytical data and a final report will be submitted to the SDRWQCB at the end of the monitoring program period, tentatively in Fall 2019.

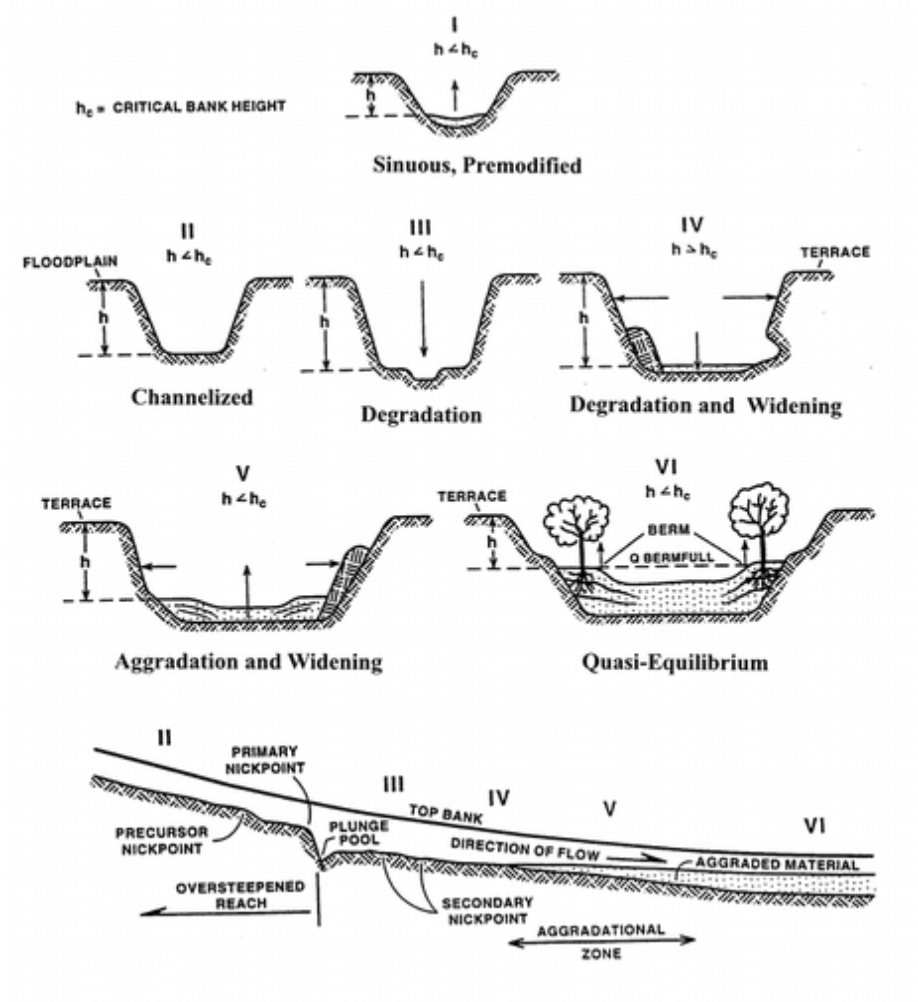
A. Data Analysis

Desktop GIS analysis for calculating drainage area, valley width, and valley slope for each site will be performed using the USGS National Elevation Dataset Digital Elevation Models.

The risk of bank failure will be calculated using a combination of bank height and bank angle field measures relative to the probability of mass wasting equation and table published in the Hydromodification Screening Tool document. Lateral and vertical susceptibility will be assessed through pebble counts, field measures, and decision trees available in the screening tool document.

Geomorphology of each site will be tracked by annually surveying each site's selected cross sectional transects. The temporal evolution in geomorphology, if any, of the surveyed channel segment will be compared to the six-stage Channel Evolution Model defined by Simon et al., as well as the previous year's cross section data, to correlate any potential impacts of urbanization to a change of channel geomorphology (Simon et al., 1992). Figure 2 illustrates the six-stage sequence of incised channel evolution (Simon et al., 1992). A channel segment will be considered stable over time if features of the channel segment (such as dimension, pattern, and profile) are maintained, and the channel system neither aggrades nor degrades. General guidance for conducting channel surveys and the classification procedure are described in more detail in Appendix F of the SMR HMP.

Figure 2: Six-Stage Channel Evolution Model



(Simon et al, 1992)

B. Mechanism for Assessing Cumulative Impacts

2010 Permit Provision F.1.h(1)(n) requires that the SMR HMP "include mechanisms for assessing and addressing cumulative impacts of Priority Development Projects within a watershed on channel morphology." The mechanism that will be implemented in upper SMR is described here:

- As described in Section III.A. above, stream susceptibility will be assessed during the first monitoring event at each site;
- Channel geometry surveys will be performed annually, using pertinent surveying techniques, including cross sectional survey, and each channel will be initially classified using the simplified Rosgen system of channel classification;
- Each subsequent year, surveyed cross section data from both monitoring locations will be compared to the previous year's cross section data to determine if significant aggradation or degradation is detected. A significant aggradation or degradation of the channel segment will be deemed by the analyst as a rapid change of the morphology of the channel (cross section) that follows Simon's Channel Evolution Model;

- Where the analyst observes a rapid change of channel morphology, the tributary area of the impacted channel segment may be investigated in an attempt to identify the potential source(s) for the degradation of the morphology of the channel segment; and
- Stream reaches identified as impacted will be considered when the SMR Co-Permittees assess and prioritize SMR WMA water quality conditions to be addressed by the SMR WQIP.

C. Reporting

The term of the SMR HMP Monitoring Program will extend through Fiscal Year 2018-2019. As previously mentioned, implementation of this SMR HMP Monitoring Program will be discussed in the Transitional SMR Annual Reports, pursuant to Regional Permit Provision F.3.b(2). Additionally, after the last monitoring year (projected to be Fiscal Year 2017-2018), data will be gathered from the two monitored sites (described in Section IV.D. below) and from the SMC southern California regional stream survey, to be compiled into a final report, which will be submitted to the SDRWQCB, tentatively in Fall 2019. The final report will contain:

- An explanation of field monitoring and GIS methods utilized;
- A summary of the monitored sites;
- A characterization of the physical conditions of monitored surface waters to Hydromodification;
- An assessment of whether any of the monitored sites exhibited impacts due to Hydromodification, and any sources which may be suspected; and
- A description of how the data gathered under this SMR HMP Monitoring Program will be used in future monitoring and/or implementation efforts.

D. Monitoring Sites

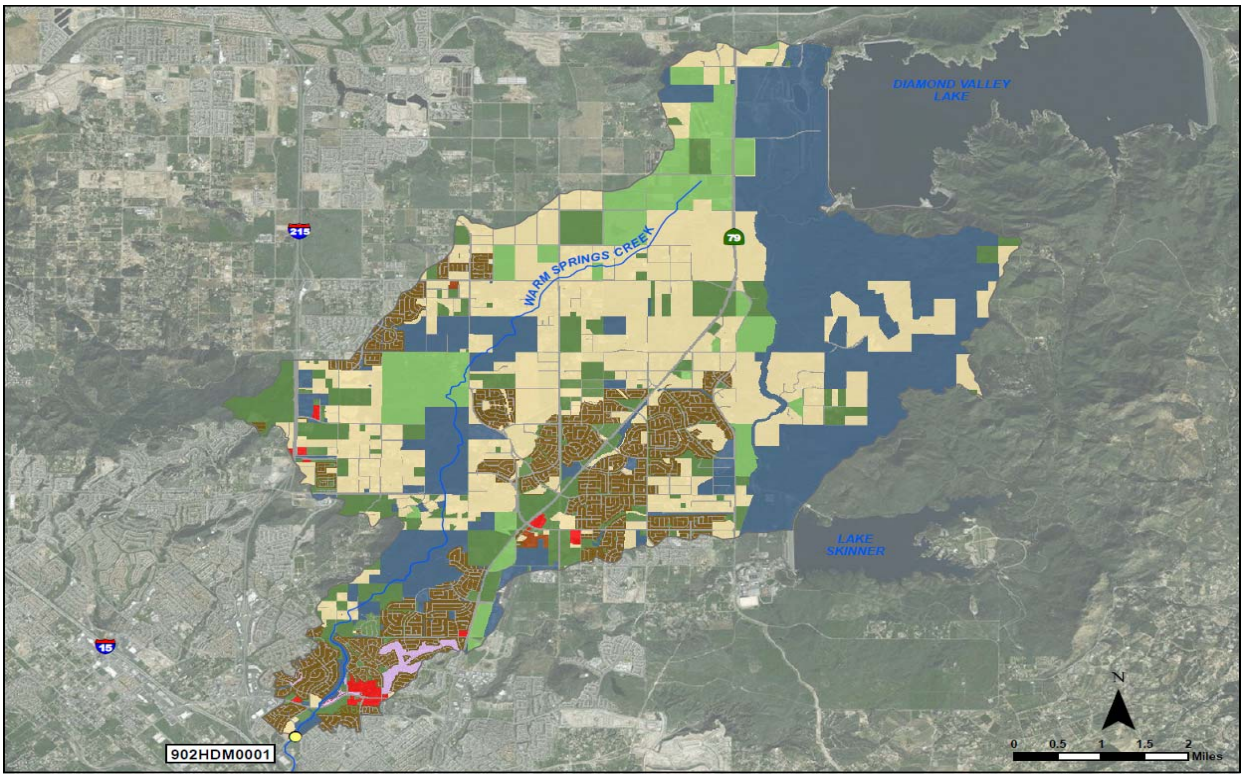
Site Name – Warm Springs Creek (902HDM001)

Location:

Latitude 33°32'54.02" N

Longitude 117°10'14.24" W

Monitoring site 902HDM001 is located in Warm Springs Creek approximately 720 meters downstream of the Murrieta Hot Springs Road crossing. The monitoring reach is approximately 165 meters long with relatively homogenous bank and channel characteristics.



*Drainage area boundary and acreage may be subject to revision as additional data is received.

MONITORING SITE

LAND USE TYPE

- AGRICULTURAL
- COMMERCIAL
- EXEMPT
- PARKS AND RECREATION
- PRESERVES OPEN SPACE
- RURAL RESIDENTIAL
- STREETS
- URBAN RESIDENTIAL

LAND USE	ACRES	LAND USE %
URBAN RESIDENTIAL	2567.93	10.20
INDUSTRIAL	39.76	0.16
COMMERCIAL	131.46	0.52
STREETS	2034.04	8.08
TOTAL URBAN	**4773.19**	**18.96**
RURAL RESIDENTIAL	7592.10	30.17
AGRICULTURE	2217.12	8.81
PRESERVES & OPEN SPACE	2888.48	11.48
PARKS & RECREATION	132.99	0.53
EXEMPT PUBLIC PROPERTIES	7561.63	30.05
TOTAL NON-URBAN	**20392.31**	**81.04**

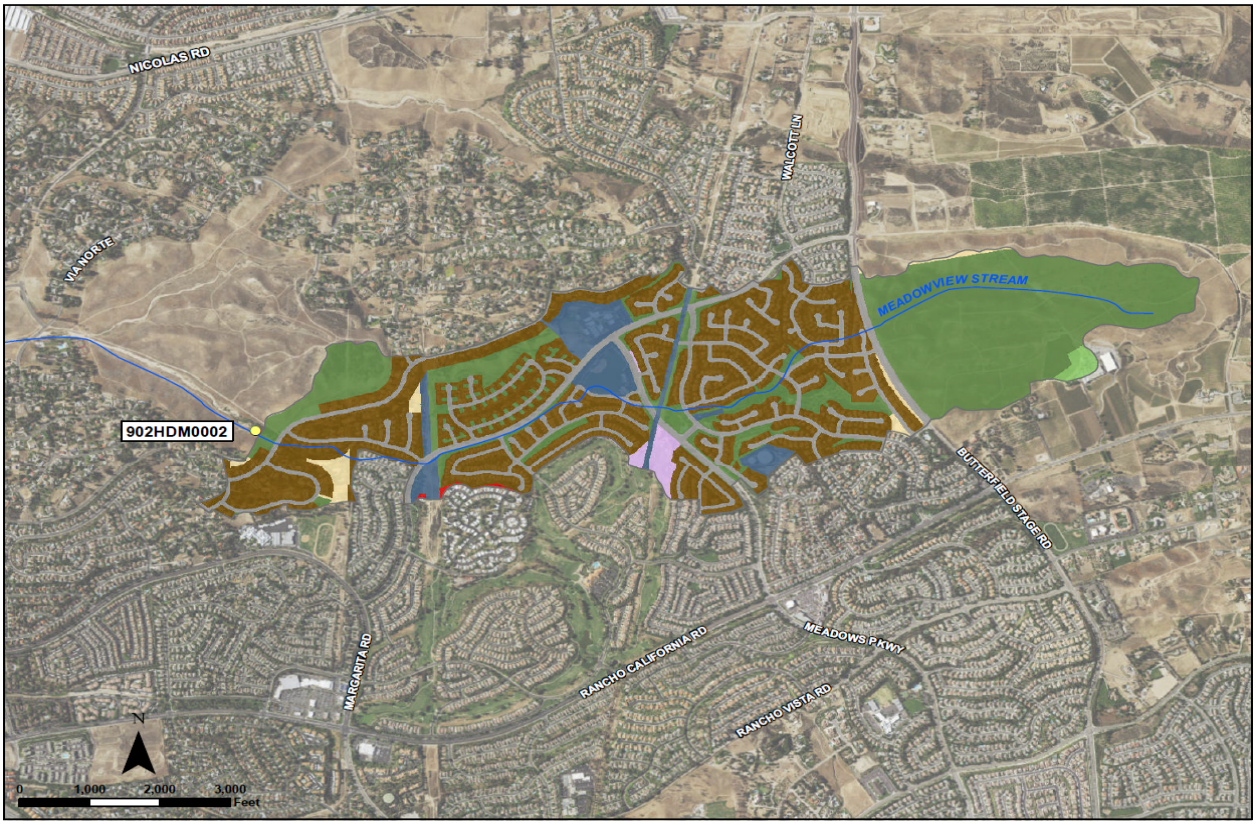
Site Name – Meadowview Stream at Meadowview Community Association (902HDM002)

Location:

Latitude 33°31'22.66" N

Longitude 117° 7'51.46" W

Monitoring site 902HDM002 is located in Meadowview Stream where it bisects property of the Meadowview Community Association. This reach of the creek is approximately 1000 meters long, between Del Rey Road at the upstream boundary and Via Norte at the downstream boundary. Surface flow is ephemeral in this reach, flowing only during storms and for a short time thereafter.



*Drainage area boundary and acreage may be subject to revision as additional data is received.

- MONITORING SITE

LAND USE TYPE

- AGRICULTURAL
- COMMERCIAL
- EXEMPT
- PARKS AND RECREATION
- PRESERVES OPEN SPACE
- RURAL RESIDENTIAL
- STREETS
- URBAN RESIDENTIAL

LAND USE	ACRES	LAND USE %
URBAN RESIDENTIAL	292.61	38.53
INDUSTRIAL	0	0
COMMERCIAL	1.37	0.18
STREETS	116.75	15.37
TOTAL URBAN	**410.73**	**54.08**
RURAL RESIDENTIAL	11.33	1.5
AGRICULTURE	4.83	0.64
PRESERVES & OPEN SPACE	276.51	36.41
PARKS & RECREATION	8.82	1.16
EXEMPT PUBLIC PROPERTIES	47.21	6.22
TOTAL NON-URBAN	**348.7**	**45.93**

Appendix 5C – County of San Diego Hydromodification Management Plan

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FINAL

HYDROMODIFICATION MANAGEMENT PLAN

Prepared for
County of San Diego, California
March 2011

Brown AND Caldwell
9665 Chesapeake Drive, Suite 201
San Diego, California 92123

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LIST OF ACRONYMS

ACCCMP	Alameda Countywide Clean Water Program
BAHM	Bay Area Hydrology Model
BEHI	Bank Erosion Hazard Index
BMP	Best Management Practice
CASQA	California Stormwater Quality Association
CCCWP	Contra Costa Clean Water Program
CEM	Channel Evolution Model
CEQA	California Environmental Quality Act
D50	Median grain size diameter
Ep	Erosion potential index
ET	Evapotranspiration
FSURMP	Fairfield-Suisun Urban Runoff Management Program
GIS	Geographical Information System
HEC-HMS	Hydrologic Modeling System; distributed by the US Army Corps of Engineers Hydrologic Engineering Center
HMP	Hydromodification Management Plan
HR	Hydraulic Radius
HSPF	Hydrologic Simulation Program FORTRAN, distributed by USEPA
IMP	Integrated Management Practices
LID	Low Impact Development
LSPC	Loading Simulation Program in C++
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
PLS	Pervious Land Surface
PWA	Philip Williams & Associates
Q	Flow
Qcrit	Critical flow
RWQCB	Regional Water Quality Control Board
SCCWRP	Southern California Coastal Water Research Project
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
STOPPP	San Mateo County Stormwater Pollution Prevention Program
SUSMP	Standard Urban Stormwater Mitigation Plan
SWM	Stanford Watershed Model
SWMM	Storm Water Management Model; distributed by USEPA
SWMP	Storm Water Management Plan
SWWM	Storm Water Management Model
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

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EXECUTIVE SUMMARY

Background

The need to address hydromodification and its influence on water quality is included in the San Diego Regional Water Board Order R9-2007-001, Provision D.1.g of California Regional Water Quality Control Board San Diego Region Order R9-2007-0001, which requires the San Diego Stormwater Copermittees to implement a Hydromodification Management Plan (HMP) "…to manage increases in runoff discharge rates and durations from all Priority Development Projects, where such increased rates and durations are likely to cause increased erosion of channel beds and banks, sediment pollutant generation, or other impacts to beneficial uses and stream habitat due to increased erosive force."

To address this permit condition, the Copermittees, represented by the County of San Diego, hired a consultant team and proceeded with developing an HMP that meets the intent of the Permit Order. The permit requires the Copermittees to develop an HMP for all Priority Development Projects (PDP), with certain exemptions. The HMP must develop standards to control flows within the geomorphically-significant flow range. Supporting analyses must be based on continuous hydrologic simulation modeling.

As required by Permit Order No. R9-2007-0001, each Copermittee shall incorporate the approved HMP into its local Standard Urban Storm Water Mitigation Plan (SUSMP) and implement the HMP for all applicable PDPs by January 14, 2011.

HMP Development Process

All 21 Copermittees participated in the development of the HMP, both financially and through their participation in the Copermittees Hydromodification/SUSMP Workgroup. The Workgroup was convened 14 times over the course of the project at times that corresponded with key decision points in developing the HMP and the update to the SUSMP. The Workgroup reviewed and commented on all drafts of the HMP and SUSMP, as well as reviewed all of the public comments received on these documents and responses to comments.

A key element of the San Diego HMP was the creation and involvement of a Technical Advisory Committee (TAC). The TAC members consisted of respected individuals from academia, technical resource agencies, the development community, consulting engineers, and environmental organizations. The TAC was tasked with providing technical input to the scientific approach and interpretation of results integral to the establishment of numerical flow control standards for the HMP, and met 11 times since October 2007.

Literature Review

Pursuant to Permit Section D.1.g(1)(e), the consultant team conducted a literature review as a basis for the initial development of the HMP. The review focused on several key technical areas, including an analysis of the flow control approaches used in past hydromodification management efforts. Concepts of effective work, critical flow, and erosion potential were reviewed along with noted stream classification strategies. Finally, hydromodification management strategies were reviewed, including LID, flow duration control basins, and in-stream mitigation. The literature review also focused on continuous simulation modeling

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approaches, rainfall data management, determination of rainfall losses due to infiltration, and determination of rainfall losses due to evaporation.

To assess the effectiveness of storm water devices to meet hydromodification criteria, peak flow frequency, and duration statistics were required to be developed. A literature review examining these statistical methods indicated that the use of a partial-duration series is preferred for climates similar to San Diego County. The need for partial-duration statistics is more pronounced for control standards based on more frequent return intervals (such as the 2-year design storm), since the peak annual series statistics do not perform as well in the estimation of such events. This phenomenon is especially pronounced in the San Diego region's semi-arid climate. Partial-duration series frequency calculations consider multiple storm events in a given year while the peak annual series considers just the peak storm event. The Hydrologic Research Center (HRC), which is located in San Diego, recommended use of the partial duration series method to most accurately estimate flow frequency response in the San Diego climate.

Methodology and Technical Approach

Per the Permit Order, a range of runoff flow rates was required to be determined to identify the range for which Priority Development Project post-project runoff flows and durations shall not exceed pre-project runoff flows and durations. The Order further required a continuous hydrologic simulation of the entire rainfall record be generated. In January 2008, Interim HMP standards were developed in order to meet the Regional Board Order. These requirements pertained only to projects disturbing 50 acres or more.

Per final hydromodification management criteria developed for San Diego County, which will be applicable to all Priority Development Projects, results of a hydromodification management analysis must adhere to the following criteria:

- For flow rates between the pre-project lower flow threshold (see below) and the pre-project 10-year runoff event, the post-project discharge rates, and durations may not deviate above the pre-project discharge rates and durations by more than 10 percent over more than 10 percent of the length of the flow duration curve.
- Lower flow thresholds may be determined using the HMP Decision Matrix (located in Chapter 6) along with a critical flow calculator and channel screening tools developed by the Southern California Coastal Water Research Project (SCCWRP), detailed in Chapter 5. These methods identify lower flow thresholds for a range of channel conditions. The critical flow calculator recommends a lower flow value of $0.1Q_2$, $0.3Q_2$, or $0.5Q_2$ dependent on the receiving channel material and dimensions. This value will be compared to the channel susceptibility rating (High, Medium, or Low) as determined from the SCCWRP screening tools located in Appendix B to determine the final lower flow threshold.
- The lower flow threshold may alternately be determined as 10 percent of the pre-project 2-year runoff event, or $0.1Q_2$. This approach, which is outlined in the HMP Decision Matrix, is available if the project applicant chooses not to complete the channel screening analysis.

Information regarding the analysis and categorization of streams from a geomorphic context has been prepared in a concurrent grant-funded hydromodification study by the Southern California Coastal Water Research Project (SCCWRP) and the County of San Diego. Screening tools developed by SCCWRP identify channel susceptibility to hydromodification impacts. These include tools to classify receiving streams as having either a High, Medium, or Low susceptibility to channel erosion impacts. Where receiving stream channels are already unstable, the standard is to avoid acceleration of the existing erosion problems. Where receiving channels are in a state of dynamic equilibrium, hydromodification management may prevent the onset of erosion or other problems.

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Requirements/Standards for Projects

Priority Development Projects are required to implement hydromodification mitigation measures so that post-project runoff flow rates and durations do not exceed pre-project flow rates and durations where such increases would result in an increased potential for erosion or significant impacts to beneficial uses. Hydromodification mitigation can provide:

- Demonstration of no post-project increase in impervious area and resultant peak flow rates as compared to pre-project conditions;
- Installation of LID BMPs, such as bioretention facilities, to control runoff flows and durations from new impervious areas;
- Mitigation of flow and durations through implementation of extended detention flow duration control basins;
- Preparation of continuous simulation hydrologic models and comparison of the pre-project and mitigated post-project runoff peaks and durations (with hydromodification flow controls) until compliance is achieved; and
- Implementation of in-stream rehabilitation controls to demonstrate that projected increases in runoff peaks and/or durations would not accelerate erosion to the rehabilitated receiving stream reach.

The HMP Decision Matrix, which leads project applicants through the HMP compliance options, is located in Chapter 6.

Exemptions

The HMP Decision Matrix outlines potential exemptions from hydromodification management criteria. These potential exemptions include discharges to exempt receiving waters such as the Pacific Ocean, to hardened conveyance systems that extend to exempt systems, as well as discharges to highly urbanized watersheds (greater than 70 percent imperviousness).

Selection and Implementation of BMPs

The project proponent may use Low-Impact Development (LID) integrated management practices to mitigate hydromodification impacts, using design procedures, criteria and sizing factors developed by the consultant team with input from the TAC and Copermittees. The sizing factor development protocol, which includes the use of a continuous simulation of runoff from the long-term rainfall record, is detailed in Chapter 7.

LID facilities must be designed to be practically built and maintained within the urban environment. Since the HMP will be implemented through the municipal development review process, design criteria have been specified and will be incorporated into conditions of approval. This HMP advocates the use of LID design approaches to provide both treatment of the 85th percentile water quality event as well as flow control to meet hydromodification criteria. To assure compliance with hydromodification flow control requirements, design criteria, specifications, and long-term operations and maintenance requirements have been provided in the Model SUSMP for a variety of LID-based flow control methods including bioretention basins, flow-through planter boxes, and bioretention systems in combination with cisterns and vaults. Provisions will also be provided for the design of larger extended detention flow duration control scenarios subsequent to approval of the HMP by the Regional Board and subsequent approval of local SUSMPs.

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Details regarding rainwater harvesting, the collection of storm water for future reuse and a potentially effective storm water quality mitigation approach, are discussed in the San Diego Model SUSMP document. Because the release of the collected water is not standardized and since a full collection facility at the onset of rainfall would provide no flow control benefit, rainwater harvesting methods are not discussed in this HMP.

Proof of a long-term, ongoing maintenance responsibility and mechanism will be required for all post-construction BMP and flow control facilities. If not properly designed or maintained, hydromodification flow control devices may create a habitat for vectors such as mosquitoes or rodents. Maintenance activities for flow control and LID devices will be specified in the proposed Project Submittal.

Monitoring and BMP Evaluation

Chapter 8 of this HMP includes an outline for a monitoring program to assess the effectiveness of hydromodification management facilities. Monitoring activities will include inflow and outflow monitoring from BMPs, baseline cross section monitoring, and flow-based sediment monitoring. These monitoring efforts will coordinate with ongoing hydromodification monitoring work conducted by SCCWRP.

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1. INTRODUCTION

Hydromodification refers to changes in the magnitude and frequency of stream flows as a result of urbanization and the resulting impacts on receiving channels in terms of erosion, sedimentation, and degradation of in-stream habitat. The degree to which a channel will erode is a function of the increase in driving force (shear stress), the resistance of the channel (critical shear stress), the change in sediment delivery, and the geomorphic condition of the channel. Critical shear stress is the stress threshold above which erosion occurs. Not all flows cause erosion -- only those that generate shear stress in excess of the critical shear stress of the bank and bed materials. Urbanization increases the shear stress exerted on the channel by stream flows and can trigger erosion in the form of incision (channel downcutting), widening (bank erosion), or both. Increases in flow below critical shear stress levels have little or no effect on the channel.

Provision D.1.g of the San Diego Regional Water Quality Control Board (RWQCB) Permit Order R9-2007-0001 requires the Copermittees to implement a HMP "…to manage increases in runoff discharge rates and durations from all Priority Development Projects, where such increased rates and durations are likely to cause increased erosion of channel beds and banks, sediment pollutant generation, or other impacts to beneficial uses and stream habitat due to increased erosive force." Where receiving stream channels are already unstable, hydromodification management can be thought of as a method to avoid accelerating or exacerbating existing problems. Where receiving stream channels are in a state of dynamic equilibrium, hydromodification management may prevent the onset of erosion or other problems.

To address the permit condition, the San Diego Storm Water Copermittees, represented by the County of San Diego, hired a consultant team and proceeded with developing an HMP that meets the intent of the Order. Permit Order R9-2007-0001 contains certain requirements that strongly influence the methodology chosen in development of the HMP. The Permit requires the Copermittees to develop an HMP for all Priority Development Projects (with certain exemptions) and develop standards to control flows within the geomorphically-significant flow range. Supporting analyses must be based on continuous hydrologic simulation modeling.

The Copermittees will incorporate HMP requirements into the local approval processes via incorporation of HMP criteria into local SUSMPs. The San Diego region's updated Model SUSMP will incorporate the Final HMP criteria. HMP criteria will be incorporated into the local SUSMP and municipal ordinances no later than 180 days following RWQCB adoption of the HMP.

It should be noted that the San Diego RWQCB jurisdiction area covers the majority of San Diego County. A portion of eastern San Diego County, all of which is part of the unincorporated County of San Diego, is under the jurisdiction of the Colorado River RWQCB and is not subject to the provisions of this HMP.

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2. COPERMITTEE HMP DEVELOPMENT PROCESS

Although the County of San Diego serves as the lead agency for development of the HMP, all 20 of the other Copermittees have participated in its development, both financially and through participation in the Copermittees' Hydromodification/SUSMP Workgroup, which is a subcommittee of the Copermittees' Land Development Workgroup. The Hydromodification/SUSMP Workgroup was convened periodically over the course of the project at times corresponding with key decision points in developing the HMP and the update to the Model SUSMP.

This workgroup was tasked with providing regional standards and consistency in the development, implementation, assessment, and reporting of urban runoff activities and programs related to hydromodification management. As required by Permit Section D.1.g, the Workgroup assisted in the development of the regional HMP.

It should be noted that Copermittees' Regional Land Development Workgroup will continue to meet to discuss and resolve any issues that may arise during the HMP implementation phase. The Workgroup will also assist in the refinement and reinforcement of methodologies, criteria, and standards established in the HMP. This Workgroup has provided training regionally to municipal staffs as well as the local engineering community on LID and hydromodification management concepts, as well as requirements in the updated Model SUSMP and HMP.

The Copermittee HMP Workgroup met 14 times since July 2007. The table below summarizes meeting dates, locations, and agenda items. In addition to the formal meetings, the Copermittee HMP Workgroup coordinated via email on countless occasions to review and discuss technical documents, deliberate regarding specific HMP-related topics and reach consensus to provide direction for the consultant team.

Table 2-1. Copermittee Workgroup Meetings Summary

Date	Location	Agenda
July 26, 2007	County of San Diego 9325 Hazard Way San Diego, CA	• Formation of a Technical Advisory Committee • Discussion of HMP requirements in other permits • Consultant contract for HMP
August 23, 2007	City of San Diego 2392 Kincaid Road San Diego, CA	• Formation of a Technical Advisory Committee • Consultant contract for HMP
October 18, 2007	County of San Diego 9325 Hazard Way San Diego, CA	• Development of interim hydromodification criteria • Technical Advisory Committee
November 5, 2007	County of San Diego 5201 Ruffin Road San Diego, CA	• Development of interim hydromodification criteria
December 13, 2007	County of San Diego 5201 Ruffin Road San Diego, CA	• Development of interim hydromodification criteria

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Table 2-1. Copermittee Workgroup Meetings Summary

Date	Location	Agenda
May 12, 2008	County of San Diego 5201 Ruffin Road San Diego, CA	• Development of interim hydromodification criteria
June 19, 2008	County of San Diego 5201 Ruffin Road San Diego, CA	• HMP progress report
October 21, 2008	County of San Diego 5201 Ruffin Road San Diego, CA	• HMP submittal to the Regional Board
December 16, 2008	County of San Diego 5201 Ruffin Road San Diego, CA	• HMP submittals to the Regional Board • Rain gauge data for HMP continuous simulation modeling
January 15, 2009	City of Chula Vista 1800 Maxwell Road Chula Vista, CA	• Approval of Draft HMP for submittal to RWQCB • Approval of Model SUSMP for submittal to RWQCB
July 20, 2009	County of San Diego 5201 Ruffin Road San Diego, CA	• HMP Decision Matrix • Discussion of potential exemptions
October 28, 2009	City of Chula Vista 1800 Maxwell Road Chula Vista, CA	• Discussion of Draft Final HMP document • Discussion of HMP implementation • HMP Design Standards
June 22, 2010	County of San Diego 5201 Ruffin Road San Diego, CA	• HMP Monitoring Plan
September 22, 2010	City of Santee 10601 Magnolia Avenue Santee, CA	• HMP Monitoring Plan • QAPP Development Process

The Copermittees will incorporate HMP requirements into the local approval processes via incorporation of HMP criteria into their local SUSMPs and municipal ordinances no later than 180 days following RWQCB adoption of the HMP. The San Diego region's updated Model SUSMP will also incorporate the Final HMP criteria.

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3. TECHNICAL ADVISORY COMMITTEE

A key element of the San Diego HMP was the creation and involvement of a TAC. The TAC members consist of respected individuals from academia, technical resource agencies, the development community, consulting engineers, and environmental organizations. Dennis Bowling of the San Diego American Public Works Association (APWA), Chair of the Water Resources Committee, chairs the TAC. A list of all TAC members and attendees to the meetings is included at the end of this section. The TAC, which has been convened on t11 occasions that correlated with key decision-making points in the development of the HMP, was tasked with providing technical input to the HMP's scientific approach and interpretation of results integral to the establishment of numerical flow control standards as well as to the Copermittees for their policy determinations. At each TAC meeting, the consultant team presented a PowerPoint presentation describing the technical approach, and solicited feedback and buy-in from TAC members. While the TAC did not always achieve consensus on recommendations to the Copermittee workgroup, its discussions and alternate views were presented to the Copermittees for their consideration. An example involves comments provided by the Natural Resources Defense Council (NRDC) and Coastkeeper. While some of their comments, such as their opinion that storm events up to the 100-year event should be considered for hydromodification mitigation, differed from the majority consensus of the TAC, their comments were considered and specifically addressed. A comment response document to Coastkeeper comments is included in Appendix C.

Some of the key input received from the TAC included agreement with the Consultant Team's approach to using a synthetic watershed modeling approach to develop flow control standards (due to time constraints and a lack of published information on local geomorphology); agreement with the selection of 20 representative rain gauges and methodology to address data gaps (to provide the historical rainfall record for the required continuous simulation hydrologic modeling); agreement on the use of scaled Lindbergh Field data to conduct the initial modeling efforts (since available local rain gauge data sets were not in a format suitable for use with continuous simulation software at the time they were required); input on development of the HMP decision matrix; lower flow threshold calculator; and SCCWRP channel screening tools/domain of analysis.

The table below summarizes meeting dates, locations, and agenda items for all TAC meetings.

Table 3-1. Technical Advisory Group Meeting Summary

Date	Location	Agenda
February 20, 2008	City of San Diego Metro Biosolids Conference Rm. San Diego, CA	• Formation of a Technical Advisory Committee • Introduction of Consultant Team • Proposed approach to developing HMP and Model SUSMP Update (presentations by Dan Cloak, Dan Cloak Environmental Consulting and Andy Collison, PWA) • Input on how much channel erosion is tolerable • Input on how aggrading channels should be addressed

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Table 3-1. Technical Advisory Group Meeting Summary

Date	Location	Agenda
May 29, 2008	City of San Diego Metro Biosolids Conference Rm. San Diego, CA	• Recap of Interim HMP Standard • Input on/agreement with approach on synthetic watershed modeling approach (presentation by Andy Collison, PWA) • Input on/agreement with approach to conducting geomorphic assessment • Discussion of approach to conducting continuous hydrologic simulation modeling
August 5, 2008	City of San Diego Metro Biosolids Conference Rm. San Diego, CA	• Input on/agreement with approach to selection of representative gauges and management of rainfall data (Presentation by Eric Mosolgo, Brown and Caldwell) • Overview of approach to conducting continuous hydrologic simulation modeling (Presentation by Eric Mosolgo, Brown and Caldwell) • Overview of BMP Sizing Tool Development (Presentation by Eric Mosolgo) • Initial results of synthetic watershed modeling based on 2 watersheds in San Diego County (Presentation by Andy Collison, PWA)
October 14, 2008	City of San Diego Stormwater Dept. Conference Rm. 9370 Chesapeake Drive San Diego, CA	• Recap of meeting with Regional Board to discuss HMP and Model SUSMP Update submittals • Input on/agreement with approach to supplementing rain gauge data sets and selection of proper rain gauge(s) for a project (Presentation by Eric Mosolgo, Brown and Caldwell) • Additional discussion of continuous hydrologic simulation modeling, including use of partial duration series data (Presentation by Eric Mosolgo and Tony Dubin, Brown and Caldwell) • Discussion of findings of synthetic watershed modeling (Presentation by Andy Collison and Christie Beeman, PWA)
February 12, 2009	City of San Diego Stormwater Dept. Conference Rm. 9370 Chesapeake Drive San Diego, CA	• Review of Draft HMP submittal to RWQCB, review of concurrent SCCWRP modeling, summary of flow threshold modeling efforts (Presentation by Eric Mosolgo, Brown and Caldwell) • Presentation of flow threshold analysis and lower threshold alternatives including watershed position and channel characteristics (Presentation by Andy Collison and Christie Beeman, PWA)
April 21, 2009	City of San Diego Stormwater Dept. Conference Rm. 9370 Chesapeake Drive San Diego, CA	• Review of comments prepared by Dr. Richard Horner, prepared on behalf of Coastkeeper, pertaining to the Draft HMP submitted to the RWQCB; review of SCCWRP work for San Diego HMP; requirements for partial duration rainfall series analysis; watershed position affects on lower flow threshold; and development of the HMP implementation decision matrix (Presentation by Eric Mosolgo, Brown and Caldwell) • Development of lower flow threshold nomograph and determination of alternate minimum flow rate (Presentation by Christie Beeman, PWA)
June 17, 2009	City of San Diego Stormwater Dept. Conference Rm. 9370 Chesapeake Drive San Diego, CA	• Summary and review of SCCWRP progress on developing the Channel Susceptibility Analysis and Domain of Analysis (Presentation by Eric Stein, SCCWRP, via telephone) • Review and discussion of lower flow threshold nomograph (Presentation by Andy Collison, PWA, via telephone) • Review of minimum flow rate and cumulative impacts (Eric Mosolgo, Brown and Caldwell) • Response to Coastkeeper comments on Draft HMP (Eric Mosolgo, Brown and Caldwell) • Discussion of BMP Sizing Calculator development (Presentation by Tony Dubin, Brown and Caldwell, via telephone, and Eric Mosolgo) • Discussion of Draft HMP Decision Matrix (Eric Mosolgo, Brown and Caldwell)

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Table 3-1. Technical Advisory Group Meeting Summary		
Date	**Location**	**Agenda**
July 29, 2009	City of San Diego Stormwater Dept. Conference Rm. 9370 Chesapeake Drive San Diego, CA	• Review of SCCWRP progress on developing the channel screening tools (Eric Mosolgo, Brown and Caldwell) • Discussion of Revised Draft HMP Decision Matrix (Eric Mosolgo, Brown and Caldwell) • Responses to RWQCB comments on Draft HMP submittal (Eric Mosolgo, Brown and Caldwell)
September 30, 2009	City of San Diego Stormwater Dept. Conference Rm. 9370 Chesapeake Drive San Diego, CA	• Summary and review of SCCWRP progress on developing the Channel Susceptibility Analysis and Domain of Analysis (Presentation by Eric Stein, SCCWRP) • Discussion of Track 1 and Track 2 flow threshold analysis development (Presentation by Andy Collison, PWA, via telephone and Webcast) • Discussion of Draft HMP Decision Matrix, HMP exemptions, design standards technical memo, and proposed monitoring plan (Eric Mosolgo, Brown and Caldwell)
October 16, 2009	City of San Diego Stormwater Dept. Conference Rm. 9370 Chesapeake Drive San Diego, CA	• Discussion of minimum orifice size (Eric Mosolgo, Brown and Caldwell) • Review of proposed monitoring plan (Eric Mosolgo, Brown and Caldwell) • Review of lower flow threshold analysis and modification to the PWA calculator (Eric Mosolgo, Brown and Caldwell) • Review and discussion of revised HMP Decision Matrix incorporating the SCCWRP Channel Susceptibility tools (Eric Mosolgo, Brown and Caldwell)
June 21, 2010	City of San Diego Stormwater Dept. Conference Rm. 9370 Chesapeake Drive San Diego, CA	• HMP Monitoring Plan

The tables below list TAC members, non-TAC member meeting attendees, and the HMP Consultant Team.

Table 3-2. Technical Advisory Committee (TAC)	
Name and Entity	**Sector Represented**
Sara Agahi, County of San Diego	San Diego Stormwater Copermittees
Edward Beighley, San Diego State University	BMP and Erosion Control Expert
Livia Borak, San Diego Coastkeeper, Natural Resources Defense Council (NRDC)	Environmental Community
Dennis Bowling, Rick Engineering	Chair of TAC
Dr. Howard Chang, San Diego State University	Geomorphology Expert
Rob Hawk, City of San Diego	Geotechnical Expert
Mikhail Ogawa, Mikhail Ogawa Engineering	TAC Coordinator
Eric Reichard, U.S. Geological Survey	Geology Expert
Eric Sattler, Spear & Associates	North County Engineers Council
Gabriel Solmer, San Diego Coastkeeper, Natural Resources Defense Council (NRDC)	Environmental Community
Eric Stein, Southern California Coastal Water Research Project (SCCRWP)	Technical Resource Agency
Garret Tam Sing, CA Department of Water Resources	Technical Resource Agency
Martin Teal, West Consultants	Consulting Engineers
Tory Walker, Tory Walker Engineering	Building Industry Association

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Table 3-3. TAC Meeting Attendees (Non-TAC Members)	
Name	**Entity/Affiliation**
David Hauser	City of Carlsbad
Glen Van Peski	City of Carlsbad
Khosro Aminpour	City of Chula Vista
Silvester Evetovich	City of Chula Vista
Tom Adler	City of Chula Vista
Jaime Campos	City of El Cajon
Masih Maher	City of Encinitas
Erik Steenblock	City of Encinitas
Cheryl Filar	City of Escondido
Homi Namdari	City of Escondido
Mo Lahsaie	City of Oceanside
Alison Witheridge	City of Oceanside
Billy Walker	City of Oceanside
Danis Bechter	City of Poway
Roger Morrison	City of Poway
Sumer Hasenin	City of San Diego
James Nabong	City of San Diego
Sassan Haghgoo	City of San Marcos
Julie Procopio	City of Santee
Greg Mayer	City of Vista
Karen Franz	Coastkeeper
Vaikko Allen	Contech Stormwater Solutions
Chris Crompton	County of Orange
George Edwards	County of Orange
Anthony Barry	County of San Diego
John Quenzer	D-MAX Engineering
Arsalan Dadkhah	D-MAX Engineering/City of National City
Dick Rol	Foothill Engineering
Jeff O'Connor	Home Fed
Dave Hammar	Hunsaker & Associates
Luis Parra	Hunsaker & Associates, Adams Engineering, URS
Eylon Shamir	Hydrologic Research Center
Rosanna Lacarra	PBS&J
Debby Reece	Project Design Consultants
Allison Gutierrez	Port of San Diego
Karen Holman	Port of San Diego
Rich Lucera	RBF
Braeden Macguire	RBF

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Table 3-3. TAC Meeting Attendees (Non-TAC Members)	
Name	**Entity/Affiliation**
Laura Henry	Rick Engineering
Bob Cullen	Riverside County Flood Control & Water Conservation District
Jason Uhley	Riverside County Flood Control & Water Conservation District
Tyler Schemper	Tory Walker Engineering
Matt Moore	URS Corporation/Port of San Diego

Table 3-4. HMP Consultant Team	
Name	**Company**
Christie Beeman	Philip Williams & Associates
Dr. Andrew Collison	Philip Williams & Associates
Dan Cloak	Dan Cloak Environmental Consulting
Tony Dubin	Brown and Caldwell
Nancy Gardiner	Brown and Caldwell
Eric Mosolgo	Brown and Caldwell

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4. LITERATURE REVIEW

Pursuant to Permit Section D.1.g(1)(e), this section provides the results of a literature review conducted as a basis for the initial development of the HMP.

4.1 Flow Control Approach

HMPs that have been developed in the San Francisco Bay Area of California (Contra Costa, Santa Clara, and Alameda Counties) vary with regard to the emphasis placed on lower flow control thresholds as compared to other approaches, such as distributed LID methods. However, there is consensus in that both the frequency and duration of flows must be controlled, requiring the use of continuous simulation hydrologic modeling (as opposed to the more standard design storm approach used for flood control design) for evaluation of potential development impacts. It is also generally accepted that events smaller than the 10-year design flow are the most critical for hydromodification management.

The Santa Clara HMP focused on the use of detention basins for hydromodification management and strongly emphasized the lower flow control limit for site runoff. Extended detention flow control basins can utilize multi-stage outlets to mitigate both the duration and magnitude of flows within a prescribed range. To avoid the erosive effects of extended low flows, the maximum rate at which runoff is discharged is set below the erosive threshold. Per the Santa Clara HMP, the lower flow control limit was defined as the flow rate that generates critical shear stress on the channel bed and banks. Both Santa Clara and Alameda Counties correlated the lower flow control limit to a value equal to 10 percent of the 2-year runoff event.

The Contra Costa HMP strongly emphasized the use of LID methods to meet hydromodification management criteria. LID approaches to hydromodification management rely on site design and distributed LID Best Management Practices (BMPs) to control the frequency and duration of flows and to mitigate hydrograph modification impacts. By minimizing directly connected impervious areas and promoting infiltration, LID approaches mimic natural hydrologic conditions to counteract the hydrologic impacts of development. Because more runoff is retained onsite and in distributed facilities the lower discharge limit is less critical for LID facilities since different facilities discharge to the stream system at different times.

The County of San Diego and Copermittees interviewed three consultant teams as part of the selection process to develop the HMP. The selection panel; which included representatives from the County of San Diego, City of San Diego, City of Chula Vista, and the City of Encinitas, selected the team led by Brown and Caldwell and included Phillip Williams Associates and Dan Cloak Engineering. This team had previously developed the HMP for Contra Costa County and thus, the Contra Costa approach was selected as the base approach for the San Diego HMP.

For the San Diego region's Interim Hydromodification Management Criteria, the range of flows to be managed under the hydrograph curve-matching approach (matching of peak flows and durations within the geomorphically significant range) was expressed as a percentage of the 5-year runoff event, based on the understanding that the 5-year runoff event is considered the dominant channel-forming discharge for Southern California streams. This assumption was based upon the paper titled, "Effect of Increases in Peak Flows and Imperviousness on the Morphology of Southern California Streams," by Coleman, MacRae, and Stein. The following list details the range of flows recommended in the San Diego region's Interim Hydromodification Criteria.

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- For flow rates between 20 percent of the pre-project 5-year runoff event and the pre-project 10-year runoff event, the post-project discharge rates and durations may not deviate above the pre-project discharge rates and durations by more than by more than 10 percent over more than 10 percent of the length of the flow duration curve.
- For flow rates between 20 percent of the pre-project 5-year runoff event and the pre-project 5-year runoff event, the post-project flows shall not exceed pre-project flows. For flow rates between the 5-year and 10-year runoff events, post-project flows may exceed pre-project flows by up to 10 percent for a 1-year frequency interval.
- The project proponent may also use LID integrated management practices to manage hydromodification impacts, using design procedures, criteria, and sizing factors (ratio of the required LID area to the tributary impervious area) specified by the Copermittees.

The Interim Hydromodification Management Criteria listed above were put in place beginning in January 2008 for development projects that disturb 50 acres or more.

Hydromodification in the context of this project refers to changes in the magnitude and frequency of stream flows as a result of urbanization and the resulting impacts on the receiving channels in terms of erosion, sedimentation, and degradation of instream habitat. The processes involved in this degradation are complex, but involve an alteration of the hydrologic regime of a watershed due to increases in impervious surfaces, more efficient and dense storm drain networks, and a change in historic sediment sources. The study of hydromodification is an evolving field, and regulations to manage the impacts of hydromodification must take into account the latest science available.

HMPs seek ways to mitigate erosion impacts by establishing requirements for controlling runoff from new development. In order to establish appropriate regulations, it is important to understand 1) how land use changes alter storm water runoff; and 2) how these changes can impact stream channels. This literature review focuses on how these issues have been addressed in HMPs adopted within the state of California as well as relevant journal articles, books, and other reports. This report builds upon previous literature reviews developed for other HMPs, and attempts to not repeat information that can be found in those reports. Instead this report is a synthesis of information that can be found in those studies and is augmented with either more recent studies or information relevant to Southern California.

4.1.1 Previous Studies

Previous hydromodification literature reviews were conducted by Geosyntec Consultants (Mangarella and Palhegyi, 2002) for the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP) and by the Contra Costa Clean Water Program (CCCWP 2004). Mangarella and Palhegyi provide a detailed overview of the geomorphic and hydrologic processes involved in hydromodification and the reader is directed there for more detailed information on the mechanics of stream erosion. Channel Assessment methods described in Section 2 of this report rely heavily on those reviewed by Bledsoe et al. (2008) for SCCWRP.

As of the date of this report, five approved HMPs have been published. These include HMPs for SCVURPPP (2005), the CCCWP (2005), the Fairfield-Suisun Urban Runoff Management Program FSURMP (2005), the Alameda Countywide Clean Water Program (ACCCMP 2005), and the San Mateo County Stormwater Pollution Prevention Program (STOPPP 2005). In addition, a number of HMPs were implemented while agencies developed their final plans. Interim HMPs are not detailed in this report due to the fact that these plans have adopted findings from the above listed HMPs.

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4.1.2 Hydrograph Modification Processes

The effects of urbanization on channel response have been the focus of many studies (see Paul and Meyer, 2001 for a review), and the widely accepted consensus is that increases in impervious surfaces associated with urbanizing land uses can cause irreversible channel degradation. Urbanization generally leads to a change in the amount and timing of runoff in a watershed, which leads to increases in erosive forces on bank and bed material. This can cause large-scale channel enlargement, stream bank failure, loss of aquatic habitat and degradation of water quality.

Channel erosion, like most physical processes, is a complex system based on a variety of influences. Channel erosion is non-linear (Philips 2003) meaning the response of streams is not directly proportional to changes in land use and flow regimes. Small changes or temporary disturbances in a watershed may lead to unrecoverable channel instability (Kirkby 1995). These disturbances may give rise to feedback systems whereby small instabilities can be propagated into larger and larger instabilities (Thomas 2001).

A variety of factors have been documented to contribute to instability in streams. These include historic land use practices such as grazing (Trimble and Mendel 1995), logging (Jana et al. 1975), wildfire patterns, (Benda et al., 2003), geologic uplift (Colin and Burbank 2007), climatic changes (Leeder 1998), or removal of flora or fauna from the watershed (Ripple et al. 2001).

Although these parameters are varied, urban runoff control programs focus on managing the effect that new impervious surfaces have on stream channels. Stream channels show some form of temporal stability, whereby they resist change until a threshold of system parameters are exceeded (Thomas 2001). A number of studies have sought to correlate the amount of urbanization in a watershed and stream instability (Bledsoe 2001; Booth 1990, 1991; Both and Jackson 1997; MacRae 1992; 1993; 1996; Coleman et al. 2005). Evidence from these studies suggests that streams resist instability until a watershed urbanization threshold is crossed. This threshold appears to be around seven to ten percent watershed urbanization for perennial streams (Schueler 1998 and Booth 1997), but may be much lower for intermittent streams such as those found in Southern California. Studies done in Santa Fe, New Mexico (Leopold and Dunne 1978) suggest that dramatic changes occur at four percent impervious area of the watershed. Initial studies by Coleman et al. (2005) suggest that this urbanization threshold may be as low as two to three percent for intermittent streams in Southern California. It is important to understand that use of impermeable cover alone is a poor predictor of channel erosion due to regional differences and differences in storm water detention and infiltration within regions.

Though it is well established that watershed urbanization causes channel degradation, a detailed understanding of how development alters runoff and how this altered runoff in turn causes erosion is still being developed. This section briefly describes these processes and summarizes methods used to quantify hydromodification impacts.

4.1.2.1 Effective Work

The ability of a stream to transport sediment is proportional to the amount of flow in the stream: as flow increases, the amount of sediment moved within a channel also increases. The ability of a stream channel to transport sediment is termed stream power, which integrated over time is work. Leopold (1964) introduced the concept of effective work, whereby the flow-frequency relationship of a channel is multiplied by sediment transport rate. This gives a mass-frequency relationship for erosion rates in a channel. Flows on the lower end of the relationship (e.g., two-year flows) may transport less material, but occur more frequently than higher flows, thereby having a greater overall effect on the work within the channel. Conversely, higher magnitude events, while transporting more material, occur infrequently so as to have less effective work. Leopold found that the maximum point on the effective work curve occurred around the 1- to 2-year frequency range. This maximum point is commonly referred to as the dominant discharge and corresponds

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roughly to a bankfull event (a flow that fills the actively scoured portion of the channel up to a well defined break in the bank slope).

Urbanization tends to have the greatest relative impact on flows that are frequent and small, and which tend to generate less-than-bankfull flows. Change is greatest in these events because prior to urbanization infiltration would have absorbed much or all of the potential runoff, but following urbanization a high percent of the rainfall runs off. Thus, events that might have generated little or no flow in a non-urbanized watershed can contribute flow in urban settings. These smaller less-than-bankfull events have been found to do a significant proportion of the work in urban streams (MaCrae 1993) due to their high frequency, and can lead to channel instability. Less frequent, larger magnitude flows (e.g., flows greater than Q10) are less strongly affected by urbanization because during such large storm events the ground rapidly becomes saturated and acts in a similar manner as impervious surfaces.

4.1.2.2 Erosion Potential

As part of the SCVURPPP's HMP process, GeoSyntec Consultants (2004) studied the Lower-Silver-Thompson Creek subwatershed in Santa Clara County to characterize the pre-development effective work and compare it to modeled post-development effective work. Stability was assessed by comparing these effective work curves via an erosion potential index (Ep). This value is the ratio of the effective work of a pre-development stream to that of a post-development stream. A developed stream with an Ep of 1.0 has the same ability to transport sediment as an undeveloped stable stream. Managing the Ep of a stream can focus on managing the hydrologic regime of a watershed or on managing the stream itself. Both of these methods are discussed in Section 4.1.4.

Ep was adopted as a hydromodification metric for the SCVURPPP's hydromodification management program, and was later incorporated into four of the five approved HMPs. In addition, its use is being promoted by several research and regulatory bodies.

4.1.2.3 Estimating Critical Q_c

Due to the increase in impervious surfaces and fewer opportunities for infiltration of storm water, urbanization creates more runoff volume than an un-urbanized watershed. Opportunities for infiltration of excess storm water exist in some areas, but many times are infeasible due to cost or land use constraints. Therefore, some of the excess storm water must be discharged to a receiving stream. In order to achieve a comparable Ep to a pre-developed condition, this excess runoff volume must be discharged at a rate at which no additional stream work is done.

Bed load sediment moves through transmission of shear stress from the flow of water to the bed load material. An increase in velocity of water corresponds to an increase in shear stress. In order to initiate movement of bed material, however, a shear stress threshold must be exceeded. This is commonly referred to as critical shear stress, and is dependent on sediment and channel characteristics. For a given point on a channel where the cross-section is known, the critical shear can be related to a stream flow. The flow that corresponds to the critical shear is known as the critical flow, or Qc. For a given cross-section, flows that are below the value for Qc do not initiate bed movement, while flows above this value do.

The SCVURPPP expressed Qc as a percentage of the two-year flow in order to develop a common metric across watersheds of different size, and allow for easy application of HMP requirements For the two watersheds studied, a similar relationship was found where Qc corresponded to 10 percent of the two-year flow. This became the basis for the lower range of geomorphically significant flows under the SCVURPPP HMP and is referred to as Qcp to indicate that it is a percentage of flow. That program also adopted the 10-year flow as the upper end of the range of flows to control with the justification that increases in stream work above the 10-year flow were small for urbanized areas.

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A similar study was conducted for the FSURMP on two watersheds in Fairfield, California following a geomorphic assessment. That study found Qcp to be 20 percent of the pre-development two-year flow. The differences in the two values may be attributable to differences in watershed characteristics in Santa Clara County and Fairfield. Channels in Fairfield were found to have a more densely vegetated riparian corridor and may have a higher resistance to increases in shear stresses (FSURMP). Values for Qcp appear to be similar among neighboring watersheds, but there appears to be no evidence for a 'universal' Qcp, and the characteristics of individual biomes (climatically and geographically defined areas of ecologically similar climatic conditions such as communities of plants, animals, and soil organisms, and are often referred to as ecosystems) should be taken into account when developing a Qcp. For example, Western Washington State, which has more densely vegetated riparian zones than either Fairfield or Santa Clara County, has adopted a Qcp of 50 percent of the 2-year flow.

A summary of flow control standards adopted in each of these HMPs is given in Table 4-1.

Table 4-1. Flow Control Standards Adopted by Selected Agencies for Hydromodification Management.

Permitting Agency	Qcp	Largest Managed Flow
Santa Clara County	10 percent of the 2-year flow (0.1Q2)	10-year flow (Q10)
Alameda County	10 percent of the 2-year flow (0.1Q2)	10-year flow (Q10)
San Mateo County	10 percent of the 2-year flow (0.1Q2)	10-year flow (Q10)
Contra Costa County	10 percent of the 2-year flow (0.1Q2)	10-year flow (Q10)
Fairfield-Suisun Urban Runoff Management Program	20 percent of the 2-year flow (0.2Q2)	10-year flow (Q10)
Western Washington State	50 percent of the 2-year flow (0.5Q2)	50-year flow (Q50)

4.1.3 Stream Channel Stability

Numerous stream channel stability assessment methods have been proposed to help identify which channels are most at risk from hydrograph modification impacts and/or define where HMP requirements should apply. Assessment strategies range from purely empirical approaches to channel evolution models to energy-based models (see Simon et al., 2007 for a critical evaluation).

4.1.3.1 Stream Classification Systems

A recent study by Bledsoe et al. (2008) for SCCWRP describes nine types of classification and mapping systems with an emphasis on assessing stream channel susceptibility in Southern California. The summary below is taken from that study. Bledsoe also provides a summary of the implications of these classification and mapping systems to the development of hydromodification tools for Southern California. The article provides a detailed breakdown of guidelines for developing hydromodification tools given the advantages and disadvantages of each system previously assessed.

Planform Classifications and Predictors

Alluvial channels form a continuum of channel types whose lateral variability is primarily governed by three factors: flow strength, bank erodibility, and relative sediment supply. Though many natural channels conform to a gradual continuum between straight and intermediate, meandering, and braided patterns, abrupt transitions in lateral variability imply the existence of geomorphic thresholds where sudden change can occur. The conceptual framework for geomorphic thresholds has proven integral to the study of the effects of disturbance on river and stream patterns. Many empirical and theoretical thresholds have been proposed relating stream power, sediment supply and channel gradient to the transition between braiding and meandering channels. Accounting for the effects of bed material size has been shown to provide a vital

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modification to the traditional approach of defining a discharge-slope combination as the threshold between meandering and braided channel patterns. The many braided planforms in Southern California indicate the need to refine and calibrate established thresholds to river networks of interest. However, at this time there is not a well accepted model to predict how hydromodification affects channel planform.

Energy-Based Classifications

The link between channel degradation and urbanization has been exhaustively studied; however, impervious area is not the solitary factor influencing channel response. Studies have shown that the ratio between specific stream power and median bed material size D50b, where b is approximately 0.4 to 0.5 for both sand- and gravel-bed channels, can be used as a valuable predictor of channel form. Stream power, which is related to the square root of total discharge, is the most comprehensive descriptor of hydraulic conditions and sedimentation processes in stream channels. Several studies have been performed relating channel stability to a combination of parameters such as discharge, median bed-material size, and bed slope, as an analog for stream power.

General Stability Assessment Procedures

By assessing an array of qualitative and quantitative parameters of stream channels and floodplains, several investigators have developed qualitative assessment systems for stream and river networks. These assessment methods have been incorporated into models used to analyze channel evolution and stability. Many parameters used to establish methodologies such as the Rosgen approach are extendable to a qualitative assessment of channel response in Californian river networks. Field investigations in Southern California have shown that grade control can be the most important factor in assessing the severity of channel response to hydromodification. Qualitative methodologies have proven extendable to many regions and utilize many parameters that may provide valuable information for similar assessments in California.

Sand vs. Gravel Behavior / Threshold vs. Live-Bed Contrasts

It is well recognized that the fluvial-geomorphic behavior varies greatly between sand and gravel/cobble systems. Live bed channels (of which sand channels are good examples) are systems where sediment moves at low flows, and where sediment is frequently in motion. Threshold channels such as gravel streams, by contrast, require considerable flow to initiate bedload movement. Live bed channels are more sensitive both to increases in flow and decreases in sediment supply than threshold channels. Scientific consensus shows that sand bed streams lacking vertical control show greater sensitivity to changes in flow and sediment transport regimes than do their gravel/cobble counterparts. Factors such as slope which affect discharge and sedimentation regimes are known to have greater impact on sand-bed streams. This can be an important issue for storm water systems that receive runoff from watersheds composed primarily of streams with sandy substrate. The transition between sand and gravel bed behavior can be rapid which may make it possible to utilize geographic mapping methods to identify channel segments according to their susceptibility to the effects of hydromodification.

Channel Evolution Models of Incising Channels

The Channel Evolution Model (CEM) developed by Schumm et al. (1984) posits five stages of incised channel instability organized by increasing degrees of instability severity, followed by a final stage of quasi-equilibrium. Work has been done to quantify channel parameters such as sediment load and specific stream power through each phase of the CEM. A dimensionless stability diagram was developed by Watson et al. (2002) to represent thresholds in hydraulic and bank stability. This conceptual diagram can be useful for engineering planning and design purposes in stream restoration projects requiring an understanding of the potential for shifts in bank stability.

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Channel Evolution models Combining Vertical and Lateral Adjustment Trajectories

Originally, CEMs focused primarily on incised channels with geotechnically, rather than fluvially, driven bank failure. Several CEMs have been proposed that incorporate channel responses to erosion and sediment transport into the original framework for channel instability. In these new systems, an emphasis is placed on geomorphic adjustments and stability phases that consider both fluvial and geomorphic factors. The state of Vermont has developed a system of stability classification that suggests channel susceptibility is primarily a function of the existing Rosgen stream type and the current stream condition referenced to a range of variability. This system places more weight on entrenchment (vertical erosion of a channel that occurs faster than the channel can widen, so that the resulting channel is more confined than the original channel) and slope than differentiation between bed types.

Equilibrium Models of Supply vs. Transport-capacity / Qualitative Response

The qualitative response model builds on an understanding of the dynamic relationship between the erosive forces of flow and slope relative to the resistive forces of grain size and sediment supply to describe channel responses to adjustments in these parameters. In this system qualitative schematics provide predictions for channel response to positive or negative fluctuations in physical channel characteristics and bed material. Refinements to such frameworks have been made to account for channel susceptibility relative to existing capacity and riparian vegetation among other influential characteristics.

Bank Instability Classifications

Early investigations provided the groundwork for bank instability classifications by analyzing shear, beam, and tensile failure mechanisms. The dimensionless stability approach developed by Watson characterized bank stability as a function of hydraulic and geotechnical stability. Rosgen (1996) proposed the widely applied Bank Erosion Hazard Index (BEHI) as a qualitative approach based on the general stability assessment procedures outlined above. Other classification systems, like the CEM, identify bank instability according to channel characteristics that control hydrogeomorphic behavior.

Hierarchical Approaches to Mapping Using Aerial Photographs / GIS

It has become increasingly common practice to characterize stream networks as hierarchical systems. This practice has presented the value in collecting channel and floodplain attributes on a regional scale. Multiple studies have exploited geographical information systems (GIS) to assess hydrogeomorphic behavior at a basin scale. Important valley scale indices such as valley slope, confinement, entrenchment, riparian vegetation influences, and overbank deposits can provide indispensable information for river networks in California. Many agencies are developing protocol for geomorphic assessment using GIS and other database associated mapping methodologies.

4.1.4 Managing Hydromodification

Most HMPs provide guidance on how Copermittees can meet the goals of their program. There are many different approaches and most HMPs provide multiple options for achieving and documenting compliance. In general, hydrograph management approaches focus on managing runoff from a developed area so as to not increase instability in a channel, and in-stream solutions focus on managing the receiving channel to accept an altered flow regime without becoming unstable. This chapter briefly summarizes various approaches for HMP compliance.

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4.1.4.1 Hydrograph Management Solutions

Facilities that detain or infiltrate runoff to mitigate development impacts are the focus of most HMP implementation guidance. They work either by reducing the volume of runoff (infiltration facilities) or by holding water and releasing it below Qc (retention facilities). These facilities, sometimes referred to as BMPs, can range from regional detention basins designed solely for flow control, to bioretention facilities that serve a number of functions. A number of BMPs including swales, bioretention, flow-through planters, and extended detention basins have been developed to manage storm water quality, and there are several resources that describe the design of storm water quality BMPs (CASQA 2003; Richman et al. 2004). In many cases these facilities can be designed to also meet hydromodification management requirements.

Many HMPs also provide guidance for applying LID approaches to site design and land use planning to preserve the hydrologic cycle of a watershed and mitigate hydromodification impacts. These plans typically include decentralized storm water management systems and protection of natural drainage features, such as wetlands and stream corridors. Runoff is typically directed toward infiltration-based storm water BMPs that slow and treat runoff.

The following sections summarize implementation guidance for designing hydromodification management BMPs that have been developed for existing HMPs.

Sizing Hydromodification BMPS

Hydromodification BMPs differ slightly from those BMPs used to meet water quality objectives in that they focus more on matching undeveloped flow-regimes than on filtering storm runoff, although these two functions can be combined into one facility. Various methods exist for sizing Hydromodification BMPs.

Hydrograph Matching. This is an approach whereby the outflow hydrograph for a particular site matches closely with the pre-project hydrograph for a design storm. This method is most traditionally used to design flood-detention facilities to mitigate for a particular storm recurrence interval (e.g., the 100-year storm). Although hydrograph matching can be employed for multiple storms, this method generally does not take into account the smaller, more frequent storms where a majority of the erosive work in stream channel is done and is therefore not widely accepted for HMP compliance.

Volume Control. This is a method for matching the pre-project and post-construction runoff volume for a project site. Any increase in runoff volume is either infiltrated on site, or discharged to another location where streams will not be impacted. The magnitude of peak flows is not controlled, and therefore this method, while ensuring that there is no increase in total volume of runoff, can result in higher erosive forces during storms.

Flow Duration Control. Refers to matching both the duration and magnitude of a specified range of storms. The entire hydrologic record is taken into account and pre-project and post-construction runoff magnitudes and volumes are matched as closely as possible. Excess runoff is either infiltrated on site, or is discharged below Qcp.

The SCVUPPP HMP reviewed each of these design approaches and concluded that a Flow Duration Control design approach was the most effective in controlling erosive flows. Two examples were evaluated using this approach, one on the Thompson Creek subwatershed in Santa Clara Valley and one on the Gobernadora Creek watershed in Orange County. The evaluation approach used continuous simulation modeling to generate flow-duration curves, and then designed a test hydromodification management facility to match pre-project durations and flows.

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In addition to the SCVURPP, the flow duration control design approach has been applied by ACCWP, STOPPP, FSURMP, and CCCWP. Among these agencies, different approaches have emerged as to how to demonstrate that proposed BMPs meet flow-duration control guidelines. Both methods employ continuous simulation to match flow-durations, but differences exist in how continuous simulation is used (site-specific simulation vs. unit area simulation). Differences also exist in the focus of the two approaches (regional detention facilities vs. on-site LID facilities). Both approaches were evaluated by the RWQCB, and deemed to be valid approaches (Butcher 2007).

BAHM Approach

The Bay Area Hydrology Model (BAHM) is a continuous simulation rainfall-runoff hydrology model developed for ACCWP, STOPPP, and SCVURPP . It was developed from the Western Washington Hydrology Model, which focuses primarily on meeting hydromodification management requirements using storm water detention ponds alone or combined with LID facilities (Butcher 2007). The Western Washington Hydrology model is based on the Hydrologic Simulation Program FORTRAN (HSPF) modeling platform, developed by the USEPA, and uses HSPF parameters in modeling watersheds.

BAHM is a standalone modeling package that is available free of charge to the public. Project proponents who want to size a hydromodification BMP select the location of their project site from a map of the county and BAHM correlates the project location to the nearest rainfall gauge and applies an adjustment factor. The adjustment factor is applied to the hourly rainfall for the nearest gauge, to produce a weighted hourly rainfall at the project site. The user then enters parameters for the proposed project site that describe soil types, slope, and land uses. BAHM then runs the continuous rainfall-runoff simulation for both the pre-project and the post-construction conditions of the project site. Output is provided in the form of flow-duration curves that compare the magnitude and timing of storms between the pre-project and the post-construction modeling runs.

If an increase in flow durations is predicted, the user can select and size mitigation BMPs from a list of modeling elements. An automatic sizing subroutine is available for sizing detention basins and outlet orifices that matches the flow duration curves between the pre-project scenario and a post-construction mitigation scenario. Manual sizing is necessary for other BMPs included in the program, such as storage vaults, bioretention areas, and gravel trenches. The program is designed so that once a BMP is selected and sized, the modeling run can be transferred to the local agency for approval. The model reviewer at the local agency can open the program and verify modeling parameters and sizing techniques.

CCCWP Approach

The CCCWP developed their own protocol for selecting and sizing hydromodification BMPs, which are referred to as Integrated Management Practices (IMPs) in their guidebook. Instead of a project proponent running a site-specific continuous simulation to size hydromodification control facilities, the CCCWP provides sizing factors for designing IMPs. Sizing factors are based on the soil type of the project site and are adjusted for Mean Annual Precipitation. Sizing factors are provided for Bioretention Facilities, Flow-Through Planters, Dry Wells and a combination Cistern and bioretention facility.

Sizing factors were developed through continuous-simulation HSPF modeling runs for a variety of development scenarios. Flow-durations were developed for a range of soil types, vegetation and land use types, and rainfall patterns for development areas in Contra Costa County. Then, based on a unit area (one acre) of impervious surface, flow-durations were modeled using several IMP designs. These IMPs were then sized to achieve flow control for the range of storms required, (from 10 percent of the 2-year storm up to the 10-year storm). These sizing factors were then transferred to a spreadsheet form for use by project proponents.

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The primary difference between the CCCWP approach and the BAHM approach is the focus on type of BMP used. Whereas the CCCWP approach focuses on meeting hydromodification management goals using lot-scale LID facilities, the BAHM approach is geared toward employing detention basins. Although the CCCWP approach is based on utilizing sizing factors for specific BMPs, the program does allow for application of site-specific continuous simulation modeling, such as HSPF, if the relevant sizing factor has not been developed, such as storm water detention basins or constructed wetlands. This approach can be used for larger developments where regional hydromodification facilities will be used.

4.1.4.2 In-Stream Stabilization Solutions

In-stream solutions focus on managing the stream corridor to protect stability and, if necessary, modify stream channels to accept an altered flow regime. In cases where development is proposed in an already degraded watershed it may be beneficial to focus on rehabilitating the stream channel with an altered flow regime in mind rather than retrofitting the watershed or only controlling a percentage of the runoff. In addition, in some cases where a master-planned watershed development plan is being implemented it may be more feasible to design a new channel to be stable under the proposed watershed land use rather than to construct distributed on-site facilities.

Newhall Ranch Natural River Management Plan

An example where in-stream solutions are being designed at the Master Plan level can be found in the Newhall Ranch Natural River Management Plan. The proposed Newhall Ranch development near Valencia, California is employing a combination of distributed storm water quality facilities to manage storm water pollutants and in-stream management actions to manage an altered flow regime. The management plan began with an analysis of post-development flow conditions, then found slopes and channel cross-sections that would be stable under these altered conditions. Biotechnical bank stabilization and stable step-pools were included to allow the new channel to resist higher shear forces. The plan has been approved by Los Angeles County Department of Public Works.

The key objectives for the in-stream channel design employed for the Newhall Ranch development were:

- Accommodate runoff flows from existing and future development;
- Stabilize the channel bed and banks so that they do not degrade;
- Preserve the waterway and canyon characteristics and environment, where applicable;
- Minimize riparian and bank disturbance during construction, where applicable;
- Implement improvements that are the most compatible with the environment and character of the region, yet sustainable on a long-term basis and
- Minimize channel maintenance requirements.

Other Methods

A number of methods exist for managing channels to accept altered flow regimes and higher shear forces. These have been covered in detail in a number of sources available to watershed groups and public agencies. (A few helpful sources include Riley 1998, Watson and Annable 2003, and FISRWG 1998.)

4.2 Continuous Simulation Modeling

As part of the HMP development, Brown and Caldwell is preparing flow control sizing tools to assess the effectiveness of hydromodification controls. A beta version of the HMP Sizing Calculator will be available by early 2010 and will be reviewed by the HMP TAC. Since those sizing tools are not yet available, Brown and Caldwell has identified specific evaluation criteria for the design and analysis of hydromodification controls

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using continuous simulation hydrologic modeling. Evaluation criteria discussed herein focuses on the following items:

- Continuous Simulation Hydrologic Modeling
- Continuous Simulation Modeling Software
- Long-Term Hourly Precipitation Gauge Data
- Parameter Validation for Rainfall Losses
- Hydromodification Control Processes
- Peak Flow and Flow Duration Statistics

Pursuant to criteria set forth by the San Diego RWQCB and by the San Diego County Copermittees in the Hydromodification Criteria, the use of continuous simulation hydrologic modeling is required to size storm water facilities to mitigate hydromodification effects. Continuous simulation modeling uses an extended time series of recorded precipitation data as input and generates hydrologic output, such as surface runoff, groundwater recharge, and evapotranspiration, for each model time step.

Continuous hydrologic models are typically run using either 1-hour or 15-minute time steps. Based on a review of available rainfall records in San Diego County, we are recommending the use of a 1-hour time step (15-minute time series rainfall data are very limited). Continuous models generate model output for each time step. In this case, hydrologic output would be generated for each hour of the continuous model. A continuous simulation model with 35 years of hourly precipitation data will generate 35 years of hourly runoff estimates, which corresponds to runoff estimates for 306,600 time steps over the 35-year simulation period.

Use of the continuous modeling approach allows for the estimation of the frequency and duration by which flows will exceed a particular threshold. The limitations to increases of the frequency and duration of flows within that geomorphically significant flow range is the key component to San Diego County's approach to hydromodification management.

For a more detailed review of continuous simulation modeling, refer to a memo prepared by Brown and Caldwell titled *Using Continuous Simulation to Size Storm Water Control Facilities* (May 2008). This memo is attached as Appendix E.

4.2.1 Continuous Simulation Modeling Software

The following public domain software models may be used to assess hydromodification controls for storm water facilities to meet the Hydromodification Criteria:

- HSPF - Hydrologic Simulation Program-FORTRAN, distributed by United States Environmental Protection Agency (USEPA)
- HEC-HMS – Hydrologic Modeling System; distributed by the US Army Corps of Engineers Hydrologic Engineering Center
- SWMM – Storm Water Management Model; distributed by USEPA

Third-party and proprietary software can be used to meet the Hydromodification Criteria provided that the software incorporates minimum design parameters summarized below:

- Input and output data from the software can interface with public domain software such as HSPF HEC-HMS, or SWMM. In other words, input files from the third-party software should have sufficient functionality to allow export to public domain software for independent validation.
- Rainfall data are selected according to an existing rainfall gauge location that is geographically and meteorologically similar to the project site location.

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- Rainfall loss parameters used in the software can be substantiated and fully referenced.
- The software's hydromodification control processes, detailed later in this memo, are substantiated and fully referenced.

All third-party and proprietary software will be subject to more rigorous review upon the adoption of the Final HMP. This review would include further testing of various development and treatment scenarios as well as an in-depth analysis of software functionality and processes.

As stated previously, Brown and Caldwell is currently preparing flow control sizing tools to assess the effectiveness of hydromodification controls. These tools will be available in association with implementation of the final HMP.

4.2.2 Parameter Validation for Rainfall Losses

In preparing computer models to assess storm water controls and meet Hydromodification Criteria, rainfall loss parameters describing soil characteristics, land cover descriptions, and evapotranspiration data should be validated to prove consistency with the local environment and climatic conditions. The validation process should include documentation of the source of evapotranspiration data and commentary of the effects of varying evapotranspiration patterns between the subject site and parameter data source. A full review of local pan evaporation and potential evapotranspiration data will be included as part of development of the final hydromodification flow control sizing tool.

To meet Hydromodification Criteria, soil and land cover parameter validation can be based on the following:

- Calibration to local stream flow data, where applicable. Examples of local calibration studies include, but are not limited to, total maximum daily load (TMDL) modeling efforts prepared for the San Diego RWQCB (*TMDL for Indicator Bacteria Project I – Beaches and Creeks in the San Diego Region*, Tetra Tech, December 2007).
- Published parameter values consistent with previous studies for San Diego County and Southern California, such as HSPF-related regional calibration studies, research projects, regional soil surveys, etc.
- Specific data prepared as part of a site-specific geotechnical investigation
- If parameters are transposed or modified from calibration efforts outside of Southern California, the source should be identified and justification should be provided stating why such data are applicable for San Diego County. Details should be provided justifying how parameters from such studies were adjusted to be applicable to San Diego conditions.
- Recommended parameter value ranges from *BASINS Technical Notice 6, Estimating Hydrology, and Hydraulic Parameters for HSPF*, USEPA, July 2000.

Storm water flow control devices designed to meet Hydromodification Criteria should be analyzed pursuant to the following criteria:

- Infiltration processes should be modeled with sufficient complexity to properly quantify the flow control benefit to the receiving streams. These infiltration processes should be transparent and fully documented.
- Infiltration quantification should include provisions for water head and pore suction effects for multiple layers of varying materials (i.e., ponding areas, amended soil layer, gravel layer, etc.), or provide justification why such complex processes are not included.
- Storage processes associated with each layer of the storm water device should be fully explained and quantified.
- Device outflow curves should consider controls associated with device underdrains. The methodology by which such stage-discharge relationships are developed should be fully documented.

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4.2.3 Peak Flow and Flow Duration Statistics

To assess the effectiveness of storm water flow control devices in mitigating hydromodification effects to meet Hydromodification Criteria, peak flow frequency statistics should be developed. Peak flow frequency statistics estimate how often flow rates will exceed a given threshold. In this case, the key peak flow frequency values would be the lower and upper bounds of the geomorphically significant flow range. Peak flow frequency statistics should be developed using either a partial-duration or peak annual series. Partial-duration series frequency calculations consider multiple storm events in a given year while the peak annual series considers just the peak annual storm event.

Flow duration statistics must also be summarized to determine how often a particular flow rate is exceeded. To determine if a storm water facility meets hydromodification criteria, peak flow frequency and flow duration curves must be generated for pre-project and post-project conditions. Both pre-project and post-project simulation runs should extend for the entire length of the rainfall record.

For a more detailed review of peak flow frequency and flow duration curves, refer to the aforementioned Brown and Caldwell memo titled *Using Continuous Simulation to Size Storm Water Control Facilities* (May 2008).

The need for partial-duration statistics is more pronounced for control standards based on more frequent return intervals (such as the 2-year runoff event), since the peak annual series does not perform as well in the estimation of such events. This phenomenon is especially pronounced in the San Diego County region's semi-arid climate. Per the advice of the Hydrologic Research Center, with whom the project team has consulted throughout the project, and a review of supporting literature, the use of a partial-duration series is recommended for semi-arid climates similar to San Diego County, where prolonged dry periods can skew peak flow frequency results determined by a peak annual series for more frequent runoff events.

For the statistical analysis of the rainfall record, partial duration series events have been separated into discrete rainfall events assuming the following criteria.

- To determine a discrete rainfall event, a lower flow limit was set to a very small value, equal to 0.002 cfs per acres of contributing drainage area.
- A new discrete event is designated when the flow falls below 0.002 cfs per acre for a time period of 24 hours.

4.3 Rainfall Data

Standards developed as part of this HMP to control runoff peak flows and durations are based on a continuous simulation of runoff using local rainfall data. To provide for clear climatic designation between coastal, foothill and mountain areas of the County, and to distinguish between the major watershed units, historical records for a series of 20 rainfall data stations located throughout San Diego County were compiled, formatted and quality controlled for analysis.

Long-term hourly rainfall records have been prepared for the 20 rainfall stations. These rainfall record files are located on the *Project Clean Water* web site for public use (www.projectcleanwater.org). Sources of the rainfall data include ALERT data from the County of San Diego (which extend back to 1982), the California Climatic Data Archive, National Oceanic and Atmospheric Administration (NOAA), the National Climatic Data Center, and the Western Regional Climate Center. In all cases, the length of the overall rainfall station record is 35 years or the overall length of the rainfall record, whichever is longer.

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Gauge selection was further governed by minimum continuous simulation modeling requirements including the following:

- The selected precipitation gauge data set should be located near the project site to ensure that long-term rainfall records are similar to the anticipated rainfall patterns for the site. Thus, gauges were selected in proximity to areas planned for future development and redevelopment.
- Recording frequency for the gauge data set should be hourly (or more frequent).
- The gauge rainfall record should extend for the entire length of the record. Where the gauge record length is less than 35 years, then adjacent gauge records were used to extend the rainfall record to at least 35 years.
- Use of the most applicable long-term rainfall gauge data, as opposed to the scaling of rainfall patterns from Lindbergh Field, is required to account for the diverse rainfall patterns across San Diego County.

Precipitation gauges identified by Brown and Caldwell, summarized in Table 4-2 below, all have recording frequencies of one hour and recording data ranges of at least 35 years.

Table 4-2. Rainfall Station Summary

Station	Elevation	Watershed
Bonita	120	Sweetwater River
Encinitas	242	San Elijo Lagoon and Batiquitos Lagoon and ocean outlets
Escondido	645	Escondido Creek
Fallbrook	675	San Luis Rey River (near ridge with Santa Margarita River watershed)
Fashion Valley	20	Lower San Diego River
Flinn Springs	880	San Diego River
Kearny Mesa	425	San Diego River (near ridge with San Clemente Canyon watershed)
Lake Cuyamaca	4,590	Upper San Diego River
Lake Heneshaw	2,990	Upper San Luis Rey River
Lake Wohlford	1,490	Upper Escondido Creek
Lindbergh Field	Near Sea Level	Coastal – San Diego Bay
Lower Otay Reservoir	491	Otay River
Morena Dam	3,075	Upper Tijuana River
Oceanside	30	San Luis Rey River
Poway	440	Los Penasquitos Canyon
Ramona	1,450	Upper San Dieguito River
San Onofre	162	North County Coastal – Pacific Ocean
San Vicente Reservoir	663	San Diego River
Santee	300	San Diego River

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For a given project location, the following factors should be considered in the selection of the appropriate rainfall data set.

- In most cases, the rainfall data set in closest proximity to the project site will be the appropriate choice. A rainfall station map has been posted to the *Project Clean Water* web site for public use.
- In some cases, the rainfall data set in closest proximity to the project site may not be the most applicable data set. Such a scenario could involve a data set with an elevation significantly different from the project site. In addition to a simple elevation comparison, the project proponent may also consult with the San Diego County's average annual precipitation isopluvial map, which is provided in the San Diego County Hydrology Manual (2003). Review of this map could provide an initial estimate as to whether the project site is in a similar rainfall zone as compared to the rainfall stations. Generally, precipitation totals in San Diego County increase with increasing elevation.
- Where possible, rainfall data sets should be chosen so that the data set and the project location are both located in the same topographic zone (coastal, foothill, mountain) and major watershed unit (Upper San Luis Rey, Lower San Luis Rey, Upper San Diego River, Lower San Diego River, etc.).

Upon implementation of final hydromodification criteria, the hydromodification flow control sizing calculator being developed by Brown and Caldwell will automate the rainfall gauge selection process.

4.4 Rainfall Losses - Infiltration Parameters

Standards developed as part of this HMP to control runoff peak flows and durations are based on a continuous simulation of runoff using locally derived parameters for initial infiltration. A review was conducted of available continuous hydrologic simulation modeling reports in Southern California. These included TMDL models developed for the San Diego RWQCB (RWQCB), regional continuous models developed by the Southern California Coastal Water Research Project (SCCWRP), and watershed-level continuous models developed for river and large creek systems in Ventura County. In conducting this review, particular interest was focused on determining how local and regional continuous hydrologic models simulated the pervious land surface[1] for various combinations of soils and land use types, because this component of hydrologic modeling is typically the most variable and difficult to describe.

The HSPF software package is the industry standard for continuous simulation hydrologic modeling, though HEC-HMS and SWMM also provide public domain continuous modeling alternatives. The Final HMP provides the option to use HEC-HMS for a project submittal but only provides infiltration data review for HSPF modeling approaches. Therefore, if a project applicant chooses to use HEC-HMS, prior authorization should be provided by the governing municipality.

[1] Characterized by PERLND/PWATER parameters in the EPA's public domain Hydrologic Simulation Program – FORTRAN, HSPF.

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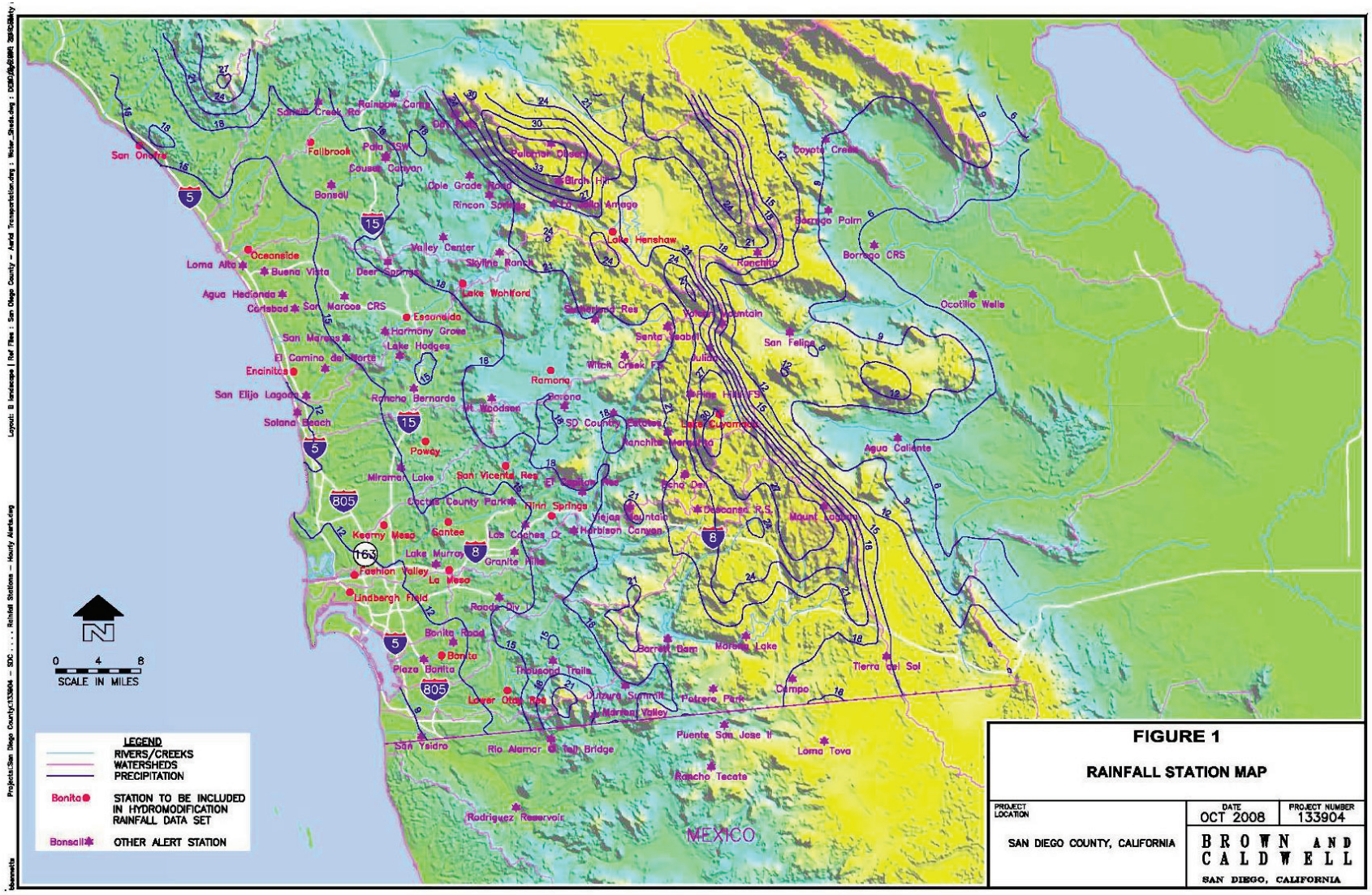

Figure 4-1. Rainfall Station Map

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In preparing computer models to assess storm water controls and meet Hydromodification Criteria, rainfall loss parameters describing soil characteristics, land cover descriptions, and slope should be validated to prove consistency with the local environment and climatic conditions. The goal, with regard to the San Diego HMP, is to develop a set of appropriate parameter ranges to account for variations of these key parameters. The final selection of rainfall loss parameters and evaporation data is part of the Sizing Calculator development process as part of HMP implementation in winter 2010.

In addition to the reports listed below, other TMDL reports from San Diego County and elsewhere in Southern California were reviewed in Table 4-3. However, only those reports with a substantial description of modeling activities were summarized in the table.

Table 4-3. Summary of HSPF Modeling Reports for Southern California

No.	Title	Authors	Date	Summary/Comments
1	TMDL to Reduce Bacterial Indicator Densities at Santa Monica Bay Beaches During Wet Weather (Preliminary Draft)	Los Angeles RWQCB / Tetra Tech	June 21, 2002	Combination of hydrologic and water quality modeling to estimate bacterial loadings to Santa Monica Bay HSPF/Loading Simulation Program in C++ (LSPC) model was calibrated and validated using stream flow data collected on Malibu Creek and Ballona Creek. (LSPC is a recoded C++ version of HSPF) No HSPF model parameters included in report
2	Technical Report – TMDLs for Indicator Bacteria in Baby Beach and Shelter Island Shoreline Park	San Diego RWQCB / Tetra Tech	June 11, 2008	Combination of hydrologic and water quality modeling HSPF/LSPC model was calibrated to flow data collected in Aliso Creek and Rose Creek. Calibrated infiltration rates were reported for Natural Resources Conservation Survey (NRCS) Group A, B, C, and D soils (in Appendix F). However, it is unclear if these rates correspond to specific HSPF model parameters. This issue of how to apply the calibrated infiltration rates should be addressed through correspondence with study authors.
3	Evaluating HSPF in an Arid, Urbanized Watershed (in Journal of the American Water Resources Association, 2005, p477-486	Drew Ackerman, Kenneth Schiff, Stephen Weisburg (SCCWRP)	February 2005	HSPF was used to simulate hydrologic processes in arid region, e.g., precipitation on dry soils, effect of irrigation. Model was calibrated to gauge data collected in lower reaches of Malibu Creek. The calibration set aggregated the soil and land cover variations in the watershed (i.e., spatially "lumped" parameters). Pervious land surface (PWATER) parameters were included in the paper.
4	TMDL for Indicator Bacteria Project I – Beaches and Creeks in the San Diego Region	San Diego RWQCB / Tetra Tech	December 12, 2007	HSPF/LSPC model parameters were selected from regional calibration. Calibration efforts used daily average stream flows as the baseline calibration condition. Appendices describe the regional calibration process. The modeling files have been provided by the San Diego RWQCB
5	Lake Elsinore and Canyon Lake Nutrient Source Assessment (Final Report) for Santa Ana Watershed Project Authority	Tetra Tech, Inc.	January 2003	HSPF/LSPC model was calibrated and validated using United States Geological Survey (USGS) gauging site data in the San Jacinto watershed Model simulated pollutant loading to Lake Elsinore and Canyon Lake Pervious land surface (PWATER) parameters were not published in the report.

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The technical reports listed in Table 4-3 demonstrate that a variety of detailed HSPF modeling studies have been conducted in the past 10 years in Southern California. However, adapting these modeling efforts for use on the San Diego HMP project would require additional work. This is because the reports listed above did not publish their HSPF parameter sets, with the exception of the Ackerman study (see No. 3 above), which published a set of generalized parameters that aggregate or "spatially lump" the contributions of different soil/land use combinations in the upper watershed.

The HSPF model described in the Ackerman paper simulates all soil and land use combinations using a single composite parameter set. In a follow-on conversation in May 2008, Drew Ackerman explained that the "Arid, Urbanized" HSPF model was calibrated only to gauge data in the lower Santa Monica Bay watershed, because the model's purpose was to estimate pollutant loadings to area beaches and water bodies. His study was understandably less focused on characterizing the variation in runoff rates and volumes among the different land uses in the upper portions of the watershed. Additionally, the effect of upstream surface water impoundments would have made the development of an accurate, detailed calibration at the sub-catchment scale very difficult to achieve. Unfortunately, this "spatially lumped" parameter set is of limited usefulness for the purpose of the HMP project, given the need to develop parameter sets that describe a variety of common soil and land use combinations.

Continuous simulation modeling files associated with the report titled *Bacteria Project I – Beaches and Creeks in the San Diego Region* (February 2009) include infiltration parameter calibrations based upon 15-20 years of average daily flows. Per discussions with Tetra Tech in November 2008 and January 2009, ongoing work related to TMDL development for San Diego County lagoons may also prove to be beneficial to the future San Diego HMP model parameter estimation effort.

The consultant team will continue to review additional HSPF studies in preparation for development of a hydromodification flow control sizing tool for San Diego County (to be completed in Winter 2010). The consultant team has had discussions with Tony Donigian of Aquaterra, who has prepared numerous HSPF models and serves as an EPA-sponsored trainer for HSPF modeling.

Aquaterra's HSPF modeling efforts in Southern California have focused on Ventura County. Aquaterra has requested permission from Ventura County to allow the San Diego HMP consultant team to review modeling results and input data sets for the Ventura County HSPF modeling efforts.

To better utilize the existing HPSF models for use in the San Diego HMP project and development of the San Diego HMP Sizing Calculator, the consultant team will be conducting the following activities:

- Contact the authors of the studies listed in Table 4-3 (and others provided by Tetra Tech, Aquaterra and SCCWRP) to obtain copies of the HSPF pervious land surface (PERLND/PWATER) parameter sets. .
- Relate the HSPF parameters to NRCS soil groups and common land use types. Develop a range of recommended HSPF input parameters that could be used to characterize the range of soil and land use types common to San Diego County.

The following model parameters were published in the Drew Ackerman et al. paper described in Figure 4-2. The specific values were selected by calibrating an HSPF model to flow monitoring data in the Santa Monica Bay watershed, specifically on Malibu Creek. The values represent a composite of the various upstream soils and land uses.

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Table 2. Model parameters utilized for modeling of Santa Monica Bay.

Pervious Parameters		Value	Units
Fraction of Remaining E-T from Active Groundwater Storage	AGEWTP	0.05	None
Basic Groundwater Recession Rate	AGWRC	0.92	1/d
Fraction of Remaining E-T from Baseflow	BASETP	0.05	None
Interception Storage Capacity	CEPSC	0.25	cm
Fraction of Groundwater to Deep Aquifer	DEEPFR	0.40	None
Forest Fraction	FOREST	0.0	%
Infiltration Equation Exponent	INFEXP	2.0	None
Ratio between the Maximum and Mean Infiltration Capacities	INFILD	2.0	None
Infiltration Capacity	INFILT	0.10	cm/hr
Interflow Inflow Parameter	INTFW	1.50	None
Interflow Recession Parameter	IRC	0.70	1/d
Groundwater Recession Flow Coefficient	KVARY	7.6	1/cm
Overland Flow Length	LSUR	61	m
Lower Zone E-T Parameter	LZETP	0.70	None
Lower Zone Nominal Storage	LZSN	25	cm
Manning's n for Overland Flow	NSUR	0.20	Complex
Temperature Maximum for Evapotranspiration (E-T)	PETMAX	1.7	°C
Temperature that E-T is Zero	PETMIN	-1.1	°C
Overland Flow Slope	SLSUR	0.03	None
Upper Zone Nominal Storage	UZSN	3.0	cm

Figure 4-2. Model Parameters Utilized by SCCWRP for Modeling of Santa Monica Bay

Additional reference material can be located in the document titled, *BASINS Technical Notice 6, Estimating Hydrology and Hydraulic Parameters for HSPF,* prepared by the U.S. EPA (July 2000). This document provides details regarding pervious and impervious land hydrology parameters along with flow routing parameters. Parameter and value range summary tables are included in the document.

4.4.1 Pervious Land Hydrology (PWATER) Parameters

The HSPF hydrology parameters of PWATER are divided into four sections, titled PARM1-4. PARM1 is a series of checks to outline any monthly variability versus constant parameter values within the simulated algorithm; whereas, PARM2 and 3 are a series of climate, geology, topography, and vegetation parameters that require numerical values to be inputted.

PARM2 involves the basic geometry of the overland flow, the impact of groundwater recession, potential snow impact due to forest cover and the expected infiltration and soil moisture storage. The main parameters of groundwater recession are KVARY and AGWRC. The infiltration and soil moisture storage parameters are INFILT and LZSN.

PARM3 involves the impact of climate temperature during active snow conditions, a wide range of evaporation parameters due to the variability of the onsite soil and existing vegetation and subsurface losses due to groundwater recharge or the existing geology. The main evaporation parameters are INFEXP, INFILD, BASETP, and AGWETP. The parameter for subsurface loss is DEEPFR which accounts for one of only three major losses from the PWATER water balance (i.e., in addition to evaporation, and lateral and stream outflows).

PARM4 involves the flow and hydrograph characteristics, the expectation of rain interception due to the inherent moisture storage capacity from existing vegetation, land use and/or near surface soil conditions and evaporation due to the root zone of the soil profile. The main interception parameters are CEPSC and UZSN. The parameter for evaporation as a primary function of vegetation is LZETP.

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PARM2

KVARY. Groundwater recession flow parameter used to describe non-linear groundwater recession rate *(/inches) (initialize with reported values, then calibrate as needed*).

KVARY is usually one of the last PWATER parameters to be adjusted; it is used when the observed groundwater recession demonstrates a seasonal variability with a faster recession (i.e., higher slope and lower AGWRC values) during wet periods, and the opposite during dry periods. Value ranges are shown in Figure 4-3. Users should start with a value of 0.0 for KVARY, and then adjust (i.e., increase) if seasonal variations are evident. Plotting daily flows with a logarithmic scale helps to elucidate the slope of the flow recession.

AGWRC. Groundwater recession rate, or ratio of current groundwater discharge to that from 24 hours earlier (when KVARY is zero) *(/day) (estimate, then calibrate).*

The overall watershed recession rate is a complex function of watershed conditions, including climate, topography, soils, and land use. Hydrograph separation techniques can be used to estimate the recession rate from observed daily flow data (such as plotting on a logarithmic scale). Value ranges are shown in Figure 4-3.

INFILT. Index to mean soil infiltration rate *(in/hr); (estimate, then calibrate).*

In HSPF, INFILT is the parameter that effectively controls the overall division of the available moisture from precipitation (after interception) into surface runoff. Since INFILT is not a maximum rate nor an infiltration capacity term, it's values are normally much less than published infiltration rates, percolation rates (from soil percolation tests), or permeability rates from the literature. In any case, initial values are adjusted in the calibration process.

INFILT is primarily a function of soil characteristics, and value ranges have been related to SCS hydrologic soil groups (Donigian and Davis, 1978, p.61, variable INFIL) as follows:

Table 4-4. INFILT Parameters

SCS Hydrologic Soil Group	INFILT Estimate		Runoff Potential
	(in/hr)	(mm/hr)	
A	0.4 - 1.0	10.0 - 25.0	Low
B	0.1 - 0.4	2.5 - 10.0	Moderate
C	0.05 - 0.1	1.25 - 2.5	Moderate to High
D	0.01 - 0.05	0.25 - 1.25	High

An alternate estimation method that has not been validated is derived from the premise that the combination of infiltration and interflow in HSPF represents the infiltration commonly modeled in the literature (e.g., Viessman et al., 1989, Chapter 4). With this assumption, the value of 2.0*INFILT*INTFW should approximate the average measured soil infiltration rate at saturation, or mean permeability.

LZSN. Lower zone nominal soil moisture storage *(inches), (estimate, then calibrate).*

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LZSN is related to both precipitation patterns and soil characteristics in the region. Viessman, et al, 1989, provide initial estimates for LZSN in the Stanford Watershed Model (SWM-IV, predecessor model to HSPF) as one-quarter of the mean annual rainfall plus four inches for arid and semiarid regions, or one-eighth annual mean rainfall plus 4 inches for coastal, humid, or subhumid climates. These formulae tend to give values somewhat higher than are typically seen as final calibrated values; since LZSN will be adjusted through calibration, initial estimates obtained through these formulae may be reasonable starting values.

PARM3

INFEXP. Exponent that determines how much a deviation from nominal lower zone storage affects the infiltration rate (HSPF Manual, p. 60) *(initialize with reported values, then calibrate).*

Variations of the Stanford approach have used a POWER variable for this parameter; various values of POWER are included in Donigian and Davis (1978, p. 58). However, the vast majority of HSPF applications have used the default value of 2.0 for this exponent. Use the default value of 2.0, and adjust only if supported by local data and conditions.

INFILD. Ratio of maximum and mean soil infiltration capacities *(initialize with reported value).*

In the Stanford approach, this parameter has always been set to 2.0, so that the maximum infiltration rate is twice the mean (i.e., input) value; when HSPF was developed, the INFILD parameter was included to allow investigation of this assumption. However, there has been very little research to support using a value other than 2.0. Use the default value of 2.0, and adjust only if supported by local data and conditions.

DEEPFR. The fraction of infiltrating water which is lost to deep aquifers (i.e., inactive groundwater), with the remaining fraction (i.e., 1-DEEPFR) assigned to active groundwater storage that contributes baseflow to the stream *(estimate, then calibrate).*

It is also used to represent any other losses that may not be measured at the flow gauge used for calibration, such as flow around or under the gauge site. Watershed areas at high elevations, or in the upland portion of the watershed, are likely to lose more water to deep groundwater (i.e., groundwater that does not discharge within the area of the watershed), than areas at lower elevations or closer to the gauge. DEEPFR should be set to 0.0 initially or estimated based on groundwater studies, and then calibrated, in conjunction with adjustments to evapotranspiration (ET) parameters.

BASETP. ET by riparian vegetation as active groundwater enters streambed; specified as a fraction of potential ET, which is fulfilled only as outflow exists *(estimate, then calibrate).*

Typical and possible value ranges are shown in Figure 4-3. If significant riparian vegetation is present in the watershed then non-zero values of BASETP should be used. If riparian vegetation is significant, start with a BASETP value of 0.03 and adjust to obtain a reasonable low-flow simulation in conjunction with a satisfactory annual water balance.

AGWETP. Fraction of model segment (i.e., pervious land segment) that is subject to direct evaporation from groundwater storage, e.g., wetlands or marsh areas, where the groundwater surface is at or near the land surface, or in areas with phreatophytic vegetation drawing directly from groundwater. This is represented in the model as the fraction of remaining potential ET (i.e., after base ET, interception ET, and upper zone ET are satisfied), that can be met from active groundwater storage *(estimate, then calibrate).*

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If wetlands are represented as a separate pervious land segment (PLS), then AGWETP should be 0.0 for all other land uses, and a high value (0.3 to 0.7) should be used for the wetlands PLS. If wetlands are not separated out as a PLS, identify the fraction of the model segment that meets the conditions of wetlands/marshes or phreatophytic vegetation and use that fraction for an initial value of AGWETP. Like BASETP, adjustments to AGWETP will be visible in changes in the low-flow simulation, and will affect the annual water balance. Follow above guidance for an initial value of AGWETP, and then adjust to obtain a reasonable low-flow simulation in conjunction with a satisfactory annual water balance.

PARM4

CEPSC. Amount of rainfall, in inches, which is retained by vegetation, that never reaches the land surface, and is eventually evaporated (*estimate, then calibrate*). Typical guidance for CEPSC for selected land surfaces is provided in Donigian and Davis (1978, p. 54, variable EPXM) as follows:

Table 4-5. Interception Parameters

Land Cover	Maximum Interception (in)
Grassland	0.10
Cropland	0.10 – 0.25
Forest Cover, light	0.15
Forest Cover, heavy	0.20

LZETP. Index to lower zone evapotranspiration (unitless) (*estimate, then calibrate*).

LZETP is a coefficient to define the ET opportunity; it affects evapotranspiration from the lower zone which represents the primary soil moisture storage and root zone of the soil profile. LZETP behaves much like a 'crop coefficient' with values mostly in the range of 0.2 to 0.7; as such it is primarily a function of vegetation. Typical and possible value ranges are shown in Figure 4-3, and the following ranges for different vegetation are expected for the 'maximum' value during the year:

Table 4-6. LZETP Coefficients

Land Cover	Input Coefficient
Forest	0.6 - 0.8
Grassland	0.4 - 0.6
Row Crops	0.5 - 0.7
Barren	0.1 - 0.4
Wetlands	0.6 - 0.9

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HSPF HYDROLOGY PARAMETERS AND VALUE RANGES

			RANGE OF VALUES					
NAME	DEFINITION	UNITS	TYPICAL		POSSIBLE		FUNCTION OF ...	COMMENT
			MIN	MAX	MIN	MAX		
PWAT - PARM2								
FOREST	Fraction forest cover	none	0.0	0.50	0.0	0.95	Forest cover	Only impact when SNOW is active
LZSN	Lower Zone Nominal Soil Moisture Storage	inches	3.0	8.0	2.0	15.0	Soils, climate	**Calibration**
INFILT	Index to Infiltration Capacity	in/hr	0.01	0.25	0.001	0.50	Soils, land use	**Calibration**, divides surface and subsurface flow
LSUR	Length of overland flow	feet	200	500	100	700	Topography	Estimate from high resolution topo maps or GIS
SLSUR	Slope of overland flow plane	ft/ft	0.01	0.15	0.001	0.30	Topography	Estimate from high resolution topo maps or GIS
KVARY	Variable groundwater recession	1/inches	0.0	3.0	0.0	5.0	Baseflow recession variation	Used when recession rate varies with GW levels
AGWRC	Base groundwater recession	none	0.92	0.99	0.85	0.999	Baseflow recession	**Calibration**
PWAT - PARM3								
PETMAX	Temp below which ET is reduced	deg. F	35.0	45.0	32.0	48.0	Climate, vegetation	Reduces ET near freezing, when SNOW is active
PETMIN	Temp below which ET is set to zero	deg. F	30.0	35.0	30.0	40.0	Climate, vegetation	Reduces ET near freezing, when SNOW is active
INFEXP	Exponent in infiltration equation	none	2.0	2.0	1.0	3.0	Soils variability	Usually default to 2.0
INFILD	Ratio of max/mean infiltration capacities	none	2.0	2.0	1.0	3.0	Soils variability	Usually default to 2.0
DEEPFR	Fraction of GW inflow to deep recharge	none	0.0	0.20	0.0	0.50	Geology, GW recharge	Accounts for subsurface losses
BASETP	Fraction of remaining ET from baseflow	none	0.0	0.05	0.0	0.20	Riparian vegetation	Direct ET from riparian vegetation
AGWETP	Fraction of remaining ET from active GW	none	0.0	0.05	0.0	0.20	Marsh/wetlands extent	Direct ET from shallow GW
PWAT - PARM4								
CEPSC	Interception storage capacity	inches	0.03	0.20	0.01	0.40	Vegetation type/density, land use	Monthly values usually used
UZSN	Upper zone nominal soil moisture storage	inches	0.10	1.0	0.05	2.0	Surface soil conditions, land use	Accounts for near surface retention
NSUR	Manning's n (roughness) for overland flow	none	0.15	0.35	0.05	0.50	Surface conditions, residue, etc.	Monthly values often used for croplands
INTFW	Interflow inflow parameter	none	1.0	3.0	1.0	10.0	Soils, topography, land use	**Calibration**, based on hydrograph separation
IRC	Interflow recession parameter	none	0.5	0.7	0.3	0.85	Soils, topography, land use	Often start with a value of 0.7, and then adjust
LZETP	Lower zone ET parameter	none	0.2	0.7	0.1	0.9	Vegetation type/density, root depth	**Calibration**

Figure 4-3. HSPF Hydrology Parameters and Value Ranges

Source: USEPA BASINS Technical Note 6

Model assumptions for stream reach infiltration rates were derived through calibration based on data collected within the reaches of Aliso Creek (11 stations) and Rose Creek (6 stations). In the model, infiltration rates vary by soil type. Stream infiltration was calibrated by adjusting a single infiltration value, which was varied for each soil type by factors established from literature ranges (USEPA 2000) of infiltration rates specific to each soil type. The final resulting infiltration rates were 1.368 in/hr (Soil Group A), 0.698 in/hr (Soil Group B), 0.209 in/hr (Soil Group C) and 0.084 in/hr (Soil Group D). The infiltration rates for Soil Groups B, C, and D are within the infiltration range given in literature (Wanielisata et al. 1997). The result for Soil Group A is below the range given in Wanielisata et al. (1997); however, this result only represented one watershed in this TMDL study.

The technical reports reviewed demonstrate that a variety of detailed HSPF modeling studies have been conducted in the past 10 years in Southern California. However, adapting these modeling efforts for use on the San Diego HMP project will require additional work, which will be completed in association with development of the implementation Sizing Calculator. That effort includes meetings with report authors, including representatives from the SCCWRP, as well as meetings with HSPF modeling experts from Aquaterra to ascertain appropriate values for initial infiltration parameters.

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4.5 Rainfall Losses - Evapotranspiration Parameters

Standards developed as part of this HMP to control runoff peak flows and durations are based on a continuous simulation of rainfall runoff using locally derived parameters for evaporation and evapotranspiration.

Known data sources for evaporation and evapotranspiration data in San Diego County are listed below.

- California Irrigation Management and Information System web site – evapotranspiration stations include San Diego, Oceanside, Escondido, Ramona, Otay Lakes, Miramar, Torrey Pines, and Borrego Springs.
- Historical Reservoir Level and Evaporation Data for Lake Heneshaw.
- Historical Evaporation Data from City of San Diego Reservoirs.
- Historical Evaporation Data from Helix Water District for Lake Cuyamaca.

The evaporation / evapotranspiration parameter validation process includes documentation of the source of data and analysis of the effects of varying patterns between the subject site and parameter data source. A full review of local pan evaporation and potential evapotranspiration data is being conducted as part of the development of the final hydromodification flow control sizing tool.

Table 4-6 below summarizes available evaporation and evapotranspiration data sources in San Diego County. Most of the available evaporation data are located close to reservoirs in the inland valley and mountain areas of the County. Monthly evaporation records are available for multiple reservoirs within the County. Evapotranspiration sensing data are generally collected in agricultural zones.

The California Irrigation Management Information Systems web site (wwwcimis.water.ca.gov/cimis/data.jsp) provides access to real-time and summarized evapotranspiration data (ETo) throughout California. For the San Diego region, average evapotranspiration values are summarized for the coastal and foothill zones of San Diego County.

Table 4-7. Summary of Evaporation and Evapotranspiration Data for San Diego County

Station Name ID	Data Type	Data Source	Recording Frequency	Start Date	End Date
Barratt Lake	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Borrego Springs	Evapotranspiration	CIMIS	Monthly	2008	2008
Chula Vista	Pan Evaporation	Western Regional Climate Center	Monthly Averages	1948	2005
El Capitain Reservoir	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Escondido / 74	Evapotranspiration	CIMIS	Monthly	1988	1998
Escondido / 153	Evapotranspiration	CIMIS	Monthly	1999	2008
Lake Cuyamaca	Pan Evaporation	Helix Water District	Monthly	1985	2006
Lake Heneshaw	Pan Evaporation	County of San Diego	Daily	1999	2005
Lake Heneshaw	Pan Evaporation	County of San Diego	Monthly	1957	2008
Lake Hodges	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Lake Jennings	Pan Evaporation	Helix Water District	Monthly	1985	2006
Lake Murray	Pan Evaporation	City of San Diego	Monthly	1950	2008

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Table 4-7. Summary of Evaporation and Evapotranspiration Data for San Diego County

Station Name ID	Data Type	Data Source	Recording Frequency	Start Date	End Date
		Water Department			
Lake Sutherland	Pan Evaporation	City of San Diego Water Department	Monthly	1954	2008
Lower Otay Reservoir	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Lower Otay / 147	Evapotranspiration	CIMIS	Monthly	1999	2008
Miramar Lake	Pan Evaporation	City of San Diego Water Department	Monthly	1960	2008
Miramar Lake / 150	Evapotranspiration	CIMIS	Monthly	1999	2008
Morena Lake	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Oceanside / 49	Evapotranspiration	CIMIS	Monthly	1986	2003
Ramona / 98	Evapotranspiration	CIMIS	Monthly	1991	1998
San Diego / 45	Evapotranspiration	CIMIS	Monthly	1985	1989
San Diego / 66	Evapotranspiration	CIMIS	Monthly	1989	2001
San Diego II / 184	Evapotranspiration	CIMIS	Monthly	2002	2008
San Vicente Reservoir	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Torrey Pines / 173	Evapotranspiration	CIMIS	Monthly	2000	2008

Long-term evaporation / evapotranspiration data sets are being generated to correspond with long-term rainfall records. The final selection of rainfall loss parameters and evaporation data is part of the Sizing Calculator development process.

In summary, the published literature reviewed as part of this study support the methods and approach taken in developing the San Diego Hydromodification Management Plan.

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5. METHODOLOGY AND TECHNICAL APPROACH TO REGIONAL HYDROMODIFICATION DEVELOPMENT

As outlined in Permit Section D.1, the San Diego Copermittees shall implement a program to manage increases in runoff discharge rates and durations from Priority Development Projects that are likely to cause increases to erosion of channel beds or banks, silt pollutant generation, or other impacts to beneficial uses and stream habitat due to increased erosive force. This section provides a detailed description of the methodology and approach used in the development of the HMP (Permit Section D.1.g(1)). Section 5.1 specifically focuses on the approach taken to identify the geomorphically significant flow range, Section 5.2 focuses on channel screening tools developed in association with this HMP, and Section 5.3 discusses cumulative watershed impacts.

5.1 Flow Control Limit Determination

5.1.1 Background

The purpose of the HMP is to identify guidelines for managing 'geomorphically-significant' flows that, if not controlled, would cause increased erosion in receiving water channels. Specifically, the HMP must identify low and high flow thresholds between which flows should be controlled so that the post-project flow rates and durations do not exceed pre-project levels between these two flow magnitudes. Specifically, the Board Order requires that the HMP shall:

> Utilize continuous simulation of the entire rainfall record to identify a range of runoff flow[1] for which Priority Development Project post-project runoff flow rates and durations shall not exceed pre-project runoff flow rates and durations, where the increased flow rates and durations will result in increased potential for erosion or other significant adverse impacts to beneficial uses, attributable to changes in the flow rates and durations. The lower boundary of the range of runoff flows identify shall correspond with the critical channel flow that produces the critical shear stress that initiates channel bed movement or that erodes the toe of channel banks. The identified range of runoff flows may be different for specific watersheds, channels or channel reaches.

For the purposes of this project, 'hydrograph modification' or 'hydromodification' is understood to mean changes to the frequency, duration and magnitude of surface runoff that, when unmitigated, cause an increase in erosion of the receiving water body. Hydromodification occurs when urbanization replaces areas of vegetated, uncompacted soil with impermeable surfaces such as buildings, roads, and compacted fill. The reduction in permeability results in increased volumes of runoff, and faster and more concentrated delivery of this water to receiving waters. These changes have the potential to cause creeks to erode faster than before development. Although the focus of hydromodification management plans has been on increased erosion, it should be noted that in rivers that are depositional, hydromodification can cause creeks to regain some

[1] The identified range of runoff flows to be controlled should be expressed in terms of peak flow rates of rainfall events, such as "10% of the pre-project 2-year peak flow up to the pre-project 10-year peak flow."

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transport equilibrium. This phenomenon is the basis for providing exemptions for river reaches which are aggrading (depositional).

Stream flows are often expressed in terms of the frequency with which a particular flow occurs. For example, Q_2 refers to the flow rate that occurs once every two years, on average over the long term runoff record. Flow frequencies are a function of rainfall and watershed characteristics, and are unique to each stream channel (and location along the channel). The effects of urbanization tend to increase the magnitude of the flow associated with a given frequency (e.g., post-development Q_2. is higher than pre-development Q_2.). Similarly, urbanization tends to increase the frequency with which any given flow rate occurs. The purpose of the HMP is to control runoff from new developments so that flow magnitudes and frequencies match pre-development conditions within a critical range of flows.

Not all runoff causes erosion. Runoff in receiving channels below a critical discharge (Qcrit) does not exert sufficient force to overcome the erosion resistance of the channel banks and bed materials. Flows greater than Qcrit cause erosion, with larger flows causing proportionally greater erosion. It has been determined through calculations and field measurements that most erosion in natural creeks is caused by flows between some fraction of Q_2 and Q_{10}. Flows in this range are referred to as 'geomorphically-significant' because they cause the majority of erosion and sediment transport in a channel system.

Flows greater than Q_{10}, though highly erosive *per event*, occur too infrequently to do as much work as smaller but more frequent flows. Hydromodification also has less impact on flows greater than Q_{10} since at such high rainfall intensities, the soil becomes saturated and the infiltration capacity of undeveloped landscapes is rapidly exceeded. When the soil is saturated, runoff rates become more similar to those from impervious surfaces. For these reasons, HMPs have focused on identifying a low flow threshold that is close to Qcrit for most receiving channels, and controlling flows between that value and Q_{10} (see Literature Review in Chapter 4 for review of HMPs completed in Santa Clara, Contra Costa, Alameda, and San Mateo Counties). By requiring mitigation (storage and either infiltration or detention) of excess runoff within the control range, and by limiting the release of excess water to Qcrit or less, HMPs seek to prevent additional erosion in receiving water channels.

5.1.2 Identifying a Low Flow Threshold

Erosion occurs when the shear stress exerted on the channel by flowing water (*boundary shear stress*) exceeds the resistance of the channel (*critical shear stress*). Critical shear stress varies by several orders of magnitude for different channel materials (Figure 5-1). *Critical flow* (Qcrit) is the channel flow which produces boundary shear stress equal to the critical shear stress for a given channel. In other words, critical flow is the flow rate that can initiate erosion in a channel. Qcrit is a function not only of the critical shear stress of the channel materials, but also channel size and channel geometry. A particular flow rate (expressed as a number of cubic feet per second) in a small, steep, confined channel will create more shear stress than the identical flow rate in a large, flat, wide open channel. Thus, Qcrit can be extremely variable depending on channel and watershed characteristics and will be different in each channel, and in each watershed.

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Boundary Category	Boundary Type	Permissible Shear Stress (lb/sq ft)
Soils	Fine colloidal sand	0.02 - 0.03
	Sandy loam (noncolloidal)	0.03 - 0.04
	Alluvial silt (noncolloidal)	0.045 - 0.05
	Silty loam (noncolloidal)	0.045 - 0.05
	Firm loam	0.075
	Fine gravels	0.075
	Stiff clay	0.26
	Alluvial silt (colloidal)	0.26
	Graded loam to cobbles	0.38
	Graded silts to cobbles	0.43
	Shales and hardpan	0.67
Gravel/Cobble	1-in.	0.33
	2-in.	0.67
	6-in.	2.0
	12-in.	4.0
Vegetation	Class A turf	3.7
	Class B turf	2.1
	Class C turf	1.0
	Long native grasses	1.2 – 1.7
	Short native and bunch grass	0.7 - 0.95
	Reed plantings	0.1-0.6
	Hardwood tree plantings	0.41-2.5
Temporary Degradable RECPs	Jute net	0.45
	Straw with net	1.5 – 1.65
	Coconut fiber with net	2.25
	Fiberglass roving	2.00
Non-Degradable RECPs	Unvegetated	3.00
	Partially established	4.0-6.0
	Fully vegetated	8.00
Riprap	6 – in. d_{50}	2.5
	9 – in. d_{50}	3.8
	12 – in. d_{50}	5.1
	18 – in. d_{50}	7.6
	24 – in. d_{50}	10.1
Soil Bioengineering	Wattles	0.2 – 1.0
	Reed fascine	0.6-1.25
	Coir roll	3 - 5
	Vegetated coir mat	4 - 8
	Live brush mattress (initial)	0.4 – 4.1
	Live brush mattress (grown)	3.90-8.2
	Brush layering (initial/grown)	0.4 – 6.25
	Live fascine	1.25-3.10
	Live willow stakes	2.10-3.10
Hard Surfacing	Gabions	10
	Concrete	12.5

[1] Ranges of values generally reflect multiple sources of data or different t

A. Chang, H.H. (1988).
B. Florineth. (1982)
C. Gerstgraser, C. (1998).
D. Goff, K. (1999).
E. Gray, D.H., and Sotir, R.B. (1996).
F. Julien, P.Y. (1995).
G. Kouwen, N.; Li, R. M.; and Simons, D.B., (1980).
H. Norman, J. N. (1975).
I. Schiechtl, H. M. and R. Stern. (1996).
J. Schoklitsch, A. (1937).

Figure 5-1. Range of Critical Shear Stresses (τ_{cr}) for Different Materials (from Fischenich)

It was the original intent of the HMP consulting team to identify a single low flow threshold for the entire County (per previous HMPs). However, an extensive assessment of channel and runoff conditions led the team to conclude that there was a very wide range in critical flows, based largely on channel material but also on channel dimensions, rainfall, and watershed area. Adopting a single standard that is conservative for the most vulnerable channels would result in controls that were excessively conservative for more resilient channels, while adopting an 'average' value would leave some channels unprotected.

Because of this natural variability, the team pursued an analytical approach for estimating Qcrit as a function of parameters such as channel materials, channel dimensions, and watershed area. Because the low flow standard is required to correspond to Qcrit (Order No. R9-2007-0001), this approach allows the low flow standard to be customized for local conditions. The following sections describe an analysis of Qcrit as a fraction of Q_2 for the range of channel conditions in San Diego County. This is followed by a description of a calculator tool that may be used to calculate Qcrit for a specific channel based on parameters that may be readily measured in the field. The analyses described in this report provide background for the selection of low flow thresholds identified in the HMP.

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5.1.3 Critical Flow Analysis

The low flow thresholds were calculated by conducting a sensitivity analysis in which a wide range of channel sizes and geometries, rainfalls, watershed areas and channel materials were modeled in a flow-erosion model to identify Qcrit as a function of Q_2. In all, 170 combinations of channel, rainfall, and watershed conditions were assessed. Based on the results of this sensitivity analysis, a series of low flow thresholds was identified.

The steps used to conduct the sensitivity analysis and determine the recommended flow thresholds were as follows:

1. Identify the typical range of rainfall conditions for the HMP area (western San Diego County).
2. Identify the range of typical watershed areas likely to be developed.
3. Identify a range of typical receiving channel dimensions for each watershed area.
4. Identify a range of typical channel materials for receiving channels.
5. Simulate a range of flows and develop rating curves (relationships between discharge and boundary shear stress).
6. Identify the flow rate at which boundary shear stress exceeds critical shear stress for the channel and material.
7. Express this flow rate as a function of Q_2.
8. Group critical flow rates by channel materials and identify appropriate low flow thresholds for each channel material type.

Steps 1 through 4 were used to define the range of parameters to use in the sensitivity testing. The intent was to identify a typical range of conditions likely to occur in the HMP area (western San Diego county), rather than provide an exhaustive description of possible watershed and channel conditions. Sensitivity testing on many combinations of parameters within this typical range allows identification of the range of channel responses and appropriate flow thresholds.

Each step in the critical flow analysis is explained in detail in the following sections.

Identify the Typical Range Of Rainfall Conditions for the HMP Area (West San Diego County)

Mean annual rainfall was used to estimate receiving channel size, Q_2, Q_5 and Q_{10} (methods described in subsequent sections). Figure 5-2 shows mean annual rainfall for San Diego County. Based on the map, three mean annual rainfalls were selected to represent the range of rainfall conditions for the simulations: 10-inch, 20-inch, and 30-inch.

Identify the Range of Typical Watershed Areas Likely to be Developed

Based on discussions with the TAC, a range of representative watershed areas for development projects was identified. These were: 0.1 sq mi, 0.5 sq mi, 1 sq mi, and 2 sq mi. The consultant team assumed that in project watersheds larger than 2 sq mi the development would either require site specific continuous simulation modeling, or would be broken into multiple smaller sub watersheds with individual points of compliance.

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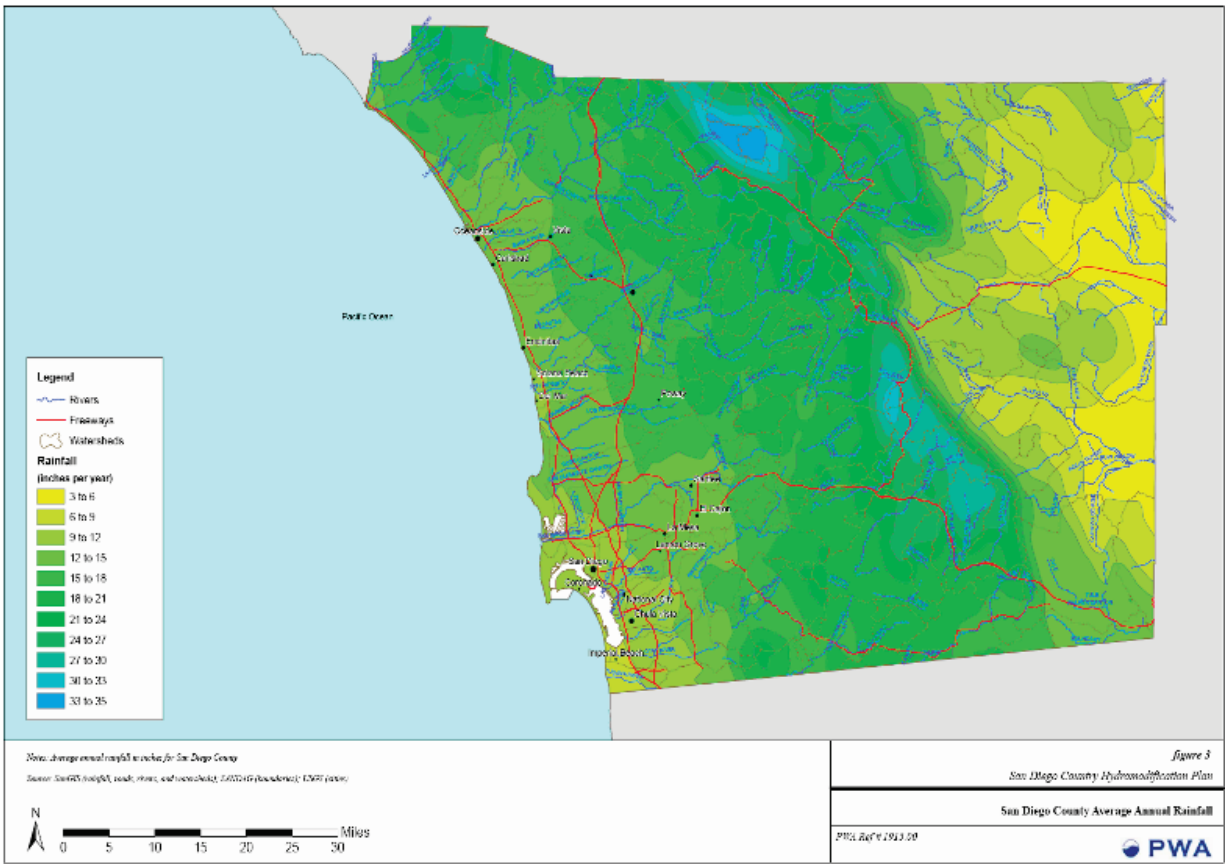

Figure 5-2. Rainfall Distribution in San Diego County

Identify a Range of Typical Receiving Channel Dimensions for Each Watershed Area

Empirical relationships have been developed to express channel dimensions (width, depth and, to a lesser extent, gradient) as a function of dominant discharge. Dominant discharge for a creek channel is the flow rate that transports the majority of sediment and creates/maintains the characteristic size and shape of the channel over time. Dominant discharge may also be referred to as bankfull flow. For undeveloped channels in semi arid parts of the US, dominant discharge is approximately equivalent to Q_5. For example, Coleman et al. (2005) found dominant discharge for streams in Southern California to average $Q_{3.5}$ (range = $Q_{2.1}$ – $Q_{6.7}$). Goodwin (1998) found dominant discharge to vary from Q_2 to Q_{10} for semi arid regions.

To capture natural variability in channel geometry, three different empirical channel geometry relationships were used to estimate receiving channel dimensions for the range of watershed areas and rainfall characteristics used in this study. The relationships were:

Coleman et al. 2005 (modified by Stein – personal communication) – derived from undeveloped channels in Southern California, tends to predict narrow, deep, steep dimensions.

$$\text{Width (ft)} = 0.6012 * Q_{bf}^{0.6875}$$
$$\text{Depth (ft)} = 0.3854 * Q_{bf}^{0.3652}$$

Where Q_{bf} is in cfs.

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Parker et al. 2007 – suitable for gravel channels, tends to predict wide, shallow, flat braided dimensions.

$$\text{Width (m)} = 4.63 * (Q_{bf}^{2/5}) / (9.81^{1/5}) * (Q_{bf} / \text{Sqrt}\,(9.81 * d_{50}) * d_{50}^{2}))^{0.0667}$$
$$\text{Depth (m)} = 0.382*((Q_{bf}^{2/5})/(9.81^{1/5})))$$

Where Q_{bf} is bankfull discharge in m^3/sec and d_{50} (diameter of median channel material) is in m.

The Parker equation was only used to assess gravel and cobble channel conditions.

Hey and Thorne 1986 tends to predict medium width, depth, and gradient channels.

$$\text{Width (m)} = 2.73*Q_{bf}^{0.5}$$

$$\text{Depth (m)} = 0.22 * \text{Width}^{0.37} * d_{50}^{-0.11}$$

Where Q_{bf} is in m^3/sec and d_{50} is in m.

(Note that original combinations of English and metric units described in the source papers were used rather than standardized these equations in one set of measurements.)

The three equations cover a wide range of likely field conditions, from deeply incised channels (Coleman et al. 2005) to wide, braided conditions (Parker 2007). Note that for the sensitivity analysis we set d50 in the Parker et al equation to the d_{50} of the channel material being tested, and did not use the equation for channels where the material was sand or silt.

The equations produce estimations of width and depth. To estimate a slope for each combination of channel dimensions, the velocity associated with each cross section was calculated (by dividing discharge by width multiplied by depth) and then the slope was calculated that corresponded with that velocity using Manning's equation.

$$\text{Velocity (ft/sec)} = \frac{1.486\ HR^{0.67} * s^{0.5}}{n}$$

Where HR is channel hydraulic radius, s is slope, and n is Manning's roughness coefficient (see definitions).

For the purposes of the sensitivity analysis, a value of n of 0.035 was assumed, corresponding to a non vegetated, straight channel with no riffles and pools. This is a reflection of the small, ephemeral receiving channels which are most prevalent in Southern California developments. A relatively low value was used at the request of the San Diego RWQCB so that the values erred on the conservative side. Some members of the TAC considered the value of n to be too conservative.

These equations all require a value for bankfull discharge. Bankfull discharge (assumed to be approximately Q_5) was estimated using the USGS regional regression for undeveloped watersheds in the South Coast region (Waananen and Crippen 1977). This equation calculates Q_5 as a function of watershed area and mean annual precipitation, based on empirical observations of USGS gauges. The relationship is:

$$Q5\ (\text{cfs}) = 0.4 * \text{Watershed Area}^{0.77} * \text{Mean Annual Precipitation}^{1.69}$$

Where watershed area is in square miles and precipitation is in inches.

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For each combination of typical watershed area and mean annual rainfall, Q_5 was calculated using the USGS regression equation, then three sets of channel dimensions were calculated based on the three channel equations. This provided the range of channel conditions to simulate for the critical flow analysis. The total number of channel conditions was as follows:

3 rainfalls (10, 20, 30 inches per year)
4 watershed areas (0.1, 0.5, 1, 2 square miles)
3 channel width, depth, and slope combinations (narrow/deep, medium, wide/shallow)
= 36 combinations of receiving channel geometry

Identify a Range of Typical Channel Materials for Receiving Channels

The consultant team identified a range of typical channel materials based on feedback from the TAC and experience gained working in San Diego County. The identified materials are not intended as a comprehensive list of possible channel materials, but to cover the range of critical shear stresses likely to be encountered in typical western San Diego County channels. The identified range is as follows:

Table 5-1. Critical Shear Stress Range in San Diego County Channels

Material	Critical Shear Stress (lb/sq ft)
Coarse Unconsolidated Sand	0.01
Alluvial Silt (Non Colloidal)	0.045
Medium gravel	0.12
Alluvial silt/clay	0.26
2.5 inch cobble	1.1

Combining the five channel material types (coarse unconsolidated sand, alluvial silt, medium gravel, alluvial silt/clay, and 2.5 inch cobble) with the 36 combinations of channel geometry produces 180 potential combinations of receiving channel characteristics. Ten sets of combinations were omitted from the analysis because they produced physically unrealistic conditions, such as slopes that were too steep to be developed. Exclusion of these results did not significantly affect the overall results.

Develop Shear Stress Rating Curves

Rating curves for the 36 different combinations of receiving channel characteristics were developed using the same Excel worksheet that forms the basis for the Qcrit calculator developed for Track 2 (described in later sections). Using channel cross section, roughness, and gradient input by the user, the tool calculates the average boundary shear stress associated with a range of different flow depths to construct a rating curve (discharge on the x axis versus shear stress on the y axis). It then identifies the flow rate where average boundary shear stress equals critical shear stress for the channel materials. This is the critical flow (Qcrit). By dividing this number by Q_2, we identify the low flow threshold for each simulation as a function of Q_2. (e.g., $0.1Q_2$ where the critical flow is one tenth of the Q_2 flow).

The tool calculates a shear stress rating curve for a range of flows between 1 and 100 percent of the bankfull flow depth. Bankfull flow depth is defined as the flow depth that corresponds to the dominant discharge for a given channel. The range 1 to 100 percent of bankfull is used because critical flow rarely falls outside these values. The tool then calculates a power function between the points to allow for interpolation. For each of the depths, the tool calculates discharge and average boundary shear stress exerted on the bed, as described below.

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Calculating Average Boundary Shear Stress

Average boundary shear stress is the force that flowing water exerts on channel materials. For a given channel cross-section, it is calculated as follows:

$$\tau_b = \gamma * HR * s$$

where τ_b = average boundary shear stress (lb/ft^2)

γ = unit weight water (62.4 lb/ft^3)

HR = Hydraulic radius (cross section area / wetted perimeter)

s = channel slope (ft/ft)

For each depth increment between 1 and 100 percent of bankfull, cross section area, wetted perimeter, HR and τ_b are calculated. Slope is a constant for the cross section. These calculations produce a rating curve for boundary shear as a function of flow depth.

Calculating Discharge

This step converts flow depth to flow rate (Q) so that the rating curve may be expressed as a function of Q. For each depth increment between 1 and 100 percent of bankfull, the flow rate is calculated using Manning's equation:

$$\text{Velocity (ft/sec)} = 1.486 \frac{HR^{0.67} * s^{0.5}}{n}$$

where V = velocity (ft/sec)

n = Manning's roughness coefficient

HR = hydraulic radius (ft)

For the sensitivity analysis, Manning's n was assumed to be 0.035, which is typical for a non-vegetated ephemeral channel. This assumption was made because most developments covered by the HMP would discharge to receiving channels relatively high in the watershed and with little summer flow. Interim sensitivity analysis found that relative to other factors such as critical shear stress, the range of roughness factors found in receiving channels had little effect on the estimated critical shear flow rate.

Discharge is calculated as velocity multiplied by cross section area (calculated for each cross section). The result of these calculations is a rating curve showing boundary shear stress for the receiving channel as a function of discharge, with the highest point representing bankfull depth (see Figure 5-3 below). Rating curves were created for each of the 36 combinations of channel characteristics.

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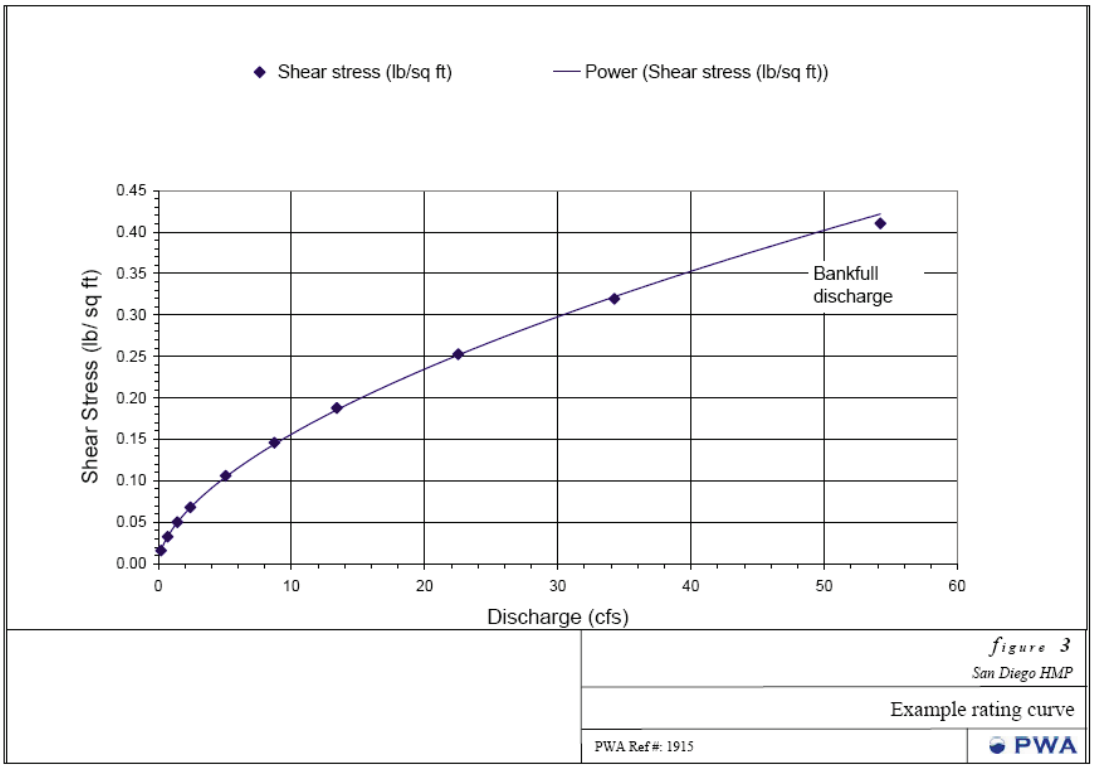

Figure 5-3. Shear Stress Rating Curve for an Example Channel (0.6%, 14 Feet Wide, 1.3 Feet Deep).

These curves were created for 36 different combinations of channel characteristics.

Identify Critical Flow for the Channel and Material

Qcrit is the flow rate at which boundary shear stress equals critical shear stress. A power function interpolates the discharge versus boundary shear stress rating curve, to allow calculation of an intercept between the rating curve and critical shear stress. The critical shear stress for each channel material was plotted horizontally from the Y axis until it intercepted the rating curve. The intercept point was extended vertically to the X axis, showing the Qcrit (Figure 5-4). In this way, Qcrit was calculated for each of the five channel materials using each of the 36 rating curves representing different channel dimensions. As mentioned above, 10 combinations unlikely to occur in nature were eliminated, resulting in a total of 170 Qcrit calculations.

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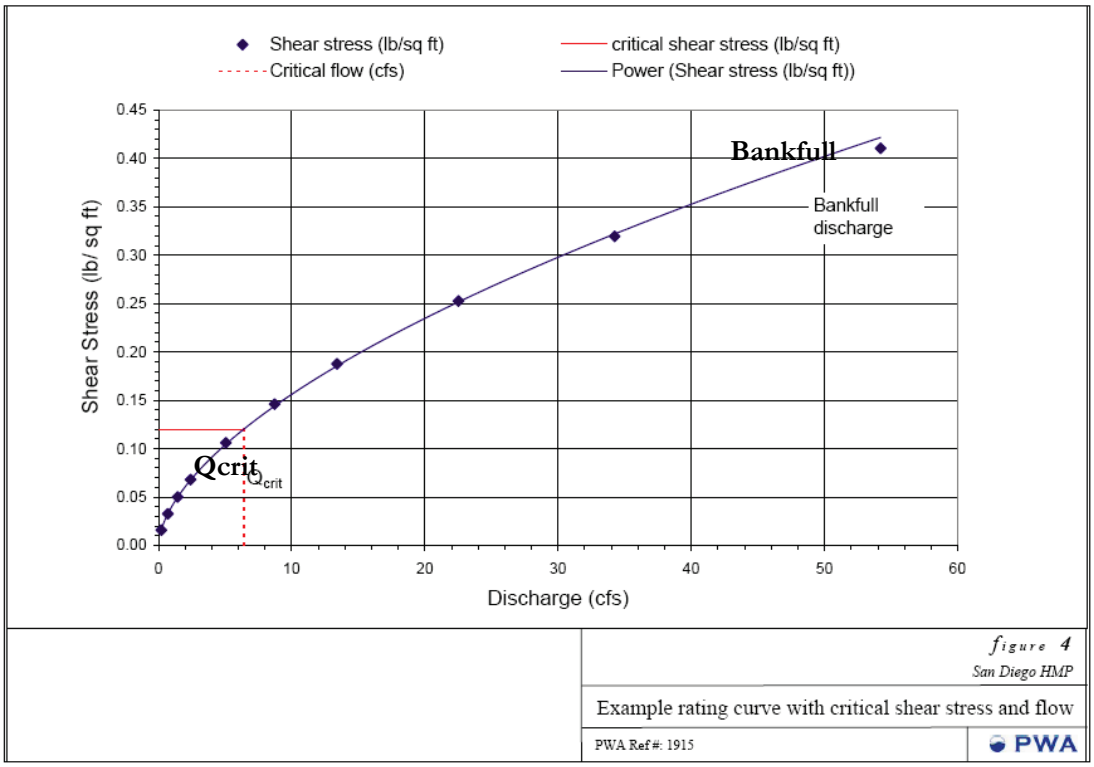

Figure 5-4. Example of a Rating Curve with Critical Shear Stress for Medium Sized Gravel.

In this example critical shear stress = 0.12 lb/sq ft and critical flow Qcrit = 6.4 cfs.

Express Critical Flow as a Function of Q_2

As described above, each rating curve represents a particular combination of watershed area and channel dimensions. Q_2 was calculated for each combination using the USGS regional regression for Q_2 as described above. By dividing the calculated Qcrit by the appropriate Q_2, Qcrit as a proportion of Q_2 was calculated for the 170 scenarios. These Qcrits were then plotted by material type, showing mean and one standard deviation either side of the mean. Note that although Q_5 is assumed as bankfull discharge, critical flow is expressed as a function of Q_2 as has become standard for HMPs.

The results show the high degree of variability in Qcrit based on different channel materials. It is important to note that in field conditions many of the most extreme cases (examples with very high or very low thresholds) would tend to evolve to conditions that yielded critical flows closer to the bankfull discharge because channels have a tendency to self equilibrate. For example, channels with materials that have very low critical flows such as unconsolidated sand tend to erode and either flatten (lowering shear stress, and so increasing critical flow rate) or armor (increasing flow resistance, and increasing critical flow rate). Likewise, channels with materials that have very high thresholds tend to either become steeper due to deposition (increasing shear stress and lowering critical flow rate) or fill in with finer material (reducing resistance and lowering critical flow rate).

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As the results of this analysis demonstrate, critical flow is extremely variable among channel materials and, for a given channel material, can vary significantly with channel configuration (slope, width/depth ratio etc.). Unconsolidated fine sediments can be mobilized by extremely low flows in the absence of clays or other consolidating elements with the structure of the channel. This result is based on literature values for critical shear stress for unconsolidated materials and may not be realistic for natural channels. Therefore in setting flow thresholds this result should be balanced with the recognition that natural channels are likely to include some consolidating fraction within their structure, as well as practical considerations associated with controlling trickle flows that represent the smaller fractions of Q_2 analyzed in this study.

5.1.4 Tool for Calculating Site-Specific Critical Flow

Background

The consultant team developed a tool for calculating a site-specific low flow threshold based on local conditions. The low flow threshold is based on Qcrit for the receiving channel, which is calculated based on channel geometry (width, depth, and gradient), channel materials, and watershed area.

The approach taken was to develop an Excel spreadsheet model to calculate the boundary shear stress associated with a range of flows up to Q_5 for a given channel width, depth and slope, then plot the critical shear stress for the channel material on this rating curve over to identify the flow where boundary shear stress equals critical shear stress.

The development steps were as follows:

1. Develop simplified channel cross section and gradient inputs
2. Calculate a shear stress rating curve
3. Characterize channel materials in terms of critical shear stress
4. Plot critical shear stress of the receiving channel on the rating curve to determine Qcrit
5. Divide the critical low flow by the project area as a proportion of the receiving water watershed area to determine the allowable flow at the point of compliance

Simplified Channel Cross Section and Gradient Inputs

The tool generates a flow rating curve based on user inputs describing the receiving channel dimensions (cross section) and gradient. The first step in developing the tool was to create a template for inputting the required channel parameters. The template assumes a simple trapezoidal cross section, with the following elements:

1. Channel width at a well defined break point corresponding to top of bank (a)
2. Channel width at the toe of the bank (b)
3. Channel depth (elevation difference between bank top and channel bed) (c)

Assumptions:

1. Receiving channels can be reasonably represented by a simple trapezoidal cross section
2. The top of bank corresponds reasonably to the level inundated by the dominant discharge (approximately equal to Q_5)

If top of bank is much higher than the dominant discharge flow depth (e.g. in an incised channel) the applicant should adjust the cross section to represent the lower part of the channel so that depth (c) corresponds approximately to the Q_5 depth.

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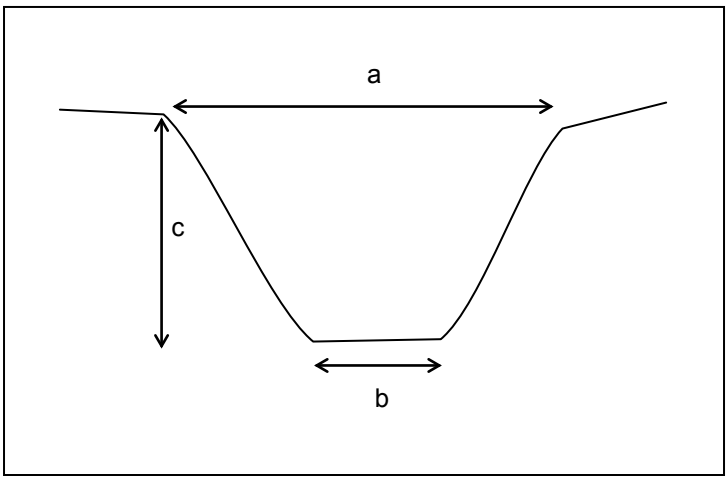

Figure 5-5. Bankfull Cross Section

Develop a Shear Stress Rating Curve

The tool creates a shear stress rating curve for a range of flows between 1 percent of the bankfull flow depth and bankfull depth [flow at depth (c)]. The range 1 to 100 percent of bankfull is used because critical flow rarely lies outside these values. The tool then calculates average boundary shear stress and discharge as previously described in section 5.1.3.

Characterize Receiving Channel Materials in Terms of Critical Shear Stress

The critical shear stress of the channel materials is estimated using a look-up table based on values published by the U.S. Army Corps of Engineers (Fischenich). The tool provides values of critical shear stress for a wide range of channel materials in a drop down box so the user can select from the list. The calculator also allows the user to input a vegetated channel material when this is appropriate (when the channel is completely lined in vegetation).

Calculating Critical Flow for the Receiving Water

Critical flow is the discharge at which boundary shear stress equals critical shear stress. The tool uses a power function to interpolate the discharge versus boundary shear stress rating curve. The critical shear stress for the weaker of the bed or banks is plotted horizontally from the Y axis until it intercepts the rating curve. The intercept point is extended vertically to the X axis, showing the critical flow (see Figure 5-4). This represents the low flow threshold for the receiving water. This value is compared to the 2-year flow in the channel to determine the allowable release rate from BMP facilities, expressed as a fraction of the 2-year flow (0.1, 0.3, or $0.5Q_2$).

Calculating Critical Flow for the Point of Compliance

The tool calculates critical flow based on the characteristics of the receiving water. Where the project watershed does not make up the entire watershed area for the receiving water, the low flow threshold can be prorated based on the percentage of the watershed that is occupied by the project site[2]. For example, if a project occupies one tenth of the receiving water's watershed at the point of compliance and the critical flow

[2]. It is not necessary to adjust the "off-the-shelf" thresholds developed for Track 1 for point of compliance, since they are expressed as a fraction of Q2 for the relevant project area.

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level is 50 cfs, the project's 'share' of the non-erosive flow is 5 cfs (50 x 1/10). This prevents the cumulative impact of future developments from exceeding critical flow in the receiving water, since the critical flow is apportioned according to watershed area.

$$\text{Critical flow at Point of Compliance} = \text{Critical Flow at Receiving Water} \times \frac{\text{Project Area}}{\text{Watershed Area}}$$

The critical flow at the point of compliance is the low flow threshold for the project draining to this point.

Conversion of Critical Flow to Flow Class

To avoid having an infinite range of flow control standards, the calculator assigns the discharge into one of three classes based on its value as a function of the estimated Q_2. These classes are: $0.1Q_2$, $0.3Q_2$, $0.5Q_2$. For example, a channel where the critical flow is $0.15Q_2$ would be assigned a flow threshold of $0.1Q_2$. Channels with critical flows less than $0.1Q_2$ are assigned to the $0.1Q_2$ class. The class flow rate is calculated (i.e. the critical flow corresponding to the assigned fraction of Q_2) and expressed as the final output of the tool.

5.1.5 Third Party Review

West Consultants conducted an in-depth, independent third-party review of the preliminary flow threshold analysis in December 2008. The following list presents a summary of the third-party review.

- Concern was noted regarding the lower flow control limit suggested by the modeling results (10 percent of the 2-year runoff event), especially with regard to implementation practicality and its derivation based solely on sediment movement.
- The review noted that literature suggests standard hydrologic design practices may be inadequate for characterizing cumulative effects of urbanization for flow events more frequent than the 2-year runoff event – specifically with regard to sediment transport and channel disturbance potential.
- The review questioned the use of a specific frequency discharge as an indicator of shear stress to move particles given the variability of other site-specific parameters such as grain size, slope, roughness, and channel shape.
- The review suggested that hydraulic and sediment transport results should be supplemented with actual field data (slope, sediment properties, roughness, and channel shape) to set thresholds (flows, shear stresses, or velocities).
- Concern was noted regarding the use of a single and conservative uniform size for sediment grain sizes. The use of a distribution of sediment grain sizes was recommended.

PWA agreed with the recommendation that additional field data (channel dimensions and slope, and sediment size distribution) is desirable both to verify receiving channel conditions and to make direct measurements of critical shear stress. Efforts were made to pursue the former data, but it was not possible to obtain field permission in time to meet the project deadlines. As the third-party review notes, any revised lower flow threshold calculated using field data is as likely to decrease as increase.

Subsequent to the preliminary flow threshold analysis, PWA ran sediment transport models using a distribution of grain sizes (rather than a single uniform size) for two channel configurations. The results of this limited sensitivity test (see discussion below titled "Summary of Sensitivity Analysis") did not show a consistent trend toward more or less erosion.

For more detailed information regarding West Consultants' independent third-party review, refer to the memo titled *Review of Hydromodification Work by Phillip Williams and Associates (PWA),* prepared by West Consultants and dated December 19, 2008 (Appendix D).

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5.1.6 Summary of Sensitivity Analysis

Subsequent to the preliminary flow threshold analysis, the Copermittees requested that a sensitivity analysis be conducted based on historical rainfall records in the vicinity of the test watershed sites. The purpose of the sensitivity analysis based on the revised rainfall input data is described below. There were two potential concerns associated with the use of the hydrologic analysis developed in the preliminary flow threshold analysis.

- First, the analysis used a single rainfall time series (Lindbergh Field) for all simulations. Rainfall records for other areas were synthesized by taking the difference in mean annual rainfall between a nearby rain gauge and developing a linear adjustment for the Lindbergh series (e.g., if the test site's mean annual rainfall is 15 percent greater than the mean annual rainfall at Lindbergh, then 15 percent is added to all hourly rainfalls). The preliminary flow threshold analysis used this scaled data approach since other data were not available at the time of the initial analysis. Long-term rainfall data for 20 gauges throughout San Diego County have subsequently been prepared and are thus more relevant to the test simulations performed for this study. A test hydrologic analysis showed significant hydrologic response differences between the historical rainfall record for Lower Otay Reservoir and the scaled data from Lindbergh Field.
- Second, the preliminary flow threshold analysis used an "annual peak" method to calculate the rainfall recurrence interval, rather than a partial duration series method. The two methods result in significantly different predictions of the two year runoff event (Q_2.). From discussions with rainfall statistical experts at the Hydrologic Research Center, it has been determined that the partial duration series is a more applicable rainfall series for the semi-arid climate in San Diego County. Partial duration flow statistics have been prepared and the test hydrologic analysis showed significant hydrologic response differences between the partial duration series and annual peak series methods.

There is significant variability in the HEC-RAS modeling results for the different channel and sediment scenarios, as reflected in the results of the preliminary flow threshold analyses. Therefore, it is important to focus on the general trends reflected in the sensitivity analysis results rather than the specific numerical results. As such, the sensitivity analysis modeling results confirm that the selection of rainfall data, flow frequency methodology, and sediment size distribution do affect the results of the flow control analysis. However, the cumulative effect of these changes did not affect the consultant's preliminary conclusion that a singular countywide lower flow threshold limit would converge on 10 percent of the 2-year runoff event.

For more detailed information regarding the PWA sensitivity analysis based on revised rainfall data, refer to the memo titled *Sensitivity of Changing Rainfall Series and Analysis on Erosion Threshold*, prepared by PWA and dated December 29, 2009 (Appendix A).

5.2 Categorization of Streams

Information for this section was prepared in association with a concurrent hydromodification study by the SCCWRP. As discussed with the San Diego RWQCB staff, results of the SCCWRP study have been included in the San Diego HMP to comply with the following Permit Order requirement.

- Identification of geomorphic standards for channel segments receiving storm water discharges from Priority Projects (Permit Section D.1.g.(1)(a) and (m)). The purpose of these standards is to maintain or improve channel stability.

The SCCWRP study, which is being conducted for the entire Southern California region between Ventura and San Diego Counties, was originally funded by a Prop 50 grant. Because of funding issues that required a work stoppage in late 2008, the County of San Diego has provided funding to SCCWRP to continue its work and meet deadlines required for the San Diego HMP submittal timeline. The overall SCCWRP study

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approach is summarized in the document titled, "*Stream Channel Mapping and Classification Systems: Implications for Assessing Susceptibility to Hydromodification Effects in Southern California," SCCWRP Technical Report 562, April 2008*.

Screening tools, prepared by SCCWRP to identify channel susceptibility to hydromodification impacts, are now available in 2009 on a testing basis. Such tools include the following:

- A tiered, hierarchical approach for channel erosion susceptibility evaluation of multiple channel types. This approach includes determination of a vertical channel stability analysis (including transportability of channel bed material) and a lateral channel stability analysis (including potential erodibility of channel banks and subsequent channel migration). These rapid assessment tools provide a preliminary rating of stream susceptibility to erosion (Very High, High, Medium, or Low) and are provided for a variety of geomorphic scenarios including alluvial fans, broad valley bottoms, incised headwater channels, etc.

Eventually, SCCWRP tools will be expanded to help quantify the effect of a proposed project on the receiving stream's susceptibility to erosion, based upon factors such as size of the project, impervious footprint, location of the project within the watershed, and stability of the receiving water body.

Development of HMPs in most Southern California counties is correlated to the ultimate findings of the SCCWRP study, which was originally scheduled for release in March 2010. Though individual regions and municipalities would not be tied to acceptance of the SCCWRP results, it is generally acknowledged that SCCWRP's formulation of regional standards for hydromodification management will serve as a solid baseline for development of HMPs for specific regions in Southern California.

For implementation with the San Diego HMP, the SCCWRP screening tools will be used in association with the decision matrix to determine the appropriate level of mitigation required for a particular project. Where receiving streams have a high susceptibility to erosion, then more restrictive mitigation solutions will be required as compared to receiving streams with a low susceptibility to erosion.

The full lateral and vertical susceptibility decision matrices are included on Pages 4 and 5 of the overall HMP Decision Matrix, located in Chapter 6 of this HMP. Page 3 of the HMP Decision Matrix includes recommendations regarding the appropriate lower flow threshold, based upon the SCCWRP susceptibility analysis as well as the critical flow calculator result.

Channel screening tools will assess the domain of analysis from a proposed project. The domain of analysis is defined as the reach lengths upstream and downstream from a project for which hydromodification assessment is required. The domain of analysis determination includes an assessment of the incremental flow accumulations downstream of the site, identification of hard points in the downstream conveyance system, and quantification of downstream tributary influences.

The effects of hydromodification may propagate for significant distances downstream (and sometimes upstream) from a point of impact such as a stormwater outfall. Accordingly, it may be necessary to conduct geomorphic screening reconnaissance across a domain spanning multiple channel types/settings and property owners.

For purposes of this HMP, the extents of the domain of analysis are defined as follows:

- Proceed downstream until reaching one of the following:
  - At least one reach downstream of the first grade-control point (preferably second downstream grade control location)
  - Tidal backwater/lentic (still water) waterbody
  - Equal order tributary (Strahler 1952)

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- Accumulation of 50 percent drainage area for stream systems (note that SCCWRP is still determining specific flow accumulation percentage)
- Accumulation of 100 percent drainage area for urban conveyance systems (storm drains, hardened channels, etc.)

OR demonstrate sufficient flow attenuation through existing hydrologic modeling.

- Proceed upstream for 20 channel top widths OR to the first grade control point, whichever comes first. Identify hard points that can check headward migration and evidence of active headcutting.

If the screening analysis is conducted on a project-specific basis, there may be instances in which a high susceptibility rating is obtained at the first point of field observation. In these cases, it may be sufficient to limit the analysis to the point/property of impact.

The SCCWRP screening tools, as well as details to determine the domain of analysis, are provided in Appendix B.

5.3 Cumulative Watershed Impacts

California Environmental Quality Act (CEQA) Guidelines §15065 mandate a finding that a project has a significant effect on the environment when it has:

> "…possible environmental effects that are individually limited but cumulatively considerable. 'Cumulatively considerable' means that the incremental effects of an individual project are significant when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probably future projects."

Such assessments are inherently difficult and rarely quantifiable. However, it is often possible to incorporate within a project measures that limit or offset potential impacts to such a degree that reasonable minds can agree the net incremental impact of the project is insignificant regardless of the connections to, or multiplying effects of, other projects. To this end, a river reach sensitivity analysis was performed for the San Diego River. The intent of this analysis was to determine the level of cumulative watershed impacts that would result in a significant alteration to the San Diego River's flow duration curve. Data from this analysis are being used to determine exemption criteria for similar-sized river systems in San Diego County, since detailed long-term hourly streamflow data is not available for most of those rivers. The results of the sensitivity analysis are discussed in detail in Section 6.1.

5.3.1 Hydromodification Management

The purpose of the HMP is to address the cumulative effect of many individual development projects on stream erosion. In the HMP, the watershed-scale effect is addressed through conditions placed on individual development projects.

Also, the HMP implements a regulatory standard. A project's compliance with regulatory standards may be used to help determine whether the project may have a significant impact on the environment, either individually or cumulatively.

Two questions have been raised with regard to how the HMP addresses cumulative impacts:

1. Are the low-flow thresholds (the maximum rate at which on-site detention facilities can be drained) low enough to prevent stream erosion, when viewed in connection with the effects of other projects?

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2. With regard to the specific exemption proposed for discharges where downstream sub-watershed imperviousness is at least 70 percent and the potential for cumulative impacts is "minimal," how will that potential be assessed?

Low Flow Thresholds

How does the low flow threshold for a receiving stream relate to the flow that must be controlled at a project site?

A low flow threshold for a receiving stream can be articulated as a particular runoff event (e.g., 0.1 Q_2., or one-tenth the 2-year peak runoff flow). Runoff to the stream is modeled based on the watershed area tributary to the stream, and the model is then calibrated to stream gauge data. In some cases, the low-flow runoff threshold developed from watershed-scale stream analysis has then been applied to each project area within the watershed. Implicitly, this standard is set so that if the entire watershed was made impervious, and runoff from the entire watershed was controlled through the facilities built to this standard, no increase in stream erosion would result.

This is an exceedingly conservative assumption, because:

- Not all areas of the watershed will be developed.
- Very low flows trickling from individual detention facilities will have losses before reaching streams.
- If bioretention facilities are used, the losses to infiltration and evapotranspiration are likely to be underestimated.

In addition to this general conservative bias, additional conservatism is built in when a project is located downstream from headwaters. To use an extreme example, a discharge from a development project near the mouth of a stream draining a large watershed would have an insignificant impact throughout the range of runoff flow rates encountered in the stream.

The degree to which these factors contribute to a conservative bias in the hydromodification standard can only be estimated; however, reasonable judgments can be made. These judgments should be subject to revision based on further insights gained in the first years of implementation.

Proposed Exemptions

How would the potential for cumulative impacts from many exempted projects be assessed? There are too many possible scenarios of development proposal and watershed condition to establish firm standards or guidelines. In this context, the concept of "minimal potential" for cumulative impacts means a judgment that—based on knowledge of the specific land use patterns and policies in the watershed—it is unlikely the total of all future newly developed projects discharging at the selected low-flow threshold would be significant when compared to the current (pre-project) total flow from the watershed. The requirements that Priority Development Projects on previously developed sites implement LID and use LID facilities such as bioretention for storm water treatment further ensure runoff rates and durations in highly developed watersheds will decrease rather than increase over time.

A similar approach applies to other proposed exemptions and in-lieu mitigation projects within the HMP. For example, the HMP states "the project proponent may consider implementation of planning measures such as buffers and restoration activities.… in lieu of implementation of storm water flow controls." In this case, cumulative impacts are addressed by the proviso that this option is available "in situations where the benefits of a proposed stream restoration project would *substantially outweigh the potential impacts* of additional runoff from a proposed project…" (emphasis added). The requirement that benefits "substantially outweigh" potential impacts for each individual project addresses the potential for cumulative impacts by

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ensuring that, even if many such scenarios were implemented in a watershed, the cumulative benefits would outweigh the cumulative impacts.

5.3.2 Summary

As with other cumulative impacts, the cumulative impacts on stream erosion of individual land development projects within a watershed can only be estimated. Judgments on the significance of potential cumulative impacts are based on a weight of evidence approach. Despite the lack of quantification and certainty, it is possible for stakeholders to agree that, in a given set of conditions, the potential for cumulative impacts is highly unlikely.

The HMP supports assessment of cumulative impacts through hydrologic modeling of entire watersheds. Translating the results of watershed modeling to standards applicable to individual development sites is a matter of estimation and judgment.

In the HMP, the potential for cumulative impacts is addressed through a built-in conservative bias in quantitative estimates of impacts and the effectiveness of flow-control measures needed to address those impacts, and through a conservative approach and individual review of proposed exemptions and in-lieu projects.

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6. REQUIREMENTS AND STANDARDS FOR PROJECTS

Priority Development Projects are required to implement hydrologic control measures so that post-project runoff flow rates and durations do not exceed pre-project flow rates and durations where they would result in an increased potential for erosion or significant impacts to beneficial uses or violate the channel standard (Permit Section D.1.g(1)(c)). The purpose of this chapter is to detail HMP applicability requirements, present hydromodification mitigation criteria and implementation options, and provide a framework for in-stream rehabilitation options.

6.1 HMP Applicability Requirements

To determine if a proposed project must implement hydromodification controls, refer to the HMP Decision Matrix in Figure 6-1 on the following page.

The HMP Decision Matrix can be used for all projects. For redevelopment projects, flow controls would only be required if the redevelopment project increases impervious area or peak flow rates as compared to pre-project conditions.

It should be noted that all Priority Development Projects will be subject to the Permit's LID and water quality treatment requirements even if hydromodification flow controls are not required.

As noted in Figure 6-1, projects may be exempt from HMP criteria under the following conditions.

- If the project is not a Priority Development Project
- If the proposed project does not increase the impervious area or peak flows to any discharge location.
- If the proposed project discharges runoff directly to an exempt receiving water such as the Pacific Ocean, San Diego Bay, an exempt river reach, an exempt reservoir, or a tidally-influenced area.
- If the proposed project discharges to a stabilized conveyance system that extends to the Pacific Ocean, San Diego Bay, a tidally-influenced area, an exempt river reach or reservoir.
- If the contributing watershed area to which the project discharges has an impervious area percentage greater than 70 percent
- If an urban infill project discharges to an existing hardened or rehabilitated conveyance system that extends beyond the "domain of analysis," the potential for cumulative impacts in the watershed are low, and the ultimate receiving channel has a Low susceptibility to erosion as defined in the SCCWRP channel assessment tool.

If the proposed project decreases the pre-project impervious area and peak flows to each discharge location, then a flow-duration analysis is implicitly not required. If continuous simulation flow-frequency and flow duration curves were developed for such a scenario, the unmitigated post-project flows and durations would be less as compared to pre-project curves.

Proposed exemptions for projects discharging runoff directly to the Pacific Ocean, San Diego Bay or to hardened conveyance systems which transport runoff directly to the Pacific Ocean or San Diego Bay are referred to the 2007 Municipal Permit. Per the Permit, hardened conveyance systems can include existing concrete channels, storm drain systems, etc.

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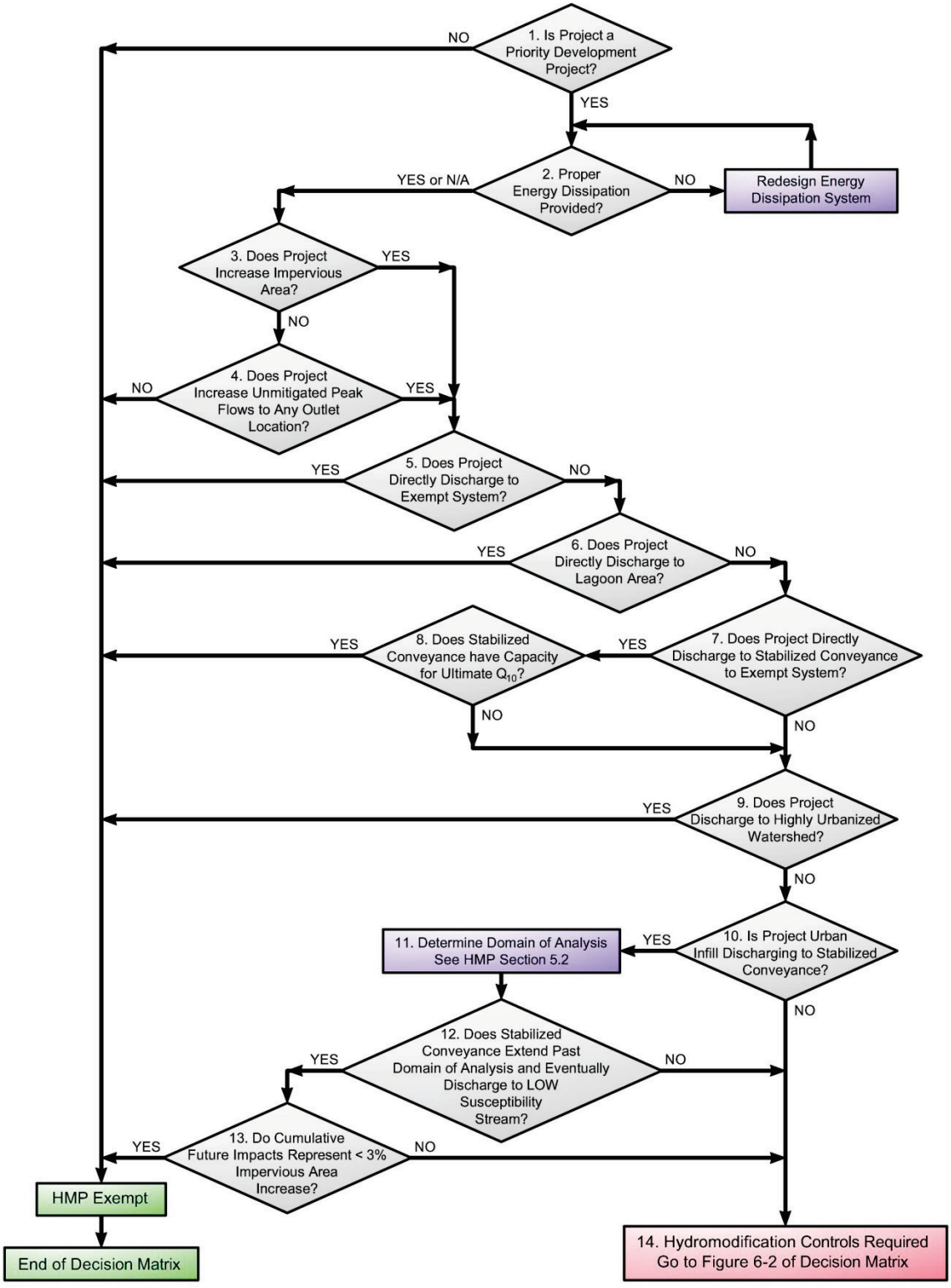

Figure 6-1. HMP Applicability Determination

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The Municipal Permit also contains language to support exemptions for projects located in highly urbanized areas where the impervious percentage exceeds 70 percent (as calculated for the sub-watershed between the project outfall downstream to the exempt receiving water).

- Figure 6-1, Node 1 – Hydromodification mitigation measures are only required if the proposed project is a Priority Development Project.
- Figure 6-1, Node 2 – Properly designed energy dissipation systems are required for all project outfalls to unlined channels. Such systems should be designed in accordance with the County of San Diego's Drainage Design Manual to ensure downstream channel protection from concentrated outfalls.
- Figure 6-1, Nodes 3 and 4 – Projects may be exempt from hydromodification criteria if the proposed project reduces the pre-project impervious area and if unmitigated post-project outflows (outflows without detention routing) to each outlet location are less as compared to the pre-project condition. The pre and post-project hydrologic analysis should be conducted for the 2 and 10-year design storms and follow single-event methodology set forth in the San Diego Hydrology Manual. This scenario may apply to redevelopment projects in particular.
- Figure 6-1, Node 5 – Potential exemptions may be granted for projects discharging runoff directly to an exempt receiving water, such as the Pacific Ocean, San Diego Bay, an exempt river system (detailed in Table 6-1), or an exempt reservoir system (detailed in Table 6-2).
- Figure 6-1, Node 6 – For projects discharging runoff directly to a tidally-influenced lagoon, potential exemptions may also be granted. Exemptions related to runoff discharging directly to tidally-influenced areas were drafted based upon precedent set in the Santa Clara HMP. Regarding the potential exemption, additional analysis would be required to assess the effects of the freshwater / saltwater balance and the resultant effects on lagoon-system biology. This assessment, which would be required by other permitting processes such as the Army Corps of Engineers, California Department of Fish and Game, etc., must be provided by a certified biologist or other specialist as approved by the governing municipality. Such discharges would include an energy dissipation system (riprap, etc.) designed to mitigate 100-year outlet velocities based upon a free outfall condition. Such a design would be protective of the channel bed and bank from an erosion standpoint.
- Figure 6-1, Nodes 7 and 8 – For projects discharging runoff directly to a hardened conveyance or rehabilitated stream system that extends to exempt receiving waters detailed in Node 5, potential exemptions from hydromodification criteria may be granted. Such hardened or rehabilitated systems could include existing storm drain systems, existing concrete channels, or stable engineered unlined channels. To qualify for this exemption, the existing hardened or rehabilitated conveyance system must continue uninterrupted to the exempt system. In other words, the hardened or rehabilitated conveyance system cannot discharge to an unlined, non-engineered channel segment prior to discharge to the exempt system. Additionally, the project proponent must demonstrate that the hardened or rehabilitated conveyance system has capacity to convey the 10-year ultimate condition flow through the conveyance system. The 10-year flow should be calculated based upon single-event hydrologic criteria as detailed in the San Diego County Hydrology Manual.
- Figure 6-1, Node 9 – As allowed per the Municipal Permit, projects discharging runoff to a highly urbanized watershed (defined as an existing, pre-project impervious percentage greater than 70 percent) may be eligible for an exemption from hydromodification criteria.

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Watershed impervious area calculations for this potential exemption will be measured between the project site discharge location and the connection to a downstream exempt receiving conveyance system, such as the Pacific Ocean, San Diego Bay, or an exempt river system. If a tributary area connects with the main line drainage path between the project site and the exempt system, then the entire watershed area contributing to the tributary shall be included in the calculation. Initial review of County land use indicates that this exemption will likely only apply in a limited number of urbanized coastal areas.

Percent imperviousness will be calculated based on an area-weighted average of impervious areas associated with commercial, industrial, single-family residential, multi-family residential, open space, and other miscellaneous areas (schools, churches, etc.) representative for the watershed. Representative percent imperviousness values for each land use type may correspond to values recommended in Table 3-1 of the County of San Diego's Hydrology Manual and detailed below or by more specific representative percent impervious calculations (using GIS, etc.), which are often required to represent impervious area percentages for park, school and church sites.

- Figure 6-1, Nodes 10 through 13 – For urban infill projects discharging runoff to an existing hardened or rehabilitated conveyance system, potential limited exemptions from hydromodification criteria may apply where the existing impervious area percentage in the watershed exceeds 40 percent. For the potential exemption application, the domain of analysis must be determined and the existing hardened or rehabilitated conveyance system must extend beyond the downstream terminus of the domain of analysis. The hardened or rehabilitated conveyance system must discharge to a receiving channel with a Low potential for channel susceptibility for this exemption to be granted (channel susceptibility determined using SCCWRP tool). Finally, continuous simulation sensitivity analysis shows that an exemption could only be granted if the potential future development impacts in the watershed would increase the watershed's impervious area percentage by less than 3 percent (as compared to the existing condition in the year 2010). If the potential future cumulative impacts in the watershed could increase the impervious area percentage by more than 3 percent (as compared to existing condition), then no exemption could be granted based on this item. Watershed impervious area calculations for this potential exemption, in which a project discharges to a watershed with an existing impervious areas greater than 40 percent, will be measured upstream from the outfall of the urban conveyance system (to a non-concrete, non-riprap-lined or non-engineered channel) to the contributing watershed boundary (the entire watershed contributing to the discharge outfall).

  Percent imperviousness will be calculated based on an area-weighted average of impervious areas associated with commercial, industrial, single-family residential, multi-family residential, open space, and other miscellaneous areas (schools, churches, etc.) representative for the watershed. Representative percent imperviousness values for each land use type may correspond to values recommended in Table 3-1 of the County of San Diego's Hydrology Manual and detailed below or by more specific representative percent impervious calculations (using GIS, etc.), which are often required to represent impervious area percentages for park, school and church sites.

Exemptions related to runoff discharging directly to certain river reaches were initially based upon the majority TAC opinion that such river reaches were depositional (aggrading) and that the effects of cumulative watershed impacts to these reaches is minimal. Subsequent justifications for the river reach exemptions were the result of a flow duration curve analysis for the San Diego River.

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Potential river reaches that would be exempt from hydromodification criteria include only those reaches for which the contributing drainage area exceeds 100 square miles and which have a 100-year design flow in excess of 20,000 cfs. For reference, proposed Caltrans HMP criteria allows for river/creek exemptions for drainage areas of only 10 square miles.

Per recommendations from members of the TAC, San Diego river systems meeting the drainage area and peak flow criteria are typically aggrading (depositional) and have very wide floodplain areas when in the natural condition. In all cases, river reaches meeting the drainage area and peak flow criteria are located downstream of large reservoir systems which effectively block outflows for most storm events. In addition, the river systems meeting these criteria typically have very low gradients. The combination of low gradients, significant peak flow attenuation, and wide floodplain areas translate to a low potential for channel erosion at the upper limit of the proposed geomorphic flow range (10-year flow event).

The intent of the San Diego River flow duration analysis was to determine the level of cumulative watershed impacts that would result in a significant alteration to the San Diego River's flow duration curve. Both the Fashion Valley and Mast Boulevard USGS stream gauge stations were used to develop long-term flow duration curves for the San Diego River. Data from this analysis will be used to determine exemption criteria for similar-sized river systems in San Diego County, since detailed long-term hourly streamflow data is not available for most of those rivers. Since the findings of the sensitivity analysis are planned to be extrapolated to other large river systems, implementation of additional gauging stations along other major river systems is recommended to analyze the differences in watershed response between the major watershed systems.

Assumptions related to the San Diego River sensitivity analysis are provided below:

- The flow duration charts show the San Diego River flow durations, plus simulated river flows durations for additional development scenarios.
- HSPF models were built to simulate converting existing undeveloped areas in the watershed into development with no stormwater flow controls.
- Increasing drainage area increments were modeled.
- To produce the 'simulated development' flow duration curves, the difference between developed and undeveloped flow duration curves was calculated for proposed hypothetical development .sites of varying sizes Then, the "difference hydrograph" was added to the San Diego River flow duration curve. This approach was used to avoid the potential problem of double-counting areas.

Tasks Related to Development of Flow Duration Analysis of San Diego River:

- Acquired 15-minute stream flow data from USGS (available from 1988 to present)
- Aggregated to 1-hour historical record
- Computed flow duration statistics for both records and determined if there is any substantial difference between the records (this is a QA step that allowed for removal any high flow 'outliers' in the record that could affect the results).
- Prepared a simple, characteristic HSPF model for the lower watershed for "existing conditions in an undeveloped area" – assumed Group D soils with sparse vegetation.
- Prepared a simple, parallel HSPF model for "developed conditions"

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- Ran both models and examined the difference between the resulting hydrographs (the hydromodification). A couple of different pre- and post-development models were generated to analyze the differences on a per unit area basis.
- Using the "difference hydrograph" created from the model simulations, progressively added development and recomputed the flow duration statistics.
- Examined the modified flow duration statistics and determined at what level of increased development the statistics became noticeably altered.

Results showed that increasing levels of development, in excess of 1,000 acres assumed to occur at the same location as the stream gauge station, would produce a very minor influence on the river's flow duration curve. These results demonstrated that certain portions of the San Diego River could be exempt from hydromodification requirements. Such HMP exemptions would only be granted for projects discharging runoff directly to the exempt river reach. Each municipality must define "direct discharge" based on the project site conditions. To qualify for the potential exemption, the outlet elevation must be between the river bottom elevation and the 100-year floodplain elevation and properly designed energy dissipation must be provided The supporting HSPF continuous modeling analysis results are summarized in a Technical Memo in Appendix F.

All exempt river reaches, which are presented in Table 6-1, have drainage areas in excess of 100 square miles and 100-year flow rates in excess of 20,000 cfs. In addition, all proposed river reaches are subject to significant upstream reservoir flow regulation, have wide floodplain or stabilized channel areas, and low gradients. This combination of factors, in association with field observations and years of historical perspective from the TAC members, justifies exemptions for direct discharges to the exempt river reaches provided that properly sized energy dissipation is provided at the outfall location.

Table 6-1. Summary of Exempt River Reaches in San Diego County

River	Downstream Limit	Upstream Limit
Otay River	Outfall to San Diego Bay	Lower Otay Reservoir Dam
San Diego River	Outfall to Pacific Ocean	Confluence with San Vicente Creek
San Dieguito River	Outfall to Pacific Ocean	Lake Hodges Dam
San Luis Rey River	Outfall to Pacific Ocean	Upstream river limit of Basin Plan subwatershed 903.1 upstream of Bonsall and near Interstate 15
Sweetwater River	Outfall to San Diego Bay	Sweetwater Reservoir Dam

Table 6-2 provides a summary of exempt reservoirs in San Diego County. Large reservoirs can be exempt systems from a hydromodification standpoint since reservoir storm water inflow velocities are naturally mitigated by the significant tailwater condition in the reservoir. HMP exemptions would only be granted for projects discharging runoff directly to the exempt reservoirs. Each municipality must define "direct discharge" based on the project site conditions. To qualify for the potential exemption, the outlet elevation of the conveyance system must be within (or below) the normal operating water surface elevations of the reservoir and properly designed energy dissipation must be provided.

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Table 6-2. Summary of Exempt Reservoirs in San Diego County	
Reservoir	**Watershed**
Barrett Lake	Tijuana River
El Capitain Reservoir	San Diego River
Lake Dixon	Escondido Creek
Lake Heneshaw	San Luis Rey River
Lake Hodges	San Dieguito River
Lake Jennings	San Diego River
Lake Murray	San Diego River
Lake Poway	San Dieguito River
Lake San Marcos	San Marcos Creek
Lake Wohlford	Escondido Creek
Loveland Reservoir	Sweetwater River
Lower Otay Reservoir	Otay River
Miramar Lake	Los Penasquitos Creek
San Vicente Reservoir	San Diego River
Sweetwater Reservoir	Sweetwater River
Upper Otay Reservoir	Otay River

The final exemption category focuses on small urban infill projects where the potential for future cumulative watershed impacts is minimal. Continuous simulation models have been prepared for subwatershed areas containing between 40 and 70 percent existing imperviousness (as measured from the project site downstream to existing storm drain outfall) with the following assumptions.

Sensitivity Analysis for Urban Watersheds:

- Prepared HSPF models for 10-, 100-, and 500-acre watersheds with 40, 50, 60 percent imperviousness. Ran simulations and computed flow duration statistics for each of the urban watershed scenarios.
- Progressively increased the level of imperviousness to simulate infill development for the 10-, 100-, 500-acre watersheds.
- Ran infill scenario simulations and computed flow duration statistics
- Examined the infill flow duration statistics and determined at what level of increased development the statistics became noticeably altered.

Per results of the continuous simulation modeling and analysis of the resultant flow duration curves, urban infill projects have a relatively minor effect on the overall watershed's flow duration curve if the future cumulative additional impacts have the potential to increase the existing watershed impervious area by less than 3 percent. Potential urban infill project exemptions are only considered if the existing impervious area percentage of the sub-watersheds is at least 40 percent. For sub-watersheds containing less than 40 percent existing impervious area, continuous simulation models indicated a more pronounced response to the flow duration curve with small urban infill developments.

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Urban infill projects may be exempt from HMP criteria if:

1. The potential future development impacts within the sub-watershed, as measured from the entire sub-watershed area draining to the existing conveyance system outfall, would not increase the composite impervious area percentage of the sub-watershed by more than 3 percent
2. The project discharges runoff to an existing hardened or rehabilitated conveyance system (storm drain, concrete channel, or engineered vegetated channel) that extends beyond the Domain of Analysis determined for the project site, and
3. The stabilized conveyance system eventually discharges to a channel with a Low susceptibility to erosion, as designed by the SCCWRP channel assessment tool.

The supporting HSPF continuous modeling analysis results, which analyzed existing sub-watershed scenarios of 40, 50, and 60 percent impervious area, are summarized in a Technical Memo in Appendix F.

As mentioned in Section 5.2, the Domain of Analysis is defined to extend downstream of a proposed project site to a location in a natural stream section to where a 50 percent flow accumulation is added to the stream system. For existing storm drain systems or hardened conveyance systems, the Domain of Analysis shall extend downstream to a location where a 100 percent flow accumulation is added to the storm drain or hardened conveyance system. These definitions may be revised in the future subsequent to ongoing work being conducted by the SCCWRP.

6.2 Flow Control Performance Criteria

Figures 6-2 and 6-3, which are part of the HMP Decision Matrix and are presented on the following pages, detail how lower flow thresholds would be determined for a project site. Figures 6-4 and 6-5, which detail the SCCWRP lateral and vertical channel susceptibility requirements, complete the HMP Decision Matrix.

The project applicant must first determine whether field investigations will be conducted pursuant to the SCCWRP channel screening tools. If the screening tools are not completed for a proposed project, then the site must mitigate peak flows and durations based on a pre-project condition lower flow threshold of $0.1Q_2$. While a project applicant would be held to the $0.1Q_2$ standard if channel screening tools and assessments are not conducted, less restrictive standards are possible for more erosion-resistant receiving channel sections if the screening tools are completed and the SCCWRP method indicates either a Medium or Low susceptibility to channel erosion.

In such a scenario, the project applicant would also use the critical shear stress calculator to assist in determination of the predicted lower flow threshold. The SCCWRP screening tools and critical shear stress calculator work in concert to determine the lower flow threshold for a given site. Lower flow limits determined by the calculator have been grouped into one of three thresholds – $0.1Q_2$, $0.3Q_2$ or $0.5Q_2$. "Low" susceptibilities from the SCCWRP tool generally correspond to the $0.5Q_2$ threshold, "Medium" susceptibilities generally correspond to the $0.3Q_2$ threshold, and "High" susceptibilities generally correspond to the $0.1Q_2$ threshold. The SCCWRP channel screening tools are required to identify channel conditions not considered by the critical shear stress calculator, which focuses on channel material and cross section. Conversely, the SCCWRP channel screening tools considers other channel conditions including channel braiding, mass wasting, and proximity to the erosion threshold. In cases where the critical shear stress calculator and the SCCWRP screening tools return divergent values, then the most conservative value shall be used as the lower flow threshold for the analysis.

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Low-Impact Development (LID) and extended detention facilities are required to meet peak flow and duration controls as follows:

1. For flow rates ranging from 10 percent, 30 percent or 50 percent of the pre-project 2-year runoff event ($0.1Q_2$, $0.3Q_2$, or $0.5Q_2$) to the pre-project 10-year runoff event (Q_{10}), the post-project discharge rates and durations shall not deviate above the pre-project rates and durations by more than 10 percent over and more than 10 percent of the length of the flow duration curve. The specific lower flow threshold will depend on results from the SCCWRP channel screening study and the critical flow calculator.
2. For flow rates ranging from the lower flow threshold to Q_5, the post-project peak flows shall not exceed pre-project peak flows. For flow rates from Q_5 to Q_{10}, post-project peak flows may exceed pre-project flows by up to 10 percent for a 1-year frequency interval. For example, post-project flows could exceed pre-project flows by up to 10 percent for the interval from Q9 to Q10 or from Q5.5 to Q6.5, but not from Q8 to Q10.

This HMP recommends the use of LID facilities to satisfy both 85th percentile water quality treatment as well as HMP flow control criteria. The Copermittees and the consultant team have developed detailed standards for LID implementation. These standards are provided in the San Diego County Model SUSMP.

The following methods may be used to meet mitigation requirements.

- Install BMPs that meet design requirements to control runoff from new impervious areas. BMPs including bioretention basins, vegetated swales, planter boxes, extended detention basins, etc. shall be designed pursuant to standard sizing and specification criteria detailed in the Model SUSMP and the HMP/LID Sizing Calculator to ensure compliance with hydromodification criteria.
- Use of the automated sizing calculator (San Diego Sizing Calculator) that will allow project applicants to select and size LID treatment devices or flow control basins. The tool, akin to the sizing calculator developed for compliance with the Contra Costa HMP, uses pre-calculated sizing factors to determine required footprint sizes for flow control BMPs. Continuous simulation hydrologic analyses are currently being developed to determine the sizing factors for various flow control options and development scenarios. The Sizing Calculator also includes an automated pond sizing tool to assist in the design of extended detention facilities for mitigation of hydromodification effects. Because of the Sizing Calculator's ease of implementation, and since hydromodification BMPs can also serve as treatment BMPs, it is anticipated that most project applicants will choose this option instead of seeking compliance through site-specific continuous simulation model preparation. The HMP/LID Sizing Calculator is an implementation tool, which is currently under development by the consultant team and will be completed by the time final HMP criteria go into effect.
- Prepare continuous simulation hydrologic models and compare the pre-project and mitigated post-project runoff peaks and durations (with hydromodification flow controls) until compliance to flow control standards can be demonstrated. The project applicant will be required to quantify the long-term pre- and post-project runoff response from the site and establish runoff routing and stage-storage-discharge relationships for the planned flow control devices. Public domain software such as HSPF, HEC-HMS and SWMM can be used for preparation of a continuous simulation hydrologic analysis.
- Points of compliance must be selected to conduct the comparisons of pre-project and post-project flows and durations. Generally, points of compliance are selected at locations along the project boundary where concentrated flows discharge from the project site. If a point of compliance is selected downstream of the project boundary, then the governing municipality should be consulted in advance of the hydromodification analysis. For projects which convey offsite runoff through the site, it is assumed that the offsite runoff would be separated from site runoff. If this is not the case, then the governing municipality should be consulted to further refine the points of compliance for the site (an interior project site point of compliance could be required in such a scenario).

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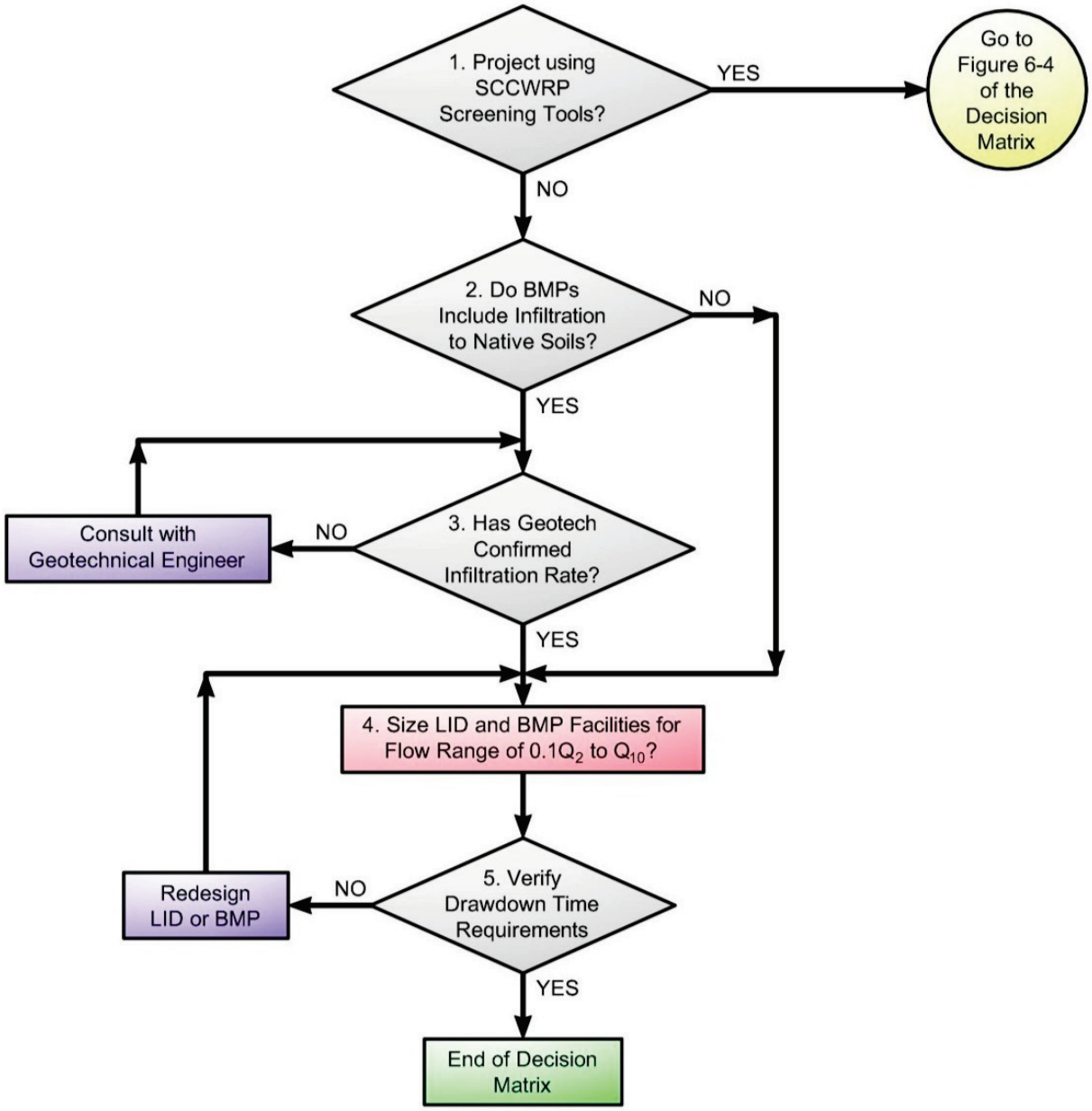

Figure 6-2. Mitigation Criteria and Implementation

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- Figure 6-2, Node 1 – If the project applicant chooses to complete SCCWRP channel screening tools, then the applicant moves to Figures 6-4 and 6-5 to assess the vertical and lateral susceptibility of the receiving channel systems. Depending on the results of the SCCWRP screening tools and critical flow calculator, it is possible that lower flow thresholds in excess of $0.1Q_2$ may be used. If the project applicant chooses not to complete the SCCWRP channel assessment, then the applicant proceeds with Figure 6-2 of the Decision Matrix.
- Figure 6-2, Node 2 – If the project's LID or BMP approach accounts for the infiltration of runoff to native surrounding soils (below amended soil layers), then consultation with a geotechnical engineer is required (Box 3). If the project mitigation approach does not account for infiltration of runoff, then the applicant would proceed to Box 4.
- Figure 6-2, Node 3 – A geotechnical engineer should determine the allowable infiltration rates to be used for the design of each LID or BMP facility. The geotechnical assessment should also identify potential portions of the project which are feasible for infiltration of runoff.
- Figure 6-2, Node 4 – In this scenario, the SCCWRP channel assessment was not conducted. Therefore, the project applicant would be held to the $0.1Q_2$ lower flow threshold. LID and extended detention facilities must be sized so that the mitigated post project flows and durations do not exceed pre-project flows and durations for the geomorphically-significant flow range of $0.1Q_2$ to Q_{10}.
- Figure 6-2, Node 5 - The Decision Matrix includes language regarding a drawdown time requirements so that standards set forth by the County's Department of Environmental Health are met. As a side note, the County's Department of Environmental Health has stated that the drawdown requirement would be applied to underground vaults in addition to extended detention basins and the surface ponding areas of LID facilities. Proper maintenance of hydromodification mitigation facilities is essential to guard against potential vector issues as well potential safety issues resulting from long-term standing water. If mitigation facility outlets clog, then runoff will bypass the system and potentially result in additional erosion problems downstream of a site.

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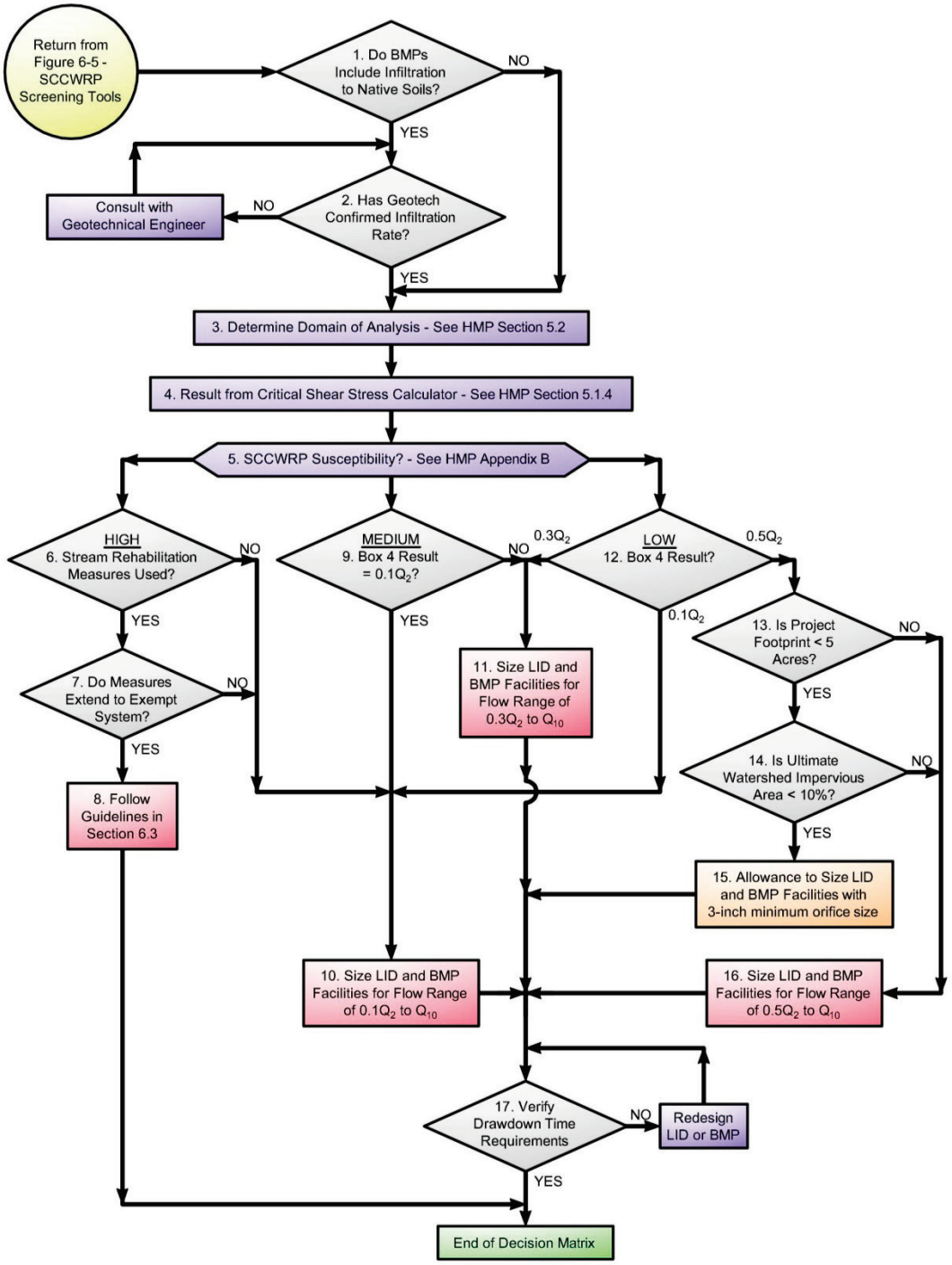

Figure 6-3. Mitigation Criteria and Implementation

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- Figure 6-3, Node 1 – Use of Figure 6-3 assumes that the project applicant conducted the SCCWRP channel assessment. Box 1 would begin following completion of both the lateral and vertical susceptibility flow charts depicted in Figures 6-4 and 6-5. Box 1 is a decision box asking if the project's LID or BMP approach accounts for the infiltration of runoff to native surrounding soils (below amended soil layers). If the answer is Yes, then consultation with a geotechnical engineer is required (Box 2). If the project mitigation approach does not account for infiltration of runoff, then the applicant would proceed to Box 3.
- Figure 6-3, Node 2 – A geotechnical engineer should determine the allowable infiltration rates to be used for the design of each LID or BMP facility. The geotechnical assessment should also identify potential portions of the project which are feasible for infiltration of runoff.
- Figure 6-3, Node 3 – Pursuant to criteria detailed in HMP Section 5.2, the Domain of Analysis is determined downstream and upstream of the project site. This determination is used to ascertain the required reach length for data collection (channel bed and bank material, channel cross section data, etc.) required for the critical flow calculator (see Box 4),
- Figure 6-3, Node 4 – Pursuant to criteria detailed in HMP Section 5.1.4, the project applicant would run the critical shear stress calculator to determine if the recommended critical flow threshold should be $0.1Q_2$, $0.3Q_2$, or $0.5Q_2$. This result will be compared to the result from the SCCWRP screening analysis (Box 5) to determine the final lower flow threshold for the project.
- Figure 6-3, Node 5 – Pursuant to criteria detailed in HMP Appendix B, the project applicant would determine both the lateral and vertical channel susceptibility rating per guidelines set forth by SCCWRP. If the lateral and vertical tools returned divergent results, then the more conservative result would be used. SCCWRP susceptibility ratings include "High", "Medium" and "Low."
- Figure 6-3, Node 6 – A project applicant would arrive at Box 6 if the SCCWRP channel susceptibility rating was determined to be "High." This decision box inquires as to whether stream rehabilitation measures such as grade control and channel widening will be used as a mitigation measure instead of flow control. It should be noted that stream rehabilitation options are only allowed if the existing receiving channel susceptibility is considered to be "High."
- Figure 6-3, Node 7 – Stream rehabilitation measures are only allowed if the proposed mitigation project extends to a downstream exempt system (such as an exempt river system). If the mitigation measure did not extend to an exempt system, then the potential for cumulative watershed impacts would be more pronounced.
- Figure 6-3, Node 8 – If stream rehabilitation measures are allowed, then guidelines outlined in Section 6.3 of the HMP should be followed to design the in-stream mitigation approach.
- Figure 6-3, Node 9 - A project applicant would arrive at Box 9 if the SCCWRP channel susceptibility rating was determined to be "Medium." If the result from the critical shear stress calculator is also "Medium" (or $0.3Q_2$), then the lower flow threshold would be $0.3Q_2$ (Box 11). If the result from the critical shear stress calculator is "High" (or $0.1Q_2$), then the more conservative value would be used and the lower flow threshold would be $0.1Q_2$ (Box 10).
- Figure 6-3, Node 10 – For stream reaches determined by either the critical flow calculator or the SCCWRP screening tools to have a "High" susceptibility to erosion, LID and extended detention flow control facilities should be sized so that the mitigated post project flows and durations do not exceed pre-project flows and durations for the geomorphically-significant flow range of $0.1Q_2$ to Q_{10}.

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- Figure 6-3, Node 11 - For stream reaches determined by either the critical flow calculator or the SCCWRP screening tools to have a "Medium" susceptibility to erosion, LID and extended detention flow control facilities should be sized so that the mitigated post project flows and durations do not exceed pre-project flows and durations for the geomorphically-significant flow range of $0.3Q_2$ to Q_{10}.
- Figure 6-3, Node 12 - A project applicant would arrive at Box 12 if the SCCWRP channel susceptibility rating was determined to be "Low." If the result from the critical shear stress calculator is also "Low" (or $0.5Q_2$), then the lower flow threshold would be $0.5Q_2$ (Box 16 – note potential waiver in Box 13). If the result from the critical shear stress calculator is "High" (or $0.1Q_2$), then the more conservative value would be used and the lower flow threshold would be $0.1Q_2$ (Box 10). If the result from the critical flow calculator is "Medium" (or $0.3Q_2$), then the more conservative value would be used and the lower flow threshold would be $0.3Q_2$ (Box 11).
- Figure 6-3, Node 13 – In some limited situations, namely small developments in rural or lightly developed areas, an allowance for a minimum outlet orifice size may be granted when the receiving channel susceptibility is "Low." This criteria may potentially be used for project footprints less than 5 acres. If the project footprint is greater than 5 acres, then the allowance may not be granted and the applicant would proceed to Box 16.
- Figure 6-3, Node 14 – The potential allowance discussed in Box 13 could only be granted if the ultimate potential impervious area in the sub-watershed is less than 10 percent. If there is potential for the sub-watershed impervious area to exceed 10 percent, then the minimum orifice size criteria may not be granted.
- Figure 6-3, Node 15 – If Boxes 12, 13, and 14 are satisfied, then mitigation facilities may be designed using a 3-inch minimum outlet orifice size.
- Figure 6-3, Node 16 - For stream reaches determined by either the critical flow calculator or the SCCWRP screening tools to have a "Low" susceptibility to erosion – and for projects where the minimum outlet orifice criteria does not apply - LID and extended detention flow control facilities should be sized so that the mitigated post project flows and durations do not exceed pre-project flows and durations for the geomorphically-significant flow range of $0.5Q_2$ to Q_{10}.
- Figure 6-3, Node 17 – For all hydromodification mitigation designs, the Decision Matrix includes language regarding drawdown time requirements so that standards set forth by the County's Department of Environmental Health are met. As a side note, the County's Department of Environmental Health has stated that the drawdown requirement would be applied to underground vaults in addition to extended detention basins and the surface ponding areas of LID facilities. Proper maintenance of hydromodification mitigation facilities is essential to guard against potential vector issues as well potential safety issues resulting from long-term standing water. If mitigation facility outlets clog, then runoff will bypass the system and potentially result in additional erosion problems downstream of a site.

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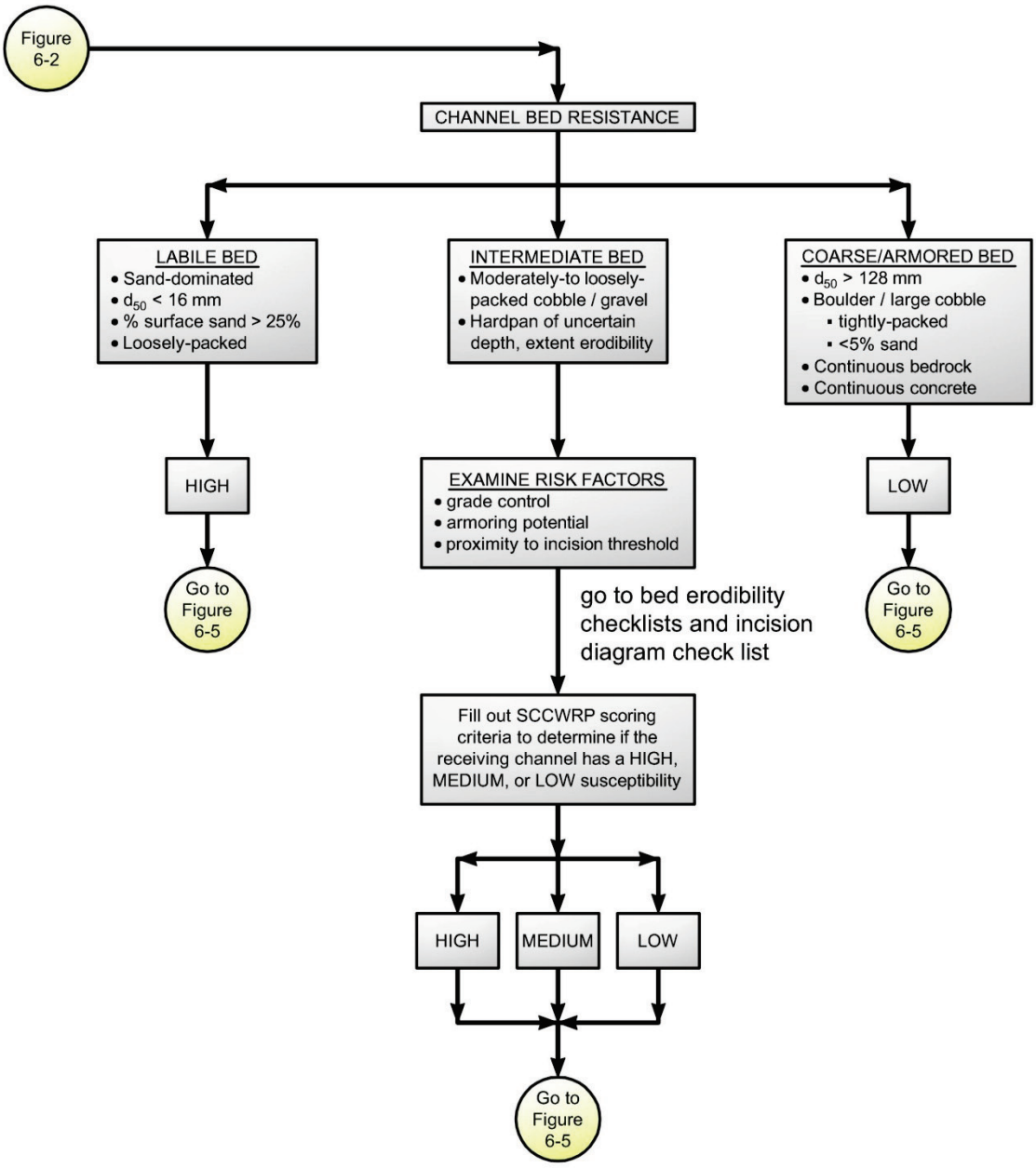

Figure 6-4. SCCWRP Vertical Susceptibility

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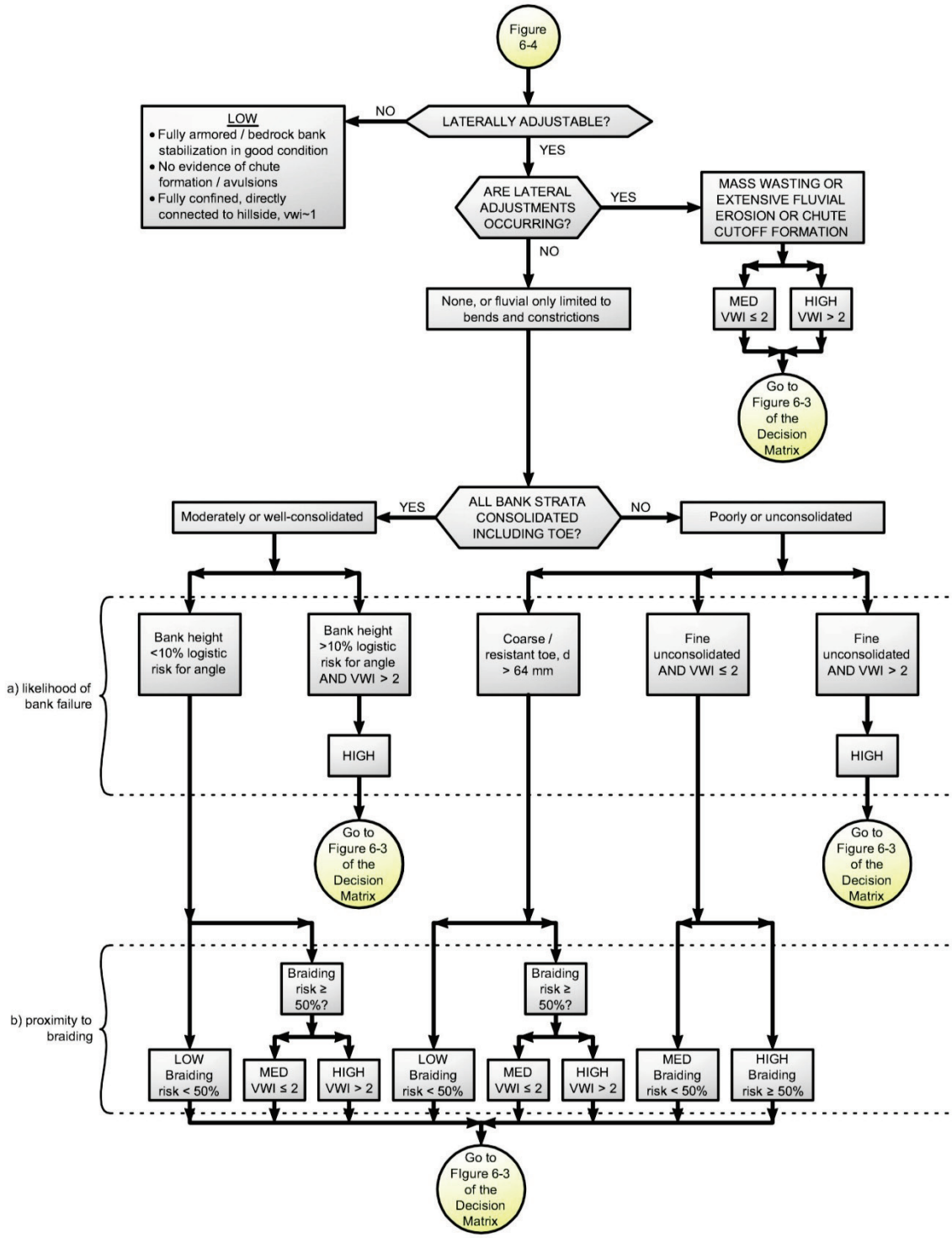

Figure 6-5. Lateral Channel Susceptibility

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A continuous simulation analysis was conducted to identify situations where a 3-inch minimum orifice size standard could be applied. For small sites where orifices less than 3-inches would be required to achieve HMP mitigation, LID implementation is recommended in lieu of extended detention facilities.

The continuous simulation analysis was based on the following assumptions:

Sensitivity Analysis for Minimum Orifice Diameter:

- Prepared HSPF models for 100 and 500 acre undeveloped watersheds – assumed Group D soils with sparse vegetation.
- Prepared simple, parallel HSPF models for 1 and 5 acre developments.
- Added detention ponds to the development models, matching the flow duration curve as much as possible using a 3-inch minimum diameter. For the pond configuration, assumed the ponds are 4 feet deep and contained two outflow control structures (low orifice = 3 inches; high weir to prevent overtopping).
- Ran the undeveloped scenario model simulations and computed the flow duration statistics
- Ran the development scenario model simulations (various levels of development) and computed flow duration statistics.
- Determined the increased level of development that would produce a noticeable difference in the flow duration statistics

The sensitivity analysis showed that cumulative basin outflows from multiple 3-inch outlet orifices from 1- and 5-acre developments would have less than significant cumulative impacts to the watershed's flow duration curve provided the impervious areas in the watershed is less than 10 percent. The supporting HSPF continuous modeling analysis results are summarized in a Technical Memo in Appendix F.

For project sites 1 acre or less in size:

1. HMP mitigation must be attained through the use of LID facilities (because a 3-inch outlet orifice would provide no significant mitigation). If LID facilities cannot fully mitigate flows to meet hydromodification criteria, then small detention facilities can be used in combination with the LID facilities.

For project sites greater than 1 acre and less than 5 acres in size:

1. HMP mitigation should be attained through the use of LID facilities to the maximum extent practicable.
2. A 3-inch minimum outlet orifice size may be used provided that the potential cumulative impacts in the subwatershed area, as measured for the entire sub-watershed (containing the project site) downstream to a natural creek confluence, would not increase the ultimate-condition composite impervious area in the subwatershed to more than 10 percent.

If the potential cumulative impacts in the subwatershed areas would result in an impervious area percentage greater than 10 percent, then the 3-inch minimum orifice size waiver would not be granted.

6.3 Stream Rehabilitation Performance Criteria

If the SCCWRP channel screening tools indicate the existing downstream channel condition has a High susceptibility to erosion, then stream rehabilitation options may be considered. Such mitigation measures must extend downstream to an exempt receiving conveyance system. If such options are chosen as hydromodification mitigation for the project site, then the following criteria must be analyzed.

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- Show that projected increases in runoff peaks and/or durations, along with sediment reductions associated with development, would not accelerate degradation or erosion of rehabilitated receiving stream reaches.
- A proposed stream rehabilitation mitigation measure can accommodate additional runoff from a proposed project, the project proponent may consider implementation of planning measures such as buffers and restoration activities, revegetation, and use of less-impacting facilities at the point of discharge in lieu of implementation of storm water flow controls.
- Such scenarios include the modification of the channel gradient, cross section, or boundary materials to achieve stable conditions in the altered flow regime. Implementation of such measures would require a geomorphic analysis to show that the proposed changes to the stream channel cross sections, vegetation, discharge rates, velocities, and durations would not have adverse impact to the receiving channel's beneficial uses.
- Such measures could not include concrete.
- Such measures must be designed considering the ultimate condition 100-year flows (as well as lower return frequency events) to the rehabilitated channel segment.

The San Diego HMP has a provision for in-channel mitigation as an alternative, or supplement, to flow volume and duration control. In-stream mitigation involves the modification of the receiving channel (primarily by altering its width, depth, slope and channel materials) to accommodate the increased flow following development. The purpose of this section is to outline for applicants and permitees what components should go into designing and implementing an in-channel mitigation program. It is not intended as an exhaustive 'cookery book' approach to designing an instream approach, but to present the principles that should be used to develop a plan. Most projects will require detailed site-specific analyses and approaches and due to differences in scale, channel type and historic condition there is not necessarily a single approach that will be applicable in all sites.

6.3.1 Goal of In-Channel Hydromod Mitigation

The goal of in-channel hydromod mitigation is to modify a receiving channel such that it supports the beneficial uses and physical and ecological functions of the channel to the same extent or greater than it did prior to the proposed development. More specifically it should:

- Be in geomorphic dynamic equilibrium (it is desirable that is should have small amounts of local scour and deposition to support biological processes, but it should not experience significant net erosion or deposition of sediment over the entire reach over a sustained period of several years).
- Provide the appropriate physical processes and forms to sustainably support the flora and fauna that existed prior to development.

A key step in any project will be to define these goals more clearly. In particular, applicants and permitees will need to agree upon whether the goal is to maintain the creek at pre-project conditions or to restore it to a previous, higher level of function. For example, if the existing condition is an incised channel with little ecological value due to historic impacts, there is little value in stabilizing the creek in this condition to accommodate higher future flows, and an alternate goal will be required such as restoring to a previous condition that is more stable.

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6.3.2 Design Principals

Understand Pre-Project Conditions and Potential Project Impacts

All proposed projects must display a clear understanding of the existing physical and ecological condition of the receiving water prior to project implementation. In particular, applicants must identify the ecological functions and values of the existing channel corridor, the physical processes that control or influence them, and the impact of the proposed project on those factors. Table 6-3 provides a hypothetical example but is not intended to be exhaustive.

Identifying the ecological conditions will require the services of a trained riparian and aquatic biologist, while identifying the physical conditions will require a trained geomorphologist or hydrologist. Methods may include field surveys and use of historical documents (maps, aerial photos).

It is important to draw a distinction between 'stability' and 'stasis', and to understand that many ecological functions require a degree of channel disturbance. For example, willow and mulefat assemblages (a common ecotype for many San Diego creeks) require somewhat depositional conditions to form, with alternating periods of sand deposition to create low terraces and subsequent scour and reformation. Many constructed and armored channels are static and do not support the geomorphic functions that underpin these ecological functions.

Table 6-3. Creek Assessment and Mitigation Approaches

Creek Function or Attribute	Current Controlling / Influencing Factors	Project Impacts on Controlling Factors	Potential Mitigation Approach
Vertical channel stability (bed erosion or deposition)	e.g. balance between coarse sediment and water supply, nature of bed materials.	e.g. runoff likely to increase, coarse sediment supply likely to decrease.	Reduce bed gradient using step-pool structures.
Lateral channel stability (e.g. widening, lateral migration)	e.g. vertical stability, riparian vegetation.	e.g. runoff likely to increase, coarse sediment supply likely to decrease.	Widen channel to appropriate geometry and stabilize with biotechnical approaches.
Mulefat assemblage	e.g. requires braided channel with low terraces subject to periodic scour and deposition.	e.g. excess sediment transport capacity over supply will erase terraces and prevent deposition.	Widen channel to lower sediment transport capacity, allow braiding and support terrace formation. Lower gradient to achieve same.
Willow assemblage	e.g. proximity of floodplain to water table.	e.g. incision will lower water table and prevent regeneration.	Prevent incision by grade control, gradient flattening, or channel widening.
Ephemeral vegetation assemblage	e.g. absence of summer nuisance flows.	e.g. presence of summer nuisance flows will allow perennial vegetation to colonize.	Elimination of nuisance flows.
Fish spawning	e.g. presence of gravel, relative absence of fine sediment, relatively low shear stresses during winter/spring flows.	e.g. fine sediment will bury spawning gravel.	Promote sediment sorting and reduce bank erosion or other fine sediment sources.
Fish rearing	e.g. channel complexity, riparian shade cover, relative rarity of high velocity flows.	e.g. excess shear stress will erode and simplify channel features, wash out fish.	Widen and flatten channel to reduce shear stresses.

Design Criteria

In-stream mitigation projects must meet the following design criteria:

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1. The proposed channel and riparian corridor must provide the same acreage of habitat as the pre-project channel and riparian corridor, and should support geomorphic processes that can reasonably be considered to sustain those acreages.
2. The cumulative sediment transport capacity of the proposed channel under the post project flow regime must not exceed that of the pre-project channel under the pre-project flow regime. Sediment transport capacity should be assessed at cross sections along the channel at least every 500 feet (minimum of three cross-sections for channels shorter than 500 feet), with the net proposed sediment transport capacity being equal or less than pre-project net sediment transport capacity, and no individual cross section having a sediment transport capacity more than 10 percent greater than under pre-project conditions.

Proposed plans for in-stream HMP mitigation must demonstrate that these criteria will be met by proving a biological report and maps showing the acreage of habitat in pre-and post project conditions, and by providing hydraulic and sediment transport analyses that show the following:

1. For projects larger than 50 acres the analysis should be based on continuous rainfall-runoff modeling, and continuous sediment transport capacity modeling. The analysis should demonstrate that the cumulative sediment transport capacity in the proposed channel based on the channel dimensions and watershed runoff under post-project conditions is the same or less than the cumulative sediment transport capacity for the existing channel based on the channel dimensions and watershed runoff under pre-project conditions. The period of analysis should be the approved rainfall record for the closest appropriate rain gauge as found on the www.projectcleanwater.org web site.
2. For projects smaller than 50 acres the analysis may be based on sediment transport capacity for a series of designated runoff events. The analysis should demonstrate that the sediment transport capacity in the proposed channel based on the channel dimensions and watershed runoff under post-project conditions is the same or less than the sediment transport capacity for the existing channel based on the channel dimensions and watershed runoff under pre-project conditions for the following events: 0.1Q2, Q2 and Q10.

Methods for performing this analysis are described below.

Matching Pre- and Post-Project Cumulative Sediment Transport Capacity

A key component of any in-channel project will be to quantify and balance the pre- and post-project sediment transport regime in channel that are stable under pre-development conditions, and to lower sediment transport capacity for channels that are unstable under existing conditions. This method is sometimes referred to as the Erosion Potential method. There are several potential tools to assess this and design the channel to meet these goals, but certain principals must be incorporated in whatever approach is used.

For developments larger than 50 acres the analysis must be based on continuous rainfall-runoff modeling, rather than event-based modeling. This is because research has shown that in most urbanized watersheds significant amounts of sediment transport occur during low magnitude, high frequency events (smaller than the two-year flow). Quantification of sediment transport capacity will not capture these processes unless continuous rainfall-runoff simulation is used. Potential models to achieve this include HEC-HMS in continuous mode, SWMM, HSPF, and the San Diego Hydrology Model. Modeling should include at least 40 years of rainfall data from a nearby rain gauge. Modeling should include pre- and post-project conditions. Output (a time series of flow) should be used to quantify pre- and post-project cumulative sediment transport capacity. This can be achieved in several ways, varying from a simple spreadsheet-based sediment transport model to a full one-dimensional hydraulic and sediment transport model such as HEC-RAS (sediment transport module), HEC-6, Fluvial-12, or MIKE-11. The model should simulate the existing and proposed channel morphology in sufficient detail to allow analysis of potential modifications to cross sections and gradient. A hypothetical example is described below.

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A hypothetical analysis might include modeling the existing watershed land use in HEC-HMS and generating a 40-year time series of flow at hourly intervals. This time series would be the input for a HEC-RAS hydraulic and sediment transport model of the existing receiving channel. The time series would be run using a sediment transport equation appropriate to the channel materials, and the cumulative sediment transport capacity over 40 years calculated. The proposed development would then be simulated in HEC-HMS and the 40-year flow output run through a HEC-RAS model of the proposed in-channel mitigation (for example with a lower gradient, in-channel step-pool structures and wider cross section). Cumulative sediment transport capacity would again be calculated. If the proposed channel-with-project cumulative sediment transport capacity was equal to or less than the existing pre-project channel cumulative sediment transport capacity then the channel would have met the sediment transport goals. If the cumulative sediment transport capacity was higher the channel design would have to be refined to lower transport rates or some flow control would be required in the watershed, until the transport capacities either matched or were lower than pre-project condition.

For developments smaller than 50 acres event based analysis may be used. The applicant must calculate the flows for $0.1Q_2$, Q_2 and Q_{10} using continuous rainfall-runoff modeling, and determine the sediment transport capacity using either a sediment transport model or spreadsheet model. If the proposed channel has an equal or lower sediment transport capacity at all three flows it would meet the sediment transport criteria. If it did not the applicant would need to iteratively vary the channel dimensions or manage runoff until the criteria were met.

Methods of Reducing Sediment Transport Capacity

It is highly likely that in a watershed experiencing hydromod without significant flow control the sediment transport capacity will be greatly increased (commonly by a factor of 5 or more for highly developed watersheds) while sediment supply will be reduced. This will likely require a significant modification in channel geometry to bring sediment transport capacity back to pre-project levels. This can be achieved in several ways:

Slope Reduction by Construction of Step-Pools or Roughened Channels

Step-pools are vertical or near vertical sections in a channel profile (step) with a flat section that dissipates the energy of the step (pool). A natural feature of upland creeks, step-pools are sometimes built into creek rehabilitation projects to concentrate bed elevation loss in a small number of hardened areas where erosion is unlikely to occur and allow the remainder of the bed to be designed at a lower gradient that reduces sediment transport capacity. Step-pools can be constructed from uncemented boulders of appropriate size (designed to be stable during design flood events such as the 100-year flow), or from soil cement or other hard materials. The gradient between steps can be designed to match the EP for the pre-project condition without the need for armor, with the difference between the channel's existing and post-project gradient being taken up in vertical steps. Steps should be designed to meet any relevant fish passage and animal migration requirements (e.g., for fish bearing streams steps should be no higher than 3 feet).

Roughened channels are a similar approach where the elevation loss occurs at armored rock reaches typically with a gradient of 10 percent over a few tens of feet (e.g., 3 feet of drop over 30 feet of roughened channel). As with step-pools these are employed between longer reaches of un-armored stable channel at a lower gradient.

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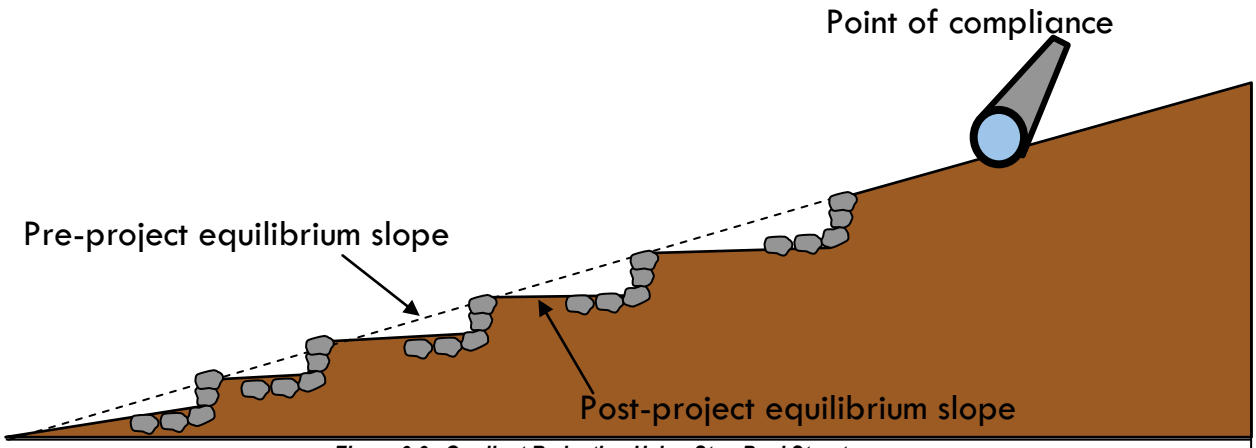

Figure 6-6. Gradient Reduction Using Step-Pool Structures

Slope Reduction by Sinuosity Increase

In some cases small reductions in slope can be achieved by increasing sinuosity (ratio of channel distance between two points to straight line distance). For example, a 30 percent reduction in slope can be achieved by converting a straight receiving channel into a channel with a sinuosity of 1.3 (typical for a meandering channel). However, it is important to understand that channel sinuosity is a dependent variable that is influenced by the valley gradient and the sediment and water regime of the watershed. As a general rule Forcing a channel to a sinuosity that is inappropriately high is likely to lead to subsequent channel avulsion to a straighter course. Channel sinuosity needs to be supported by a geomorphic basis of design that shows the proposed form and gradient to be appropriate for the valley slope and sediment and water regime. This may take the form of reference reaches in similar watersheds that have support the proposed morphology over a significant period of time, or comparison between the proposed form and typical literature values.

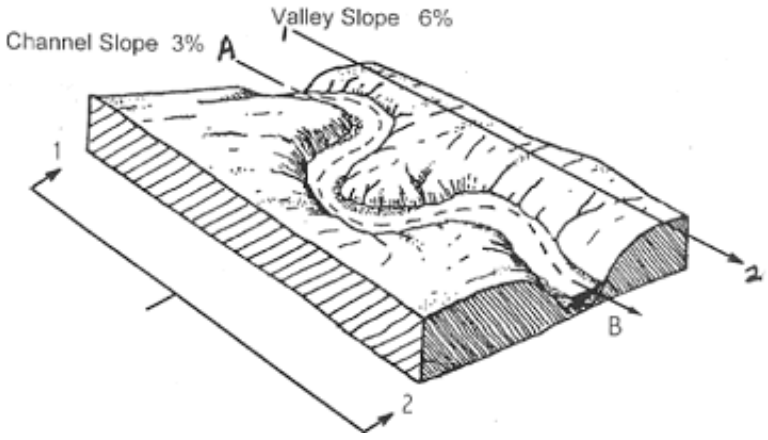

Figure 6-7. Gradient Reduction by Increasing Sinuosity

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Increased Width:Depth Ratio

Sediment transport capacity can be reduced by increasing width:depth ratio for the channel (both low flow channel and floodplain). By spreading flows out over a wider cross section with lower depths, shear stress is reduced for any given flow rate. This approach can be a useful mitigation strategy in incised creeks to bring them back to equilibrium conditions once vertical incision has ceased. However, as with sinuosity, it is important to develop a robust geomorphic basis of design that shows the increase in width:depth ratio to be sustainable. For example, for sand bed channels in watersheds where the coarse sediment supply is greatly reduced by urbanization, low flows may cut into the bed of an over-widened channel, leading to a positive feedback loop of incision and flow concentration. Proposed designs will need to show (using stable analogous reference reaches or analytical methods such as sediment transport analysis) that width:depth ratios are sustainable.

6.3.3 Size Channel for Changed Dominant Discharge

A mitigated channel is likely to consist of a low flow channel that provides the aquatic functions of the pre-project channel, and a floodplain corridor that supports the pre-project riparian functions. The low flow channel should be sized to meet the new dominant discharge of the post-project watershed. In most cases this will be a more frequent event than under pre-development conditions. For example, a low flow channel may accommodate the five year flow under pre-development conditions but be sized for the one-two year flow under developed conditions. For large developments, the EP analysis used to determine cumulative sediment transport capacity will provide the dominant discharge. If EP is plotted as a histogram of sediment transport capacity binned into flow ranges the flow range that produces the highest sediment transport capacity will be the dominant discharge. The floodplain area of the riparian corridor should be designed so as to match the inundation frequencies, areas, and elevations of the pre-project channel.

6.3.4 Upstream and Downstream Limits of In-Channel Mitigation Projects

It is likely that in-channel mitigation projects will have to be negotiated with permitting agencies on a case by case basis due to different site conditions. However, for guideline purposes we recommend the following approach to identifying the limits of in-channel mitigation projects.

The upstream limit of an in-channel mitigation project will typically be the point of compliance (PoC ; point at which stormwater is discharged into the receiving water). However, as a precaution against potential unplanned erosion following a project it is recommended that either the project extend upstream to the next grade control, or that grade control be added immediately upstream of the point of compliance.

The downstream limit of an in-channel project would be the connection to an exempt system (such as the confluence with an exempt river system).

6.3.5 Relationship Between In-Channel HMP Mitigation and Existing Permit Requirements

The HMP does not replace existing permit requirements for in-channel projects. In addition to meeting the HMP requirements, applicants proposing an in-channel mitigation project will likely require the following permits:

- A CEQA/NEPA review and document
- California Department of Fish and Game – 1602 Streambed Alteration Agreement
- US Fish and Wildlife Service – Authorization Under the Endangered Species Act

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- US Army Corps of Engineers – Nationwide 404 Permit
- Regional Water Quality Control Board – 401 Water Quality Certification
- County of San Diego – Grading Permit

These permits have their own requirements that may involve additional studies beyond those described above.

6.4 HMP Design Standards

6.4.1 Introduction

This Technical Memorandum details criteria for the analysis and methodology used to assess mitigation of hydromodification effects. As mandated by Regional Water Quality Control Board (RWQCB) Order R9-2007-0001, San Diego Copermittees must develop criteria for the mitigation of development-related increases to peak flows and flow durations within the geomorphically significant flow range. The purpose of the hydromodification management criteria is to prevent development-related changes in storm water runoff from causing, or further accelerating, stream channel erosion or other adverse impacts to beneficial stream uses.

Three specific areas are discussed in this memorandum.

- Partial Duration Series Calculations
- Drawdown Calculations
- Offsite Area Restrictions

Information contained in this memorandum will be incorporated into a Final Technical Reference Document in support of the final HMP document.

6.4.2 Partial Duration Series Calculations

Preliminary review of continuous simulation hydrologic analyses prepared for multiple project sites throughout the County of San Diego indicates the need for partial duration series calculations to determine estimated return flow frequencies. Because of San Diego's semi-arid climate, in which long periods of time can elapse between significant rainfall events, use of the peak annual series tends to unrealistically underestimate flow return event values (since only the peak event in any given year is considered in the analysis). This effect is particularly pronounced for more frequent return events such as the 2-year flow and the 5-year flow (note: the 2-year flow is the runoff rate which statistically has a 50 percent chance of occurrence in any given year). The partial duration series calculations consider all significant rainfall events in the long-term rainfall record (which for the San Diego area corresponds to a minimum historical record of hourly rainfall totals for 35 years).

This partial duration series data provided below were prepared based on a sample project in south San Diego County. Using the Lower Otay Reservoir rainfall gauge as the historical rainfall record, the subsequent commentary shows how a partial duration series analysis should be conducted to estimate peak runoff rates for frequencies of 2-, 5-, and 10-year recurrence given hydrologic modeling results for hypothetical Basins A, B, C and D.

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6.4.3 Data

Four modeling files, corresponding to Basins A, B, C and D from a proposed development project, were prepared using the HSPF hydrologic modeling software. Relevant time series were output to WDM files, which were named for the modeled basin (e.g., *Basin A.wdm*). Two land use conditions were generated:

- Pre-developed flow in cubic feet per second (cfs)
- Post-developed (unmitigated) flow in cfs

Given two flow scenarios (above) and four basins, a total of 8 sets of time series data were identified for flow frequency analysis. Plots of these flow data are included later in this document.

6.4.4 Analysis

Each of the 8 time series data files described in the previous section were exported from the WDM file using *WDM Util*. The exported files were then imported into MatLAB and a previously developed script was used to convert the complete duration-time series to a partial duration time series using the criteria shown in Table 6-4 below.

The previously developed partial duration script was developed in association with development of the Contra Costa HMP / LID Sizing Tool, which was approved by the San Francisco Regional Water Quality Control Board for review of project-specific hydromodification plans (*Contra Costa Hydromodification Management Plan* - May 15, 2005). Similar methodology is included in the San Diego HMP / LID Sizing Calculator.

Table 6-4. Partial Duration Series Criteria

Basin and Scenario		Separation Event (hours)	Flow Floor (cfs)	Number of Events
Basin A	Pre-developed	24	0.1	357
	Post-developed (unmitigated)	24	0.1	620
Basin B	Pre-developed	24	0.01	63
	Post-developed (unmitigated)	24	0.1	540
Basin C	Pre-developed	24	0.01	73
	Post-developed (unmitigated)	24	0.1	535
Basin D	Pre-developed	24	0.1	104
	Post-developed (unmitigated)	24	0.1	558

The columns listed in Table 6-4 describe criteria detailed below.

- A separation event, defined as time period in which runoff does not exceed a prescribed threshold, is required to parse the long-term flow records into discrete runoff events. The separation event corresponds to the required number of consecutive time intervals (hours in this case because the long-term rainfall records were prepared in hourly time steps) with a flow value less than Flow Floor 1 (which is calculated as an artificially low flow value based on a fraction of the contributing watershed areas – for instance, the flow floor could correspond to ratios in the range of 0.002 cfs/acre to 0.005 cfs/acre).
- Flow Floor 1 is the maximum value for the inter-event time period (allows for separation of events). In other words, if no flow value exceeds the Flow Floor 1 value for a time equal to or greater than the Separation Event, then the preceding runoff event is viewed as a discrete runoff event. Flow Floor 1 is typically set as an artificially low flow value based on a fraction of the contributing watershed area.

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- Flow Floor 1 is also the minimum value for the rainfall event. In other words, if no flow value in the event exceeds Flow Floor 1, then the minor runoff is not considered a discrete runoff event.
- Number of events corresponds to the total number of discrete runoff events generated for the long-term rainfall record. As noted in Table 6-4 and graphically depicted in the figures at the end of this section, impervious area addition associated with development dramatically increases the number of discrete runoff events for the sample basins.

The partial duration series data were ranked and the plotted using the Cunnane equation for plotting return frequency. The Cunnane equation documentation can be referenced in the "Handbook of Hydrology" by David R. Maidment, published in 1994 (Table 18.3.1).

6.4.5 Results

Flow frequency plots are included later in this document. Flow frequency estimates were obtained from these plots for the 2-, 5-, and 10-year recurrence intervals. The results are summarized in Table 6-5.

Table 6-5. Flow Frequency by Partial Duration Series Analysis

Basin and Scenario		Peak Runoff (cfs) by Recurrence Interval		
		2-year	5-year	10-year
Basin A	Pre-developed	1.2	3.1	6.3
	Post-developed (Unmitigated)	4.8	6.9	8.8
Basin B	Pre-developed	0.2	0.6	1.2
	Post-developed (Unmitigated)	1.2	2.0	2.4
Basin C	Pre-developed	0.2	0.9	1.8
	Post-developed (Unmitigated)	1.5	2.5	3.0
Basin D	Pre-developed	0.5	1.2	2.5
	Post-developed (Unmitigated)	1.4	2.0	2.5

As shown in Figures 6-8 and 6-9, impervious area increases associated with proposed development dramatically increases the frequency and intensity of flows throughout the rainfall record. While the scenario modeled above depicts a worst-case scenario where undeveloped land is converted to highly impervious industrial land, similar but less pronounced increases to flow frequency and peak flows would be expected for other development types. The degree of change is dependent on the degree of impervious areas and landform modification.

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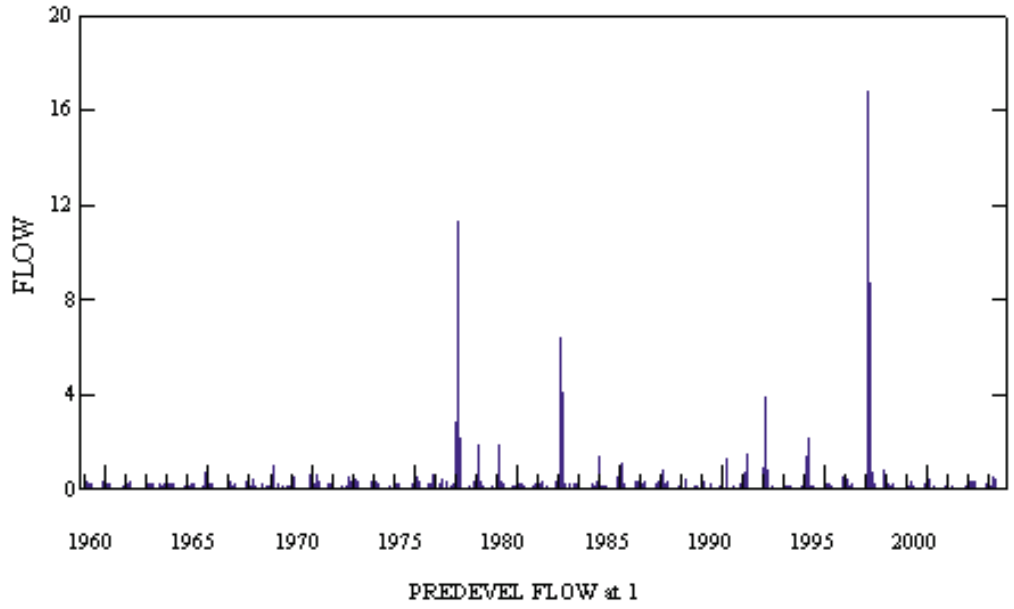

Figure 6-8. Pre-Developed Flow Time Series for Basin A

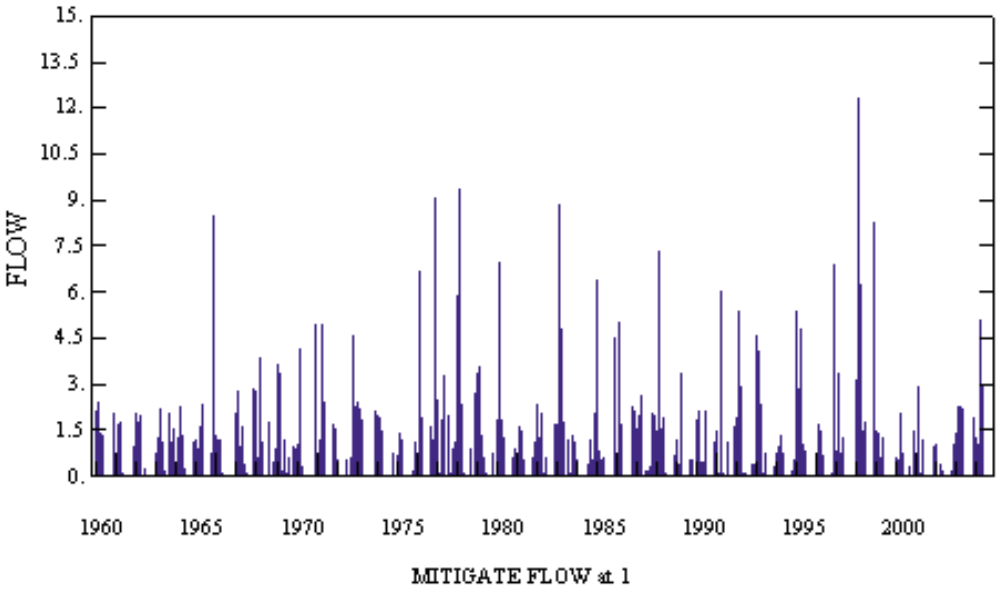

Figure 6-9. Post-Developed (unmitigated) Flow Time Series for Basin A

As shown in Figures 6-10 and 6-11, increases in impervious areas associated with development create a significant flow regime change for the full range of flows. These changes are most pronounced for frequent flow events. As detailed on the figures, development would increase the 1-year pre-project flow of 0.5 cfs to a 1-year post-project flow of 3.0 cfs. At the 5-year event, the pre-project flow is 3 cfs while the post-project flow increases to 7 cfs. At the 10-year event, the pre-project is 6.5 cfs while the post-project flow is 9 cfs.

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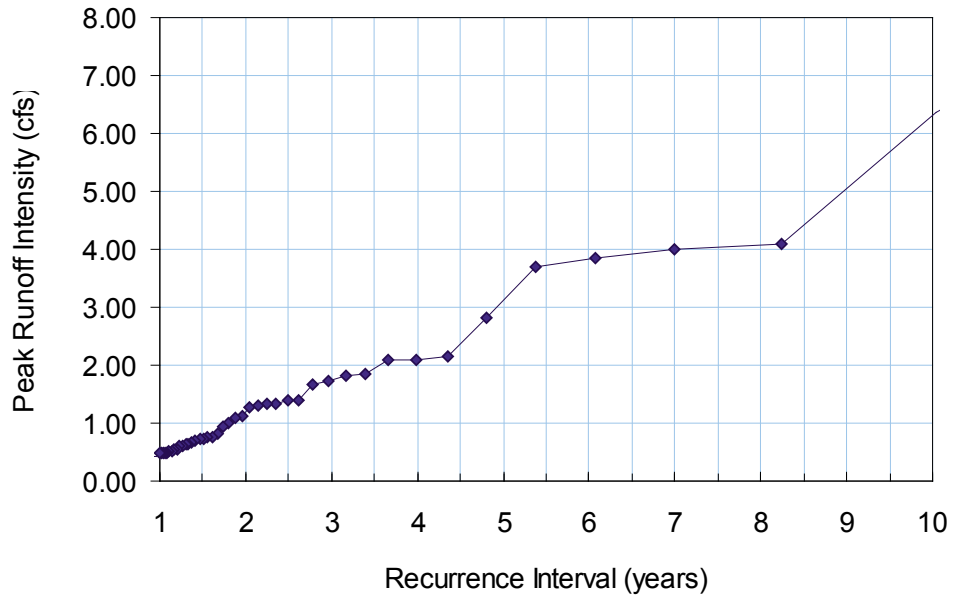

Figure 6-10. Pre-Developed Flow Frequency Basin A

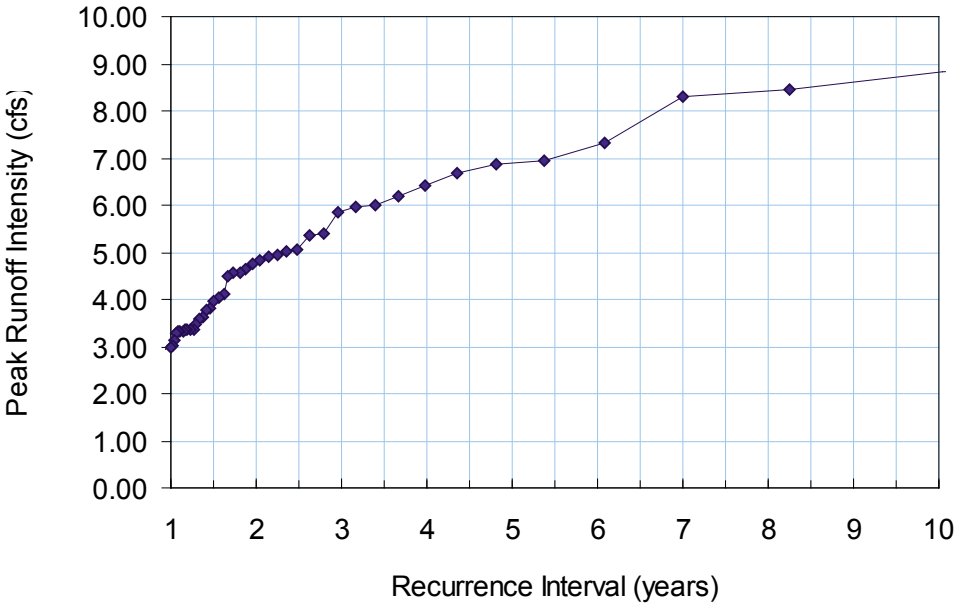

Figure 6-11. Post-Developed (Unmitigated) Flow Frequency Basin A

6.4.6 Drawdown Calculations

Per instruction from the County of San Diego's Department of Environmental Health (DEH), the drawdown time in hydromodification flow control facilities, as well as other flow control facilities such as peak flow attenuation detention basins and water quality extended detention basins, shall be limited to 96 hours. This restriction was implemented as mitigation to potential vector breeding issues and the subsequent risk to human health. The standard applies to, but is not limited to, the following flow control facilities:

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- Detention basins (extended detention and peak flow attenuation)
- Underground storage vaults
- Above-ground storage area in LID facilities

As is the case for peak flow attenuation detention basins and water quality extended detention basins, the drawdown time for hydromodification flow control facilities can be calculated by assuming a starting water surface elevation coincident with the peak operating level in the facility (such as the elevation at the riser overflow or emergency spillway overflow).

Using a hydrologic computer program such HEC-HMS or other public domain software, the basin's dewatering time can be determined given the basin's stage-storage and stage-discharge information. Provided that the basin has completely dewatered after 96 hours, the basin is considered to meet the drawdown criteria.

If an applicant cannot achieve the 96-hour drawdown requirement, a vector management plan may be an acceptable alternative if approved by the governing municipality.

For extended detention flow control facilities, protective fencing may be required to address safety concerns associated with the extended duration of ponded water. Specifications regarding protective fencing requirements will be determined by each individual Copermittee. If a riser is installed in the basin, it is assumed that flows would exit the basin via a small orifice or a series of orifices cut into the side of the riser. To prevent clogging, debris capture devices should be designed to protect the principal outflow orifice. Failure to prevent clogging could actually make downstream erosion problems worse, since basin inflows would simply overtop the riser and flow unattenuated downstream.

6.4.7 Offsite Area Restrictions

Runoff from offsite areas should be routed around hydromodification flow control facilities. This is required because of the following:

- Offsite areas containing sediment should be allowed to pass to the receiving channel to maintain the natural sediment balance in the receiving conveyance system. This is especially true when the offsite area contains significant loads of coarse sediment. Capture and removal of natural sediment from the downstream watercourse can create "hungry water" conditions and the increased potential for downstream erosion. The "hungry water" phenomenon occurs when the natural sediment load decreases and the erosive force of the runoff increases as a natural counterbalance, as described by Lane's Equation.
- The addition of runoff from offsite areas to a hydromodification flow control facility increases the total runoff volume to the basin, which increases the required water quality treatment volume as well as the hydromodification and peak flow attenuation design peak inflows to the basin.

If geometric constraints prohibit the rerouting of flows around a hydromodification flow control facility, then a detailed description of the constraints should be submitted to the governing municipality. Methods to route flows around flow control facilities include the addition of parallel storm drain systems and by simply designing the site to avoid natural drainage courses. It is assumed that off-site runoff would be separated from site runoff. If this is not the case, then the governing municipality should be consulted to further refine the points of compliance for the site (an interior project site point of compliance could be required in such a scenario).

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7. SELECTION AND IMPLEMENTATION OF BMPS

7.1 BMP Selection Criteria

As detailed in Permit Section D.1.d(4), LID BMPs should be implemented where feasible. Selection of the appropriate flow control treatment device will depend on the susceptibility of the receiving channel, geologic conditions in the area surrounding the proposed mitigation facility, impacts of the proposed development, and water quality sensitivity of the receiving streams.

Use of LID BMPs minimizes the impacts of urban runoff discharges to receiving waters by collectively minimizing directly connected impervious areas. By directing urban runoff to landscaped areas, LID BMPs help restore the pre-development condition hydrologic cycle of the site, allowing for filtration and infiltration of urban runoff which can significantly reduce post-development peak runoff rates, velocities, volumes, and pollutant loadings in urban runoff.

The San Diego HMP encourages the use of LID facilities for the dual treatment of the 85th percentile water quality event as well as hydromodification mitigation flow control. When LID facilities are used for both functions, they are known as Integrated Management Practices.

Unless specifically deemed infeasible, LID practices are encouraged to be implemented on the vast majority of proposed development sites to meet hydromodification criteria. Defining the infiltration potential of a site is recommended to provide for sound engineering design. In some cases, infiltration to native soils may not be feasible. These situations include the following:

- Underlying native soils with very low infiltration rates (clay soils, etc.)
- Lenses beneath soil layers that cause lateral migration of flows
- Potential for structural foundation or roadway damage from infiltrated runoff
- High groundwater table

Even if infiltration is shown to be infeasible, LID facilities can be designed as filtration-type or evaporation-type facilities instead of infiltration-based facilities. Filtration type facilities, such as bioretention basins, can be implemented through the use of amended soils. In some cases, LID approaches may need to be implemented in series or in combination with an extended detention type approach to satisfy vector control and hydromodification criteria.

To assure compliance with hydromodification flow control requirements, design criteria and specifications have been provided in the San Diego Model SUSMP for a variety of LID-based flow control methods including the following:

- Bioretention basins
- Flow-through planter boxes
- Infiltration facilities
- Bioretention in series with a cistern
- Bioretention in series with an underground vault
- Self-retaining areas.

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Sizing factors have been developed by the consultant team through the use of continuous simulation hydrologic modeling and these factors will be built into the San Diego LID/HMP Sizing Calculator to assist with HMP implementation. Sizing factors are ratios of the required mitigation size (in area or volume) as compared to the contributing developed area. The same concepts used to develop sizing factors in Contra Costa County are being used to develop sizing factors based on conditions in the San Diego area. Tables 7-1 through 7-5 detail sizing factors which have been determined to ensure compliance with peak flow and flow duration criteria as outlined in this HMP.

Table 7-1. Sizing Factors for Bioretention Facilities

Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
$0.5Q_2$	A	Flat	Lindbergh	0.060	0.0500	N/A
$0.5Q_2$	A	Moderate	Lindbergh	0.055	0.0458	N/A
$0.5Q_2$	A	Steep	Lindbergh	0.045	0.0375	N/A
$0.5Q_2$	B	Flat	Lindbergh	0.093	0.0771	N/A
$0.5Q_2$	B	Moderate	Lindbergh	0.085	0.0708	N/A
$0.5Q_2$	B	Steep	Lindbergh	0.065	0.0542	N/A
$0.5Q_2$	C	Flat	Lindbergh	0.100	0.0833	0.0600
$0.5Q_2$	C	Moderate	Lindbergh	0.100	0.0833	0.0600
$0.5Q_2$	C	Steep	Lindbergh	0.075	0.0625	0.0450
$0.5Q_2$	D	Flat	Lindbergh	0.080	0.0667	0.0480
$0.5Q_2$	D	Moderate	Lindbergh	0.080	0.0667	0.0480
$0.5Q_2$	D	Steep	Lindbergh	0.060	0.0500	0.0360
$0.5Q_2$	A	Flat	Oceanside	0.070	0.0583	N/A
$0.5Q_2$	A	Moderate	Oceanside	0.065	0.0542	N/A
$0.5Q_2$	A	Steep	Oceanside	0.060	0.0500	N/A
$0.5Q_2$	B	Flat	Oceanside	0.098	0.0813	N/A
$0.5Q_2$	B	Moderate	Oceanside	0.090	0.0750	N/A
$0.5Q_2$	B	Steep	Oceanside	0.075	0.0625	N/A
$0.5Q_2$	C	Flat	Oceanside	0.075	0.0625	0.0450
$0.5Q_2$	C	Moderate	Oceanside	0.075	0.0625	0.0450
$0.5Q_2$	C	Steep	Oceanside	0.060	0.0500	0.0360
$0.5Q_2$	D	Flat	Oceanside	0.065	0.0542	0.0390
$0.5Q_2$	D	Moderate	Oceanside	0.065	0.0542	0.0390
$0.5Q_2$	D	Steep	Oceanside	0.050	0.0417	0.0300
$0.5Q_2$	A	Flat	L Wohlford	0.050	0.0417	N/A
$0.5Q_2$	A	Moderate	L Wohlford	0.045	0.0375	N/A
$0.5Q_2$	A	Steep	L Wohlford	0.040	0.0333	N/A
$0.5Q_2$	B	Flat	L Wohlford	0.048	0.0396	N/A
$0.5Q_2$	B	Moderate	L Wohlford	0.045	0.0375	N/A
$0.5Q_2$	B	Steep	L Wohlford	0.040	0.0333	N/A

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Table 7-1. Sizing Factors for Bioretention Facilities						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
$0.5Q_2$	C	Flat	L Wohlford	0.065	0.0542	0.0390
$0.5Q_2$	C	Moderate	L Wohlford	0.065	0.0542	0.0390
$0.5Q_2$	C	Steep	L Wohlford	0.050	0.0417	0.0300
$0.5Q_2$	D	Flat	L Wohlford	0.055	0.0458	0.0330
$0.5Q_2$	D	Moderate	L Wohlford	0.055	0.0458	0.0330
$0.5Q_2$	D	Steep	L Wohlford	0.045	0.0375	0.0270
$0.3Q_2$	A	Flat	Lindbergh	0.060	0.0500	N/A
$0.3Q_2$	A	Moderate	Lindbergh	0.055	0.0458	N/A
$0.3Q_2$	A	Steep	Lindbergh	0.045	0.0375	N/A
$0.3Q_2$	B	Flat	Lindbergh	0.098	0.0813	N/A
$0.3Q_2$	B	Moderate	Lindbergh	0.090	0.0750	N/A
$0.3Q_2$	B	Steep	Lindbergh	0.070	0.0583	N/A
$0.3Q_2$	C	Flat	Lindbergh	0.110	0.0917	0.0660
$0.3Q_2$	C	Moderate	Lindbergh	0.110	0.0917	0.0660
$0.3Q_2$	C	Steep	Lindbergh	0.085	0.0708	0.0510
$0.3Q_2$	D	Flat	Lindbergh	0.100	0.0833	0.0600
$0.3Q_2$	D	Moderate	Lindbergh	0.100	0.0833	0.0600
$0.3Q_2$	D	Steep	Lindbergh	0.070	0.0583	0.0420
$0.3Q_2$	A	Flat	Oceanside	0.070	0.0583	N/A
$0.3Q_2$	A	Moderate	Oceanside	0.065	0.0542	N/A
$0.3Q_2$	A	Steep	Oceanside	0.060	0.0500	N/A
$0.3Q_2$	B	Flat	Oceanside	0.098	0.0813	N/A
$0.3Q_2$	B	Moderate	Oceanside	0.090	0.0750	N/A
$0.3Q_2$	B	Steep	Oceanside	0.075	0.0625	N/A
$0.3Q_2$	C	Flat	Oceanside	0.100	0.0833	0.0600
$0.3Q_2$	C	Moderate	Oceanside	0.100	0.0833	0.0600
$0.3Q_2$	C	Steep	Oceanside	0.080	0.0667	0.0480
$0.3Q_2$	D	Flat	Oceanside	0.085	0.0708	0.0510
$0.3Q_2$	D	Moderate	Oceanside	0.085	0.0708	0.0510
$0.3Q_2$	D	Steep	Oceanside	0.065	0.0542	0.0390
$0.3Q_2$	A	Flat	L Wohlford	0.050	0.0417	N/A
$0.3Q_2$	A	Moderate	L Wohlford	0.045	0.0375	N/A
$0.3Q_2$	A	Steep	L Wohlford	0.040	0.0333	N/A
$0.3Q_2$	B	Flat	L Wohlford	0.060	0.0500	N/A
$0.3Q_2$	B	Moderate	L Wohlford	0.055	0.0458	N/A
$0.3Q_2$	B	Steep	L Wohlford	0.045	0.0375	N/A
$0.3Q_2$	C	Flat	L Wohlford	0.075	0.0625	0.0450

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Table 7-1. Sizing Factors for Bioretention Facilities						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
$0.3Q_2$	C	Moderate	L Wohlford	0.075	0.0625	0.0450
$0.3Q_2$	C	Steep	L Wohlford	0.060	0.0500	0.0360
$0.3Q_2$	D	Flat	L Wohlford	0.065	0.0542	0.0390
$0.3Q_2$	D	Moderate	L Wohlford	0.065	0.0542	0.0390
$0.3Q_2$	D	Steep	L Wohlford	0.050	0.0417	0.0300
$0.1Q_2$	A	Flat	Lindbergh	0.060	0.0500	N/A
$0.1Q_2$	A	Moderate	Lindbergh	0.055	0.0458	N/A
$0.1Q_2$	A	Steep	Lindbergh	0.045	0.0375	N/A
$0.1Q_2$	B	Flat	Lindbergh	0.100	0.0833	N/A
$0.1Q_2$	B	Moderate	Lindbergh	0.095	0.0792	N/A
$0.1Q_2$	B	Steep	Lindbergh	0.080	0.0667	N/A
$0.1Q_2$	C	Flat	Lindbergh	0.145	0.1208	0.0870
$0.1Q_2$	C	Moderate	Lindbergh	0.145	0.1208	0.0870
$0.1Q_2$	C	Steep	Lindbergh	0.120	0.1000	0.0720
$0.1Q_2$	D	Flat	Lindbergh	0.160	0.1333	0.0960
$0.1Q_2$	D	Moderate	Lindbergh	0.160	0.1333	0.0960
$0.1Q_2$	D	Steep	Lindbergh	0.115	0.0958	0.0690
$0.1Q_2$	A	Flat	Oceanside	0.070	0.0583	N/A
$0.1Q_2$	A	Moderate	Oceanside	0.065	0.0542	N/A
$0.1Q_2$	A	Steep	Oceanside	0.060	0.0500	N/A
$0.1Q_2$	B	Flat	Oceanside	0.103	0.0854	N/A
$0.1Q_2$	B	Moderate	Oceanside	0.090	0.0750	N/A
$0.1Q_2$	B	Steep	Oceanside	0.075	0.0625	N/A
$0.1Q_2$	C	Flat	Oceanside	0.130	0.1083	0.0780
$0.1Q_2$	C	Moderate	Oceanside	0.130	0.1083	0.0780
$0.1Q_2$	C	Steep	Oceanside	0.110	0.0917	0.0660
$0.1Q_2$	D	Flat	Oceanside	0.130	0.1083	0.0780
$0.1Q_2$	D	Moderate	Oceanside	0.130	0.1083	0.0780
$0.1Q_2$	D	Steep	Oceanside	0.065	0.0542	0.0390
$0.1Q_2$	A	Flat	L Wohlford	0.050	0.0417	N/A
$0.1Q_2$	A	Moderate	L Wohlford	0.045	0.0375	N/A
$0.1Q_2$	A	Steep	L Wohlford	0.040	0.0333	N/A
$0.1Q_2$	B	Flat	L Wohlford	0.090	0.0750	N/A
$0.1Q_2$	B	Moderate	L Wohlford	0.085	0.0708	N/A
$0.1Q_2$	B	Steep	L Wohlford	0.065	0.0542	N/A
$0.1Q_2$	C	Flat	L Wohlford	0.110	0.0917	0.0660
$0.1Q_2$	C	Moderate	L Wohlford	0.110	0.0917	0.0660

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Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
$0.1Q_2$	C	Steep	L Wohlford	0.090	0.0750	0.0540
$0.1Q_2$	D	Flat	L Wohlford	0.100	0.0833	0.0600
$0.1Q_2$	D	Moderate	L Wohlford	0.100	0.0833	0.0600
$0.1Q_2$	D	Steep	L Wohlford	0.075	0.0625	0.0450

Q_2 = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records
Q_{10} = 10-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records
A = Surface area sizing factor
V_1 = Surface volume sizing factor
V_2 = Subsurface volume sizing factor

Table 7-2. Sizing Factors for Bioretention Plus Cistern Facilities						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
$0.5Q_2$	A	Flat	Lindbergh	0.020	0.1200	N/A
$0.5Q_2$	A	Moderate	Lindbergh	0.020	0.1000	N/A
$0.5Q_2$	A	Steep	Lindbergh	0.020	0.1000	N/A
$0.5Q_2$	B	Flat	Lindbergh	0.020	0.3900	N/A
$0.5Q_2$	B	Moderate	Lindbergh	0.020	0.2000	N/A
$0.5Q_2$	B	Steep	Lindbergh	0.020	0.1200	N/A
$0.5Q_2$	C	Flat	Lindbergh	0.020	0.1200	N/A
$0.5Q_2$	C	Moderate	Lindbergh	0.020	0.1200	N/A
$0.5Q_2$	C	Steep	Lindbergh	0.020	0.1000	N/A
$0.5Q_2$	D	Flat	Lindbergh	0.020	0.1000	N/A
$0.5Q_2$	D	Moderate	Lindbergh	0.020	0.1000	N/A
$0.5Q_2$	D	Steep	Lindbergh	0.030	0.0800	N/A
$0.5Q_2$	A	Flat	Oceanside	0.020	0.1600	N/A
$0.5Q_2$	A	Moderate	Oceanside	0.020	0.1400	N/A
$0.5Q_2$	A	Steep	Oceanside	0.030	0.1200	N/A
$0.5Q_2$	B	Flat	Oceanside	0.020	0.1900	N/A
$0.5Q_2$	B	Moderate	Oceanside	0.025	0.1600	N/A
$0.5Q_2$	B	Steep	Oceanside	0.035	0.1400	N/A
$0.5Q_2$	C	Flat	Oceanside	0.030	0.1400	N/A
$0.5Q_2$	C	Moderate	Oceanside	0.035	0.1400	N/A
$0.5Q_2$	C	Steep	Oceanside	0.040	0.1200	N/A
$0.5Q_2$	D	Flat	Oceanside	0.035	0.1200	N/A
$0.5Q_2$	D	Moderate	Oceanside	0.040	0.1200	N/A
$0.5Q_2$	D	Steep	Oceanside	0.040	0.1000	N/A
$0.5Q_2$	A	Flat	L Wohlford	0.025	0.1800	N/A
$0.5Q_2$	A	Moderate	L Wohlford	0.040	0.1400	N/A

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Table 7-2. Sizing Factors for Bioretention Plus Cistern Facilities						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
$0.5Q_2$	A	Steep	L Wohlford	0.040	0.0800	N/A
$0.5Q_2$	B	Flat	L Wohlford	0.040	0.2100	N/A
$0.5Q_2$	B	Moderate	L Wohlford	0.040	0.2000	N/A
$0.5Q_2$	B	Steep	L Wohlford	0.040	0.1400	N/A
$0.5Q_2$	C	Flat	L Wohlford	0.040	0.1400	N/A
$0.5Q_2$	C	Moderate	L Wohlford	0.040	0.1400	N/A
$0.5Q_2$	C	Steep	L Wohlford	0.040	0.1000	N/A
$0.5Q_2$	D	Flat	L Wohlford	0.040	0.1000	N/A
$0.5Q_2$	D	Moderate	L Wohlford	0.040	0.1000	N/A
$0.5Q_2$	D	Steep	L Wohlford	0.040	0.0800	N/A
$0.3Q_2$	A	Flat	Lindbergh	0.020	0.1200	N/A
$0.3Q_2$	A	Moderate	Lindbergh	0.020	0.1000	N/A
$0.3Q_2$	A	Steep	Lindbergh	0.020	0.1000	N/A
$0.3Q_2$	B	Flat	Lindbergh	0.020	0.5900	N/A
$0.3Q_2$	B	Moderate	Lindbergh	0.020	0.3600	N/A
$0.3Q_2$	B	Steep	Lindbergh	0.020	0.1800	N/A
$0.3Q_2$	C	Flat	Lindbergh	0.020	0.1800	N/A
$0.3Q_2$	C	Moderate	Lindbergh	0.020	0.1800	N/A
$0.3Q_2$	C	Steep	Lindbergh	0.020	0.1400	N/A
$0.3Q_2$	D	Flat	Lindbergh	0.020	0.1400	N/A
$0.3Q_2$	D	Moderate	Lindbergh	0.020	0.1400	N/A
$0.3Q_2$	D	Steep	Lindbergh	0.020	0.0800	N/A
$0.3Q_2$	A	Flat	Oceanside	0.020	0.1600	N/A
$0.3Q_2$	A	Moderate	Oceanside	0.020	0.1400	N/A
$0.3Q_2$	A	Steep	Oceanside	0.020	0.1200	N/A
$0.3Q_2$	B	Flat	Oceanside	0.020	0.2200	N/A
$0.3Q_2$	B	Moderate	Oceanside	0.020	0.1800	N/A
$0.3Q_2$	B	Steep	Oceanside	0.020	0.1600	N/A
$0.3Q_2$	C	Flat	Oceanside	0.020	0.1600	N/A
$0.3Q_2$	C	Moderate	Oceanside	0.020	0.1600	N/A
$0.3Q_2$	C	Steep	Oceanside	0.025	0.1400	N/A
$0.3Q_2$	D	Flat	Oceanside	0.020	0.1400	N/A
$0.3Q_2$	D	Moderate	Oceanside	0.025	0.1400	N/A
$0.3Q_2$	D	Steep	Oceanside	0.030	0.1200	N/A
$0.3Q_2$	A	Flat	L Wohlford	0.020	0.1800	N/A
$0.3Q_2$	A	Moderate	L Wohlford	0.025	0.1400	N/A
$0.3Q_2$	A	Steep	L Wohlford	0.030	0.0800	N/A

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Table 7-2. Sizing Factors for Bioretention Plus Cistern Facilities						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
$0.3Q_2$	B	Flat	L Wohlford	0.025	0.2600	N/A
$0.3Q_2$	B	Moderate	L Wohlford	0.025	0.2400	N/A
$0.3Q_2$	B	Steep	L Wohlford	0.030	0.1800	N/A
$0.3Q_2$	C	Flat	L Wohlford	0.030	0.1800	N/A
$0.3Q_2$	C	Moderate	L Wohlford	0.030	0.1800	N/A
$0.3Q_2$	C	Steep	L Wohlford	0.035	0.1400	N/A
$0.3Q_2$	D	Flat	L Wohlford	0.030	0.1400	N/A
$0.3Q_2$	D	Moderate	L Wohlford	0.035	0.1400	N/A
$0.3Q_2$	D	Steep	L Wohlford	0.040	0.1000	N/A
$0.1Q_2$	A	Flat	Lindbergh	0.020	0.1200	N/A
$0.1Q_2$	A	Moderate	Lindbergh	0.020	0.1000	N/A
$0.1Q_2$	A	Steep	Lindbergh	0.020	0.1000	N/A
$0.1Q_2$	B	Flat	Lindbergh	0.020	0.5400	N/A
$0.1Q_2$	B	Moderate	Lindbergh	0.020	0.7800	N/A
$0.1Q_2$	B	Steep	Lindbergh	0.020	0.3400	N/A
$0.1Q_2$	C	Flat	Lindbergh	0.020	0.3600	N/A
$0.1Q_2$	C	Moderate	Lindbergh	0.020	0.3600	N/A
$0.1Q_2$	C	Steep	Lindbergh	0.020	0.2400	N/A
$0.1Q_2$	D	Flat	Lindbergh	0.020	0.2600	N/A
$0.1Q_2$	D	Moderate	Lindbergh	0.020	0.2600	N/A
$0.1Q_2$	D	Steep	Lindbergh	0.020	0.1600	N/A
$0.1Q_2$	A	Flat	Oceanside	0.020	0.1600	N/A
$0.1Q_2$	A	Moderate	Oceanside	0.020	0.1400	N/A
$0.1Q_2$	A	Steep	Oceanside	0.020	0.1200	N/A
$0.1Q_2$	B	Flat	Oceanside	0.020	0.5100	N/A
$0.1Q_2$	B	Moderate	Oceanside	0.020	0.3400	N/A
$0.1Q_2$	B	Steep	Oceanside	0.020	0.2400	N/A
$0.1Q_2$	C	Flat	Oceanside	0.020	0.2600	N/A
$0.1Q_2$	C	Moderate	Oceanside	0.020	0.2600	N/A
$0.1Q_2$	C	Steep	Oceanside	0.020	0.2000	N/A
$0.1Q_2$	D	Flat	Oceanside	0.020	0.2000	N/A
$0.1Q_2$	D	Moderate	Oceanside	0.020	0.2000	N/A
$0.1Q_2$	D	Steep	Oceanside	0.020	0.1800	N/A
$0.1Q_2$	A	Flat	L Wohlford	0.020	0.1800	N/A
$0.1Q_2$	A	Moderate	L Wohlford	0.020	0.1400	N/A
$0.1Q_2$	A	Steep	L Wohlford	0.020	0.0800	N/A
$0.1Q_2$	B	Flat	L Wohlford	0.020	0.4400	N/A

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Table 7-2. Sizing Factors for Bioretention Plus Cistern Facilities						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
$0.1Q_2$	B	Moderate	L Wohlford	0.020	0.4000	N/A
$0.1Q_2$	B	Steep	L Wohlford	0.020	0.3200	N/A
$0.1Q_2$	C	Flat	L Wohlford	0.020	0.3200	N/A
$0.1Q_2$	C	Moderate	L Wohlford	0.020	0.3200	N/A
$0.1Q_2$	C	Steep	L Wohlford	0.020	0.2200	N/A
$0.1Q_2$	D	Flat	L Wohlford	0.020	0.2400	N/A
$0.1Q_2$	D	Moderate	L Wohlford	0.020	0.2400	N/A
$0.1Q_2$	D	Steep	L Wohlford	0.020	0.1800	N/A

Q_2 = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records

Q_{10} = 10-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records

A = Bioretention surface area sizing factor

V_1 = Cistern volume sizing factor

Table 7-3. Sizing Factors for Bioretention Plus Vault Facilities						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
$0.5Q_2$	A	Flat	Lindbergh	N/A	N/A	N/A
$0.5Q_2$	A	Moderate	Lindbergh	N/A	N/A	N/A
$0.5Q_2$	A	Steep	Lindbergh	N/A	N/A	N/A
$0.5Q_2$	B	Flat	Lindbergh	0.040	0.3600	N/A
$0.5Q_2$	B	Moderate	Lindbergh	0.040	0.2400	N/A
$0.5Q_2$	B	Steep	Lindbergh	0.040	0.1400	N/A
$0.5Q_2$	C	Flat	Lindbergh	0.040	0.1600	N/A
$0.5Q_2$	C	Moderate	Lindbergh	0.040	0.1600	N/A
$0.5Q_2$	C	Steep	Lindbergh	0.040	0.1200	N/A
$0.5Q_2$	D	Flat	Lindbergh	0.040	0.1400	N/A
$0.5Q_2$	D	Moderate	Lindbergh	0.040	0.1400	N/A
$0.5Q_2$	D	Steep	Lindbergh	0.040	0.1000	N/A
$0.5Q_2$	A	Flat	Oceanside	N/A	N/A	N/A
$0.5Q_2$	A	Moderate	Oceanside	N/A	N/A	N/A
$0.5Q_2$	A	Steep	Oceanside	N/A	N/A	N/A
$0.5Q_2$	B	Flat	Oceanside	0.040	0.2100	N/A
$0.5Q_2$	B	Moderate	Oceanside	0.040	0.1800	N/A
$0.5Q_2$	B	Steep	Oceanside	0.040	0.1400	N/A
$0.5Q_2$	C	Flat	Oceanside	0.040	0.1400	N/A
$0.5Q_2$	C	Moderate	Oceanside	0.040	0.1400	N/A
$0.5Q_2$	C	Steep	Oceanside	0.040	0.1200	N/A
$0.5Q_2$	D	Flat	Oceanside	0.040	0.1400	N/A

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Table 7-3. Sizing Factors for Bioretention Plus Vault Facilities						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
$0.5Q_2$	D	Moderate	Oceanside	0.040	0.1400	N/A
$0.5Q_2$	D	Steep	Oceanside	0.040	0.1200	N/A
$0.5Q_2$	A	Flat	L Wohlford	N/A	N/A	N/A
$0.5Q_2$	A	Moderate	L Wohlford	N/A	N/A	N/A
$0.5Q_2$	A	Steep	L Wohlford	N/A	N/A	N/A
$0.5Q_2$	B	Flat	L Wohlford	0.040	0.2600	N/A
$0.5Q_2$	B	Moderate	L Wohlford	0.040	0.2200	N/A
$0.5Q_2$	B	Steep	L Wohlford	0.040	0.1200	N/A
$0.5Q_2$	C	Flat	L Wohlford	0.040	0.1400	N/A
$0.5Q_2$	C	Moderate	L Wohlford	0.040	0.1400	N/A
$0.5Q_2$	C	Steep	L Wohlford	0.040	0.1000	N/A
$0.5Q_2$	D	Flat	L Wohlford	0.040	0.1200	N/A
$0.5Q_2$	D	Moderate	L Wohlford	0.040	0.1200	N/A
$0.5Q_2$	D	Steep	L Wohlford	0.040	0.0800	N/A
$0.3Q_2$	A	Flat	Lindbergh	N/A	N/A	N/A
$0.3Q_2$	A	Moderate	Lindbergh	N/A	N/A	N/A
$0.3Q_2$	A	Steep	Lindbergh	N/A	N/A	N/A
$0.3Q_2$	B	Flat	Lindbergh	0.040	0.4500	N/A
$0.3Q_2$	B	Moderate	Lindbergh	0.040	0.3200	N/A
$0.3Q_2$	B	Steep	Lindbergh	0.040	0.1800	N/A
$0.3Q_2$	C	Flat	Lindbergh	0.040	0.1800	N/A
$0.3Q_2$	C	Moderate	Lindbergh	0.040	0.1800	N/A
$0.3Q_2$	C	Steep	Lindbergh	0.040	0.1400	N/A
$0.3Q_2$	D	Flat	Lindbergh	0.040	0.1600	N/A
$0.3Q_2$	D	Moderate	Lindbergh	0.040	0.1600	N/A
$0.3Q_2$	D	Steep	Lindbergh	0.040	0.1200	N/A
$0.3Q_2$	A	Flat	Oceanside	N/A	N/A	N/A
$0.3Q_2$	A	Moderate	Oceanside	N/A	N/A	N/A
$0.3Q_2$	A	Steep	Oceanside	N/A	N/A	N/A
$0.3Q_2$	B	Flat	Oceanside	0.040	0.2500	N/A
$0.3Q_2$	B	Moderate	Oceanside	0.040	0.2000	N/A
$0.3Q_2$	B	Steep	Oceanside	0.040	0.1600	N/A
$0.3Q_2$	C	Flat	Oceanside	0.040	0.1600	N/A
$0.3Q_2$	C	Moderate	Oceanside	0.040	0.1600	N/A
$0.3Q_2$	C	Steep	Oceanside	0.040	0.1400	N/A
$0.3Q_2$	D	Flat	Oceanside	0.040	0.1400	N/A
$0.3Q_2$	D	Moderate	Oceanside	0.040	0.1400	N/A

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Table 7-3. Sizing Factors for Bioretention Plus Vault Facilities						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
$0.3Q_2$	D	Steep	Oceanside	0.040	0.1200	N/A
$0.3Q_2$	A	Flat	L Wohlford	N/A	N/A	N/A
$0.3Q_2$	A	Moderate	L Wohlford	N/A	N/A	N/A
$0.3Q_2$	A	Steep	L Wohlford	N/A	N/A	N/A
$0.3Q_2$	B	Flat	L Wohlford	0.040	0.2900	N/A
$0.3Q_2$	B	Moderate	L Wohlford	0.040	0.2600	N/A
$0.3Q_2$	B	Steep	L Wohlford	0.040	0.1600	N/A
$0.3Q_2$	C	Flat	L Wohlford	0.040	0.1600	N/A
$0.3Q_2$	C	Moderate	L Wohlford	0.040	0.1600	N/A
$0.3Q_2$	C	Steep	L Wohlford	0.040	0.1200	N/A
$0.3Q_2$	D	Flat	L Wohlford	0.040	0.1200	N/A
$0.3Q_2$	D	Moderate	L Wohlford	0.040	0.1200	N/A
$0.3Q_2$	D	Steep	L Wohlford	0.040	0.0800	N/A
$0.1Q_2$	A	Flat	Lindbergh	N/A	N/A	N/A
$0.1Q_2$	A	Moderate	Lindbergh	N/A	N/A	N/A
$0.1Q_2$	A	Steep	Lindbergh	N/A	N/A	N/A
$0.1Q_2$	B	Flat	Lindbergh	0.040	0.5900	N/A
$0.1Q_2$	B	Moderate	Lindbergh	0.040	0.5000	N/A
$0.1Q_2$	B	Steep	Lindbergh	0.040	0.3200	N/A
$0.1Q_2$	C	Flat	Lindbergh	0.040	0.3400	N/A
$0.1Q_2$	C	Moderate	Lindbergh	0.040	0.3400	N/A
$0.1Q_2$	C	Steep	Lindbergh	0.040	0.2400	N/A
$0.1Q_2$	D	Flat	Lindbergh	0.040	0.2600	N/A
$0.1Q_2$	D	Moderate	Lindbergh	0.040	0.2600	N/A
$0.1Q_2$	D	Steep	Lindbergh	0.040	0.1800	N/A
$0.1Q_2$	A	Flat	Oceanside	N/A	N/A	N/A
$0.1Q_2$	A	Moderate	Oceanside	N/A	N/A	N/A
$0.1Q_2$	A	Steep	Oceanside	N/A	N/A	N/A
$0.1Q_2$	B	Flat	Oceanside	0.040	0.4300	N/A
$0.1Q_2$	B	Moderate	Oceanside	0.040	0.3400	N/A
$0.1Q_2$	B	Steep	Oceanside	0.040	0.2400	N/A
$0.1Q_2$	C	Flat	Oceanside	0.040	0.2600	N/A
$0.1Q_2$	C	Moderate	Oceanside	0.040	0.2600	N/A
$0.1Q_2$	C	Steep	Oceanside	0.040	0.2000	N/A
$0.1Q_2$	D	Flat	Oceanside	0.040	0.2200	N/A
$0.1Q_2$	D	Moderate	Oceanside	0.040	0.2200	N/A
$0.1Q_2$	D	Steep	Oceanside	0.040	0.1600	N/A

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Table 7-3. Sizing Factors for Bioretention Plus Vault Facilities						
Lower Flow Threshold	**Soil Group**	**Slope**	**Rain Gauge**	**A**	**V_1**	**V_2**
$0.1Q_2$	A	Flat	L Wohlford	N/A	N/A	N/A
$0.1Q_2$	A	Moderate	L Wohlford	N/A	N/A	N/A
$0.1Q_2$	A	Steep	L Wohlford	N/A	N/A	N/A
$0.1Q_2$	B	Flat	L Wohlford	0.040	0.4300	N/A
$0.1Q_2$	B	Moderate	L Wohlford	0.040	0.3800	N/A
$0.1Q_2$	B	Steep	L Wohlford	0.040	0.2800	N/A
$0.1Q_2$	C	Flat	L Wohlford	0.040	0.2800	N/A
$0.1Q_2$	C	Moderate	L Wohlford	0.040	0.2800	N/A
$0.1Q_2$	C	Steep	L Wohlford	0.040	0.2000	N/A
$0.1Q_2$	D	Flat	L Wohlford	0.040	0.2200	N/A
$0.1Q_2$	D	Moderate	L Wohlford	0.040	0.2200	N/A
$0.1Q_2$	D	Steep	L Wohlford	0.040	0.1400	N/A

Q_2 = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records

Q_{10} = 10-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records

A = Bioretention surface area sizing factor

V_1 = Cistern volume sizing factor

Table 7-4. Sizing Factors for Flow-Through Planters						
Lower Flow Threshold	**Soil Group**	**Slope**	**Rain Gauge**	**A**	**V_1**	**V_2**
0.5Q2	A	Flat	Lindbergh	N/A	N/A	N/A
0.5Q2	A	Moderate	Lindbergh	N/A	N/A	N/A
0.5Q2	A	Steep	Lindbergh	N/A	N/A	N/A
0.5Q2	B	Flat	Lindbergh	N/A	N/A	N/A
0.5Q2	B	Moderate	Lindbergh	N/A	N/A	N/A
0.5Q2	B	Steep	Lindbergh	N/A	N/A	N/A
0.5Q2	C	Flat	Lindbergh	0.115	0.0958	0.0690
0.5Q2	C	Moderate	Lindbergh	0.115	0.0958	0.0690
0.5Q2	C	Steep	Lindbergh	0.080	0.0667	0.0480
0.5Q2	D	Flat	Lindbergh	0.085	0.0708	0.0510
0.5Q2	D	Moderate	Lindbergh	0.085	0.0708	0.0510
0.5Q2	D	Steep	Lindbergh	0.065	0.0542	0.0390
0.5Q2	A	Flat	Oceanside	N/A	N/A	N/A
0.5Q2	A	Moderate	Oceanside	N/A	N/A	N/A
0.5Q2	A	Steep	Oceanside	N/A	N/A	N/A
0.5Q2	B	Flat	Oceanside	N/A	N/A	N/A
0.5Q2	B	Moderate	Oceanside	N/A	N/A	N/A
0.5Q2	B	Steep	Oceanside	N/A	N/A	N/A
0.5Q2	C	Flat	Oceanside	0.075	0.0625	0.0450

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Table 7-4. Sizing Factors for Flow-Through Planters						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
0.5Q2	C	Moderate	Oceanside	0.075	0.0625	0.0450
0.5Q2	C	Steep	Oceanside	0.065	0.0542	0.0390
0.5Q2	D	Flat	Oceanside	0.070	0.0583	0.0420
0.5Q2	D	Moderate	Oceanside	0.070	0.0583	0.0420
0.5Q2	D	Steep	Oceanside	0.050	0.0417	0.0300
0.5Q2	A	Flat	L Wohlford	N/A	N/A	N/A
0.5Q2	A	Moderate	L Wohlford	N/A	N/A	N/A
0.5Q2	A	Steep	L Wohlford	N/A	N/A	N/A
0.5Q2	B	Flat	L Wohlford	N/A	N/A	N/A
0.5Q2	B	Moderate	L Wohlford	N/A	N/A	N/A
0.5Q2	B	Steep	L Wohlford	N/A	N/A	N/A
0.5Q2	C	Flat	L Wohlford	0.070	0.0583	0.0420
0.5Q2	C	Moderate	L Wohlford	0.070	0.0583	0.0420
0.5Q2	C	Steep	L Wohlford	0.050	0.0417	0.0300
0.5Q2	D	Flat	L Wohlford	0.055	0.0458	0.0330
0.5Q2	D	Moderate	L Wohlford	0.055	0.0458	0.0330
0.5Q2	D	Steep	L Wohlford	0.045	0.0375	0.0270
0.3Q2	A	Flat	Lindbergh	N/A	N/A	N/A
0.3Q2	A	Moderate	Lindbergh	N/A	N/A	N/A
0.3Q2	A	Steep	Lindbergh	N/A	N/A	N/A
0.3Q2	B	Flat	Lindbergh	N/A	N/A	N/A
0.3Q2	B	Moderate	Lindbergh	N/A	N/A	N/A
0.3Q2	B	Steep	Lindbergh	N/A	N/A	N/A
0.3Q2	C	Flat	Lindbergh	0.130	0.1083	0.0780
0.3Q2	C	Moderate	Lindbergh	0.130	0.1083	0.0780
0.3Q2	C	Steep	Lindbergh	0.100	0.0833	0.0600
0.3Q2	D	Flat	Lindbergh	0.105	0.0875	0.0630
0.3Q2	D	Moderate	Lindbergh	0.105	0.0875	0.0630
0.3Q2	D	Steep	Lindbergh	0.075	0.0625	0.0450
0.3Q2	A	Flat	Oceanside	N/A	N/A	N/A
0.3Q2	A	Moderate	Oceanside	N/A	N/A	N/A
0.3Q2	A	Steep	Oceanside	N/A	N/A	N/A
0.3Q2	B	Flat	Oceanside	N/A	N/A	N/A
0.3Q2	B	Moderate	Oceanside	N/A	N/A	N/A
0.3Q2	B	Steep	Oceanside	N/A	N/A	N/A
0.3Q2	C	Flat	Oceanside	0.105	0.0875	0.0630
0.3Q2	C	Moderate	Oceanside	0.105	0.0875	0.0630
0.3Q2	C	Steep	Oceanside	0.085	0.0708	0.0510
0.3Q2	D	Flat	Oceanside	0.090	0.0750	0.0540

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Table 7-4. Sizing Factors for Flow-Through Planters						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
0.3Q2	D	Moderate	Oceanside	0.090	0.0750	0.0540
0.3Q2	D	Steep	Oceanside	0.070	0.0583	0.0420
0.3Q2	A	Flat	L Wohlford	N/A	N/A	N/A
0.3Q2	A	Moderate	L Wohlford	N/A	N/A	N/A
0.3Q2	A	Steep	L Wohlford	N/A	N/A	N/A
0.3Q2	B	Flat	L Wohlford	N/A	N/A	N/A
0.3Q2	B	Moderate	L Wohlford	N/A	N/A	N/A
0.3Q2	B	Steep	L Wohlford	N/A	N/A	N/A
0.3Q2	C	Flat	L Wohlford	0.085	0.0708	0.0510
0.3Q2	C	Moderate	L Wohlford	0.085	0.0708	0.0510
0.3Q2	C	Steep	L Wohlford	0.060	0.0500	0.0360
0.3Q2	D	Flat	L Wohlford	0.065	0.0542	0.0390
0.3Q2	D	Moderate	L Wohlford	0.065	0.0542	0.0390
0.3Q2	D	Steep	L Wohlford	0.050	0.0417	0.0300
0.1Q2	A	Flat	Lindbergh	N/A	N/A	N/A
0.1Q2	A	Moderate	Lindbergh	N/A	N/A	N/A
0.1Q2	A	Steep	Lindbergh	N/A	N/A	N/A
0.1Q2	B	Flat	Lindbergh	N/A	N/A	N/A
0.1Q2	B	Moderate	Lindbergh	N/A	N/A	N/A
0.1Q2	B	Steep	Lindbergh	N/A	N/A	N/A
0.1Q2	C	Flat	Lindbergh	0.250	0.2083	0.1500
0.1Q2	C	Moderate	Lindbergh	0.250	0.2083	0.1500
0.1Q2	C	Steep	Lindbergh	0.185	0.1542	0.1110
0.1Q2	D	Flat	Lindbergh	0.200	0.1667	0.1200
0.1Q2	D	Moderate	Lindbergh	0.200	0.1667	0.1200
0.1Q2	D	Steep	Lindbergh	0.130	0.1083	0.0780
0.1Q2	A	Flat	Oceanside	N/A	N/A	N/A
0.1Q2	A	Moderate	Oceanside	N/A	N/A	N/A
0.1Q2	A	Steep	Oceanside	N/A	N/A	N/A
0.1Q2	B	Flat	Oceanside	N/A	N/A	N/A
0.1Q2	B	Moderate	Oceanside	N/A	N/A	N/A
0.1Q2	B	Steep	Oceanside	N/A	N/A	N/A
0.1Q2	C	Flat	Oceanside	0.190	0.1583	0.1140
0.1Q2	C	Moderate	Oceanside	0.190	0.1583	0.1140
0.1Q2	C	Steep	Oceanside	0.140	0.1167	0.0840
0.1Q2	D	Flat	Oceanside	0.160	0.1333	0.0960
0.1Q2	D	Moderate	Oceanside	0.160	0.1333	0.0960
0.1Q2	D	Steep	Oceanside	0.105	0.0875	0.0630
0.1Q2	A	Flat	L Wohlford	N/A	N/A	N/A

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Table 7-4. Sizing Factors for Flow-Through Planters						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
0.1Q2	A	Moderate	L Wohlford	N/A	N/A	N/A
0.1Q2	A	Steep	L Wohlford	N/A	N/A	N/A
0.1Q2	B	Flat	L Wohlford	N/A	N/A	N/A
0.1Q2	B	Moderate	L Wohlford	N/A	N/A	N/A
0.1Q2	B	Steep	L Wohlford	N/A	N/A	N/A
0.1Q2	C	Flat	L Wohlford	0.135	0.1125	0.0810
0.1Q2	C	Moderate	L Wohlford	0.135	0.1125	0.0810
0.1Q2	C	Steep	L Wohlford	0.105	0.0875	0.0630
0.1Q2	D	Flat	L Wohlford	0.110	0.0917	0.0660
0.1Q2	D	Moderate	L Wohlford	0.110	0.0917	0.0660
0.1Q2	D	Steep	L Wohlford	0.080	0.0667	0.0480

Q_2 = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records
Q_{10} = 10-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records
A = Surface area sizing factor
V_1 = Surface volume sizing factor
V_2 = Subsurface volume sizing factor

Table 7-5. Sizing Factors for Infiltration Facilities						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
0.5Q2	A	Flat	Lindbergh	0.040	0.1040	N/A
0.5Q2	A	Moderate	Lindbergh	0.040	0.1040	N/A
0.5Q2	A	Steep	Lindbergh	0.035	0.0910	N/A
0.5Q2	B	Flat	Lindbergh	0.058	0.1495	N/A
0.5Q2	B	Moderate	Lindbergh	0.055	0.1430	N/A
0.5Q2	B	Steep	Lindbergh	0.050	0.1300	N/A
0.5Q2	C	Flat	Lindbergh	N/A	N/A	N/A
0.5Q2	C	Moderate	Lindbergh	N/A	N/A	N/A
0.5Q2	C	Steep	Lindbergh	N/A	N/A	N/A
0.5Q2	D	Flat	Lindbergh	N/A	N/A	N/A
0.5Q2	D	Moderate	Lindbergh	N/A	N/A	N/A
0.5Q2	D	Steep	Lindbergh	N/A	N/A	N/A
0.5Q2	A	Flat	Oceanside	0.045	0.1170	N/A
0.5Q2	A	Moderate	Oceanside	0.045	0.1170	N/A
0.5Q2	A	Steep	Oceanside	0.040	0.1040	N/A
0.5Q2	B	Flat	Oceanside	0.065	0.1690	N/A
0.5Q2	B	Moderate	Oceanside	0.065	0.1690	N/A
0.5Q2	B	Steep	Oceanside	0.060	0.1560	N/A
0.5Q2	C	Flat	Oceanside	N/A	N/A	N/A
0.5Q2	C	Moderate	Oceanside	N/A	N/A	N/A

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Table 7-5. Sizing Factors for Infiltration Facilities						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
0.5Q2	C	Steep	Oceanside	N/A	N/A	N/A
0.5Q2	D	Flat	Oceanside	N/A	N/A	N/A
0.5Q2	D	Moderate	Oceanside	N/A	N/A	N/A
0.5Q2	D	Steep	Oceanside	N/A	N/A	N/A
0.5Q2	A	Flat	L Wohlford	0.050	0.1300	N/A
0.5Q2	A	Moderate	L Wohlford	0.050	0.1300	N/A
0.5Q2	A	Steep	L Wohlford	0.040	0.1040	N/A
0.5Q2	B	Flat	L Wohlford	0.078	0.2015	N/A
0.5Q2	B	Moderate	L Wohlford	0.075	0.1950	N/A
0.5Q2	B	Steep	L Wohlford	0.065	0.1690	N/A
0.5Q2	C	Flat	L Wohlford	N/A	N/A	N/A
0.5Q2	C	Moderate	L Wohlford	N/A	N/A	N/A
0.5Q2	C	Steep	L Wohlford	N/A	N/A	N/A
0.5Q2	D	Flat	L Wohlford	N/A	N/A	N/A
0.5Q2	D	Moderate	L Wohlford	N/A	N/A	N/A
0.5Q2	D	Steep	L Wohlford	N/A	N/A	N/A
0.3Q2	A	Flat	Lindbergh	0.040	0.1040	N/A
0.3Q2	A	Moderate	Lindbergh	0.040	0.1040	N/A
0.3Q2	A	Steep	Lindbergh	0.035	0.0910	N/A
0.3Q2	B	Flat	Lindbergh	0.058	0.1495	N/A
0.3Q2	B	Moderate	Lindbergh	0.055	0.1430	N/A
0.3Q2	B	Steep	Lindbergh	0.050	0.1300	N/A
0.3Q2	C	Flat	Lindbergh	N/A	N/A	N/A
0.3Q2	C	Moderate	Lindbergh	N/A	N/A	N/A
0.3Q2	C	Steep	Lindbergh	N/A	N/A	N/A
0.3Q2	D	Flat	Lindbergh	N/A	N/A	N/A
0.3Q2	D	Moderate	Lindbergh	N/A	N/A	N/A
0.3Q2	D	Steep	Lindbergh	N/A	N/A	N/A
0.3Q2	A	Flat	Oceanside	0.045	0.1170	N/A
0.3Q2	A	Moderate	Oceanside	0.045	0.1170	N/A
0.3Q2	A	Steep	Oceanside	0.040	0.1040	N/A
0.3Q2	B	Flat	Oceanside	0.065	0.1690	N/A
0.3Q2	B	Moderate	Oceanside	0.065	0.1690	N/A
0.3Q2	B	Steep	Oceanside	0.060	0.1560	N/A
0.3Q2	C	Flat	Oceanside	N/A	N/A	N/A
0.3Q2	C	Moderate	Oceanside	N/A	N/A	N/A
0.3Q2	C	Steep	Oceanside	N/A	N/A	N/A
0.3Q2	D	Flat	Oceanside	N/A	N/A	N/A
0.3Q2	D	Moderate	Oceanside	N/A	N/A	N/A

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Table 7-5. Sizing Factors for Infiltration Facilities						
Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
0.3Q2	D	Steep	Oceanside	N/A	N/A	N/A
0.3Q2	A	Flat	L Wohlford	0.050	0.1300	N/A
0.3Q2	A	Moderate	L Wohlford	0.050	0.1300	N/A
0.3Q2	A	Steep	L Wohlford	0.040	0.1040	N/A
0.3Q2	B	Flat	L Wohlford	0.078	0.2015	N/A
0.3Q2	B	Moderate	L Wohlford	0.075	0.1950	N/A
0.3Q2	B	Steep	L Wohlford	0.065	0.1690	N/A
0.3Q2	C	Flat	L Wohlford	N/A	N/A	N/A
0.3Q2	C	Moderate	L Wohlford	N/A	N/A	N/A
0.3Q2	C	Steep	L Wohlford	N/A	N/A	N/A
0.3Q2	D	Flat	L Wohlford	N/A	N/A	N/A
0.3Q2	D	Moderate	L Wohlford	N/A	N/A	N/A
0.3Q2	D	Steep	L Wohlford	N/A	N/A	N/A
0.1Q2	A	Flat	Lindbergh	0.040	0.1040	N/A
0.1Q2	A	Moderate	Lindbergh	0.040	0.1040	N/A
0.1Q2	A	Steep	Lindbergh	0.035	0.0910	N/A
0.1Q2	B	Flat	Lindbergh	0.058	0.1495	N/A
0.1Q2	B	Moderate	Lindbergh	0.055	0.1430	N/A
0.1Q2	B	Steep	Lindbergh	0.050	0.1300	N/A
0.1Q2	C	Flat	Lindbergh	N/A	N/A	N/A
0.1Q2	C	Moderate	Lindbergh	N/A	N/A	N/A
0.1Q2	C	Steep	Lindbergh	N/A	N/A	N/A
0.1Q2	D	Flat	Lindbergh	N/A	N/A	N/A
0.1Q2	D	Moderate	Lindbergh	N/A	N/A	N/A
0.1Q2	D	Steep	Lindbergh	N/A	N/A	N/A
0.1Q2	A	Flat	Oceanside	0.045	0.1170	N/A
0.1Q2	A	Moderate	Oceanside	0.045	0.1170	N/A
0.1Q2	A	Steep	Oceanside	0.040	0.1040	N/A
0.1Q2	B	Flat	Oceanside	0.065	0.1690	N/A
0.1Q2	B	Moderate	Oceanside	0.065	0.1690	N/A
0.1Q2	B	Steep	Oceanside	0.060	0.1560	N/A
0.1Q2	C	Flat	Oceanside	N/A	N/A	N/A
0.1Q2	C	Moderate	Oceanside	N/A	N/A	N/A
0.1Q2	C	Steep	Oceanside	N/A	N/A	N/A
0.1Q2	D	Flat	Oceanside	N/A	N/A	N/A
0.1Q2	D	Moderate	Oceanside	N/A	N/A	N/A
0.1Q2	D	Steep	Oceanside	N/A	N/A	N/A
0.1Q2	A	Flat	L Wohlford	0.050	0.1300	N/A
0.1Q2	A	Moderate	L Wohlford	0.050	0.1300	N/A

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Table 7-5. Sizing Factors for Infiltration Facilities

Lower Flow Threshold	Soil Group	Slope	Rain Gauge	A	V_1	V_2
0.1Q2	A	Steep	L Wohlford	0.040	0.1040	N/A
0.1Q2	B	Flat	L Wohlford	0.078	0.2015	N/A
0.1Q2	B	Moderate	L Wohlford	0.075	0.1950	N/A
0.1Q2	B	Steep	L Wohlford	0.065	0.1690	N/A
0.1Q2	C	Flat	L Wohlford	N/A	N/A	N/A
0.1Q2	C	Moderate	L Wohlford	N/A	N/A	N/A
0.1Q2	C	Steep	L Wohlford	N/A	N/A	N/A
0.1Q2	D	Flat	L Wohlford	N/A	N/A	N/A
0.1Q2	D	Moderate	L Wohlford	N/A	N/A	N/A
0.1Q2	D	Steep	L Wohlford	N/A	N/A	N/A

Q_2 = 2-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records
Q_{10} = 10-year pre-project flow rate based upon partial duration analysis of long-term hourly rainfall records
A = Surface area sizing factor
V_1 = Infiltration volume sizing factor

Rainfall basin boundaries were determined based upon mean annual precipitation values as determined by the County of San Diego and specific precipitation totals at the three base rainfall stations (Lindbergh Field, Oceanside and Lake Wohlford). The final rainfall basin map is provided in the San Diego BMP Sizing Calculator.

Per the County's chief hydrologist Rand Allan, the 3 base rainfall stations have the following mean annual precipitation values for the time period of 1971-2001 (period of time depicted on the mean annual precipitation map created by the County of San Diego).

Lindbergh Field = 10.2 inches
Oceanside = 13.3 inches
Lake Wohlford = 20.0 inches

To determine the east-west boundary between Oceanside and Lake Wohlford, the average of the mean annual precipitation values between Oceanside and Lake Wohlford was determined:

(13.3 inches + 20.0 inches) / 2 = 16.7 inches

The 17 inch isopluvial line was used as the boundary – anything east of the 17 inch isopluvial line would be part of the Lake Wohlford basin.

To determine the east-west boundary between Oceanside and Lindbergh, the average of the mean annual precipitation values between Oceanside and Lindbergh was determined:

(13.3 inches + 10.2 inches) = 11.8 inches

The 12 inch isopluvial line was used as the boundary – anything west of the 12 inch isopluvial line would be part of the Lindbergh basin.

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To determine the east-west boundary between Lindbergh and Lake Wohlford (used only for extreme south county areas), the average of the mean annual precipitation values between Lindbergh and Lake Wohlford was determined:

(10.2 inches + 20.0 inches) / 2 = 15.1 inches

The 15 inch isopluvial line was used as the boundary – anything east of the 15-inch isopluvial line would be part of the Lake Wohlford basin.

Areas located between the 12 inch and 17 inch isopluvial lines and also located north of Sweetwater Reservoir/San Miguel Mountain were designated as part of the Oceanside basin.

Additional notes:

1. The southern extent of the Oceanside basin was limited to the area near Sweetwater Reservoir and San Miguel Mountain. At that location, the previously discussed 15 inch and 17 inch isopluvial lines are in close proximity.
2. There is a short reach of 12 inch isopluvial line near the coastline between Encinitas and Los Penasquitos lagoon. Even though this area has a mean annual precipitation less than 12 inches, it is included in the Oceanside basin pursuant to Rand Allan's determination that a north-south divide between the Lindbergh and Oceanside basins occurs north of La Jolla.

For situations where LID implementation cannot fully achieve the required hydromodification flow mitigation, the project applicant will have the option to implement extended detention facilities in combination with LID facilities. The San Diego HMP / LID sizing calculator will have a basin sizing component to assist with the design of extended detention flow duration control facilities as well as LID facilities.

Facilities must be designed, built, and maintained to practically function within the urban environment. Soil compaction associated with grading activities affects infiltration rates and should be considered. Underdrains are typically required for urban projects where the anticipated infiltration rate is low or where infiltrated runoff could pose an adjacent stability risk.

Since the HMP will be implemented through the municipal development review process, design criteria must be specified and be incorporated into conditions of approval.

Development of sizing factors and the San Diego HMP / LID sizing calculator is currently being conducted and includes the following tasks.

- Develop and document the major assumptions and model parameters that will be used in subsequent HSPF simulations to size Low-Impact Design (LID) facilities, detention ponds, and non-structural stormwater controls. This task includes three steps.
  1. Document LID facility configurations included in the Sizing Calculator
  2. Select the range of input parameters to use in the HSPF model simulations
  3. Develop and document the approach to computing BMP sizing factors
- Develop configurations of each of the LID BMPs included in the Model SUSMP, including the dimensions of the ponding layers, growing medium, storage layer, and outlet piping. The following LID BMPs will be modeled for flow control and water quality treatment:
  1. Bioretention
  2. Cistern with bioretention
  3. Bioretention with flow control vault
  4. Flow-through planter

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5. Dry well
6. Vegetated bioswale (for water quality treatment only)

- Select a recommended set of HSPF input parameters for simulating hydrologic processes on pervious surfaces, known in HSPF as PERLNDs. Parameters will be selected that represent specific combinations of the following:
  - Soils
  - Land Cover
  - Slope
- Develop LID sizing factors for NRCS Group A, B, C, and D soils. LID facilities built in Group C and D soils will include an underdrain and a flow control orifice. LID facilities built in Group A and B soils will have no underdrain, requiring infiltration to surrounding soils.
- Develop sizing for traditional stormwater BMPs using an automated approach to size stormwater detention ponds. The automated pond sizing algorithm is incorporated into the BMP Sizing Calculator.
  - Select specific allowable range of pond configuration parameters, such as side slopes and the number of outlets
  - Develop an algorithm that will read in long-term model simulation results and iteratively vary pond volume and outlet dimensions until the flow control requirements are met
- Develop BMP Sizing Calculator. The BMP Sizing Calculator will help streamline the process of sizing the BMPs listed in the County's Model SUSMP. The software will have the following features:
  - Sizing of BMPs for "flow control + water quality treatment" and "water quality treatment-only" permit requirements
  - Include all LID BMPs listed in the County's SUSMP, including stormwater detention ponds
  - Include sizing criteria for self-retaining areas and self-treating areas, as described in the Model SUSMP

7.2 Inspection and Maintenance Schedule

If not properly designed or maintained, hydromodification flow control devices may create a habitat for vectors such as mosquitoes or rodents as well as potential safety hazards due to standing water. Vector habitat creation can be avoided through collaboration with municipalities and both local vector control agencies and the State Department of Health Services during the development and implementation of Project Submittals (Storm Water Management Plans or Water Quality Technical Reports).

Proof of long-term ongoing maintenance responsibility and mechanism are required for all post-construction BMPs, including hydromodification mitigation facilities. Maintenance activities for flow control and LID devices will be specified in the proposed Project Submittal (Storm Water Management Plan or Water Quality Technical Report).

A blockage in the storm drain system can cause water to back up into the treatment facilities and cause damage. For this reason, inspection and maintenance of the storm drain system is considered part of the inspection and maintenance of the treatment facilities. Normal functioning of the facilities may involve retention of water for up to 72 hours following significant storm events.

As required by Permit Provision D.1.c.(5), local municipalities require submittal of proof of a mechanism under which ongoing long-term maintenance of stormwater treatment and flow-control facilities will be conducted. Municipalities may require one of more of the following items be included in the Project Submittal:

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1. A means to finance and implement facility maintenance in perpetuity.
2. Acceptance of responsibility for maintenance from the time the facilities are constructed until responsibility for operation and maintenance is legally transferred. A warranty covering a period following construction may also be required.
3. An outline of general maintenance requirements for the selected treatment and flow-control facilities.

Local municipalities may also require preparation and submittal of a detailed plan that sets forth a maintenance schedule for each of the treatment and flow-control facilities built on the project site and names the responsible parties for this action.

Before completing the Project Submittal, the applicant should ensure the stormwater control design is fully coordinated with the site plan, grading plan, and landscaping plan being proposed for the site.

Information submitted and presentations to design review committees, planning commissions, and other decision-making bodies must incorporate relevant aspects of the stormwater design. In particular, ensure:

- Curb elevations, elevations, grade breaks, and other features of the drainage design are consistent with the delineation of Drainage Management Areas (DMAs).
- The top edge (overflow) of each bioretention facility is level all around its perimeter—this is particularly important in parking lot medians.
- The resulting grading and drainage design is consistent with the design for parking and circulation.
- Bioretention facilities and other IMPs do not create conflicts with pedestrian access between parking and building entrances.
- Vaults and utility boxes can be accommodated outside bioretention facilities and will not be placed within bioretention facilities.
- The visual impact of stormwater facilities, including planter boxes at building foundations and any terracing or retaining walls required for the stormwater control design, is shown in renderings and other architectural drawings.
- Landscaping plans, including planting plans, show locations of bioretention facilities, and the plant requirements are consistent with the engineered soils and conditions in the bioretention facilities.
- Renderings and representation of street views incorporate any stormwater facilities located in street-side buffers and setbacks

Other design considerations to assist with long-term maintenance include:

- For effective, low-maintenance operation, locate facilities so drainage into and out of the device is by gravity flow. Pumped systems are feasible, but are expensive, require more maintenance, are prone to untimely failure, and can cause mosquito control problems. Most IMPs require 3 feet or more of head.
- If the property is being subdivided now or in the future, the facility should be in a common, accessible area. In particular, avoid locating facilities on private residential lots. Even if the facility will serve only one site owner or operator, make sure the facility is located for ready access by inspectors from the local municipality and local mosquito control agency.
- The facility must be accessible to equipment needed for its maintenance. Access requirements for maintenance will vary with the type of facility selected. Planter boxes and bioretention areas will typically need access for the same types of equipment used for landscape maintenance.

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8. MONITORING AND BMP EVALUATION

8.1 Introduction

This section presents a summary of the San Diego HMP's revised Monitoring Plan. The summary explains technical concepts and proposes approaches to monitor the effectiveness of the HMP as required by provision D.1.g of Regional Board Order No. R9-2007-0001.

Part 1(k) of provision D.1.g requires that the HMP shall "include a description of pre- and post-project monitoring and other program evaluations to be conducted to assess the effectiveness of implementation of the HMP." For the purposes of developing an HMP monitoring approach, an effective HMP is defined as a program that ensures compliance with HMP design criteria and results in no significant stream degradation due to increased erosive force caused by new development.

The proposed monitoring approach provides for the optimum 5-year effectiveness assessment within currently available funding resources. Monitoring Plan activities were selected to achieve statistical data collection requirements while balancing regional financial constraints and highly variable scientific, regulatory, and physical elements. Monitoring plan activities presented herein have been developed to answer the following questions regarding HMP program effectiveness assessment:

- **Do field observations confirm that the HMP appropriately defines the flow rate (expressed as a function of the 2-year runoff event) that initiates movement of channel bed or bank materials?** Since most of the sediment transport modeling prepared as part of the HMP development relied on laboratory flume data, it is important to supplement the sediment transport data set with field observations. This data may be used in the next permit cycle to determine whether critical shear stress is the appropriate parameter for selecting the lower flow threshold of the geomorphically significant flow range.
- **Are mitigation facilities adequately meeting flow duration design criteria outlined in the HMP?** Observed HMP mitigation facility outflow data can be analyzed to determine if mitigation facilities are reducing the mitigated post-project peak flow frequency and flow duration curves to the pre-project curves (within tolerances set forth in the HMP). This data can also be used to analyze the precision of LID sizing factors, extended detention facility design criteria, and to potentially recommend changes to more closely match the mitigated post-project curves to pre-project condition peak flow frequency and flow duration curves.
- **What is the effect of development on downstream cross section incision and widening?** Since the mitigation of accelerated channel degradation as a result of development is the central purpose of the HMP, analysis of channel cross sections downstream of development projects is a component of the monitoring plan. However, uncertainties involved with this comparison tool (namely the determination of pre-project condition trends regarding channel incision and channel widening rates) make policy determinations less likely within the time frame of the 5-year monitoring plan (as compared to sediment transport modeling and flow duration modeling detailed in the previous two questions).

Such a question-driven plan is consistent with the draft hydromodification monitoring framework prepared by the Southern California Coastal Water Research Project (SCCWRP – report dated December 9, 2009).

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In an effort to effectively address the wide variability of potential monitoring scenarios and competing needs outlined above, the Copermittees and Brown and Caldwell have consulted with technical experts in a variety of critical disciplines including Dr. Eric Stein of SCCWRP (geomorphology expert), San Diego Regional Water Quality Control Board staff, Dr. Andy Collison of Phillip Williams Associates (geomorphology expert), Dr. Khalil Abusaba (formerly of the San Francisco Regional Water Quality Control Board and currently with Brown and Caldwell – expert in statistical analysis of water quality data), and members of the San Diego HMP Technical Advisory Committee.

8.2 Technical Concepts

8.2.1 Hydromodification Concepts

As required in the Permit, the evaluation of increased erosive force is limited to the geomorphically significant flow range, which is defined between the flow associated with critical shear stress and the ten-year return flow (Q10). The value of the lower flow threshold indicates the flow at which sediment erosion from the stream bed or banks begins to occur. The HMP uses two calculation tools (the low flow calculator and the SCCWRP channel assessment tool) to determine the low flow threshold based upon substrate type, channel slope, roughness, channel cross section, and other stream assessment conditions. The resulting lower flow threshold will be expressed as a multiple of the two-year return flow (Q2):

- $0.1Q_2$ for streams with HIGH susceptibility to channel erosion
- $0.3Q_2$ for streams with MEDIUM susceptibility to channel erosion
- $0.5Q_2$ for streams with LOW susceptibility to channel erosion

8.2.2 HMP Effectiveness Validation Measures

Sediment Transport Studies. This approach monitors sediment concentration (SSC) throughout a storm event and can be used to directly evaluate the validity of a lower flow threshold for a particular stream segment. Measuring the continuous SSC to flow relationship over a range of flows allows HMP effectiveness to be evaluated based on whether or not significant post-project increases in SSC (as compared to pre-project conditions) are observed at a given flow rate. This approach is the most costly, because it involves measuring flow and SSC. The SSC measurements will involve continuous turbidity monitoring, which would include calibration of turbidity meters using stream cross-sectional sediment sampling to correlate SSC to turbidity, or an approved equivalent metric. SSC values can also be determined through a laboratory analysis using United States Geological Survey (USGS) procedures. The final analysis method, along with data collection specifications, will be determined following future discussions with the Copermittees and members of the Technical Advisory Committee. These approaches are most likely to produce information on HMP effectiveness on a relatively short time frame, provided that a sufficient range of storm event sizes can be sampled in a given year.

Flow Duration Curves. Another measure of HMP effectiveness is determining if, within the geomorphically significant flow range, the post-project flow-duration curve is comparable to or below the pre-project flow duration curve. Flow-duration curves are monitored by installing continuous flow monitoring devices downstream of a planned project prior to development to establish pre-project conditions. If the flow monitoring facilities used for the sediment transport studies (detailed above) are located just downstream of a proposed development, then data from the sediment transport studies can be used for the pre-project flow duration data. This approach is consistent with the draft SCCWRP monitoring framework, which recommends stream flow monitoring to be provided just downstream of a hydromodification mitigation management device. Post-development mitigated flow duration monitoring data is analyzed to evaluate whether significant changes in the flow-duration curve have occurred. This monitoring approach can also be

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used to validate sizing factors for LID and extended detention BMPs. Depending on the range of rainfall events encountered in a particular year, monitoring of flow-duration curves can help develop pre-project conditions and evaluate post-project effectiveness on a relatively short time scale (i.e., 2 to 3 years each).

Channel Incision and Widening. The most obvious measure of stream degradation is to physically measure the pre-project and post-project cross sections, and determine if the channel is incising and / or widening. This is accomplished by conducting geomorphic assessments and channel surveys downstream of a planned development before and after construction. In addition to physical measurements, comparison of current and historical photos, aerial photography, and site inspection for signs of channel degradation can provide important supporting evidence. The labor for conducting such an assessment at a single location is lower compared to the effort needed to conduct sediment transport studies. Costs are driven by the number of sites assessed, as well as the need for establishing pre-project trends (e.g., rate of pre-project channel incision per year). Although this monitoring approach is the most direct measure of whether stream degradation is occurring, it is difficult to use the method to differentiate between existing geomorphic effects and post-project geomorphic effects. To do so would require a long-term baseline of pre-project channel incision and widening rates along with post-project monitoring. To capture the range of annual rainfall conditions encountered in Southern California, decades of information are generally recommended to quantify pre-project baseline trends. Therefore, while baseline data will be collected and be useful for future comparison analyses, this monitoring plan focuses on validation measures likely to provide meaningful data within 2 to 5 years. It is possible that tentative conclusions may be reached regarding channel incision and widening at the conclusion of the 5-year monitoring plan. Finally, it should be noted that the Copermittees will centralize stream assessment information collected as part of project development processes. This information may be used for future channel condition assessments and will be utilized by the Copermittees to the extent practicable. While such stream assessment information will not be required for all Priority Development Projects, it would be required for all projects proposing the use of stream rehabilitation mitigation measures (e.g., constructed channel widening, drop structures) and for projects using lower flow thresholds in excess of 0.1Q2. The Copermittees are currently considering other requirements for pre-project stream assessments, including project size, contributing impervious area cover, and receiving channel material.

8.2.3 Temporal and Spatial Variability of Monitoring Locations

Temporal Variability. As noted above, the single most important factor affecting the temporal variability inherent to measuring stream degradation is variable inter-annual rainfall frequency and intensity. Droughts in California can last years, with little to no rainfall occurring in Southern California. During El Nino years, anomalously high storm frequencies and intensities can result in sudden geomorphic changes. Rainfall intensity also varies intra-annually. However, if a sufficient range of storm intensities is encountered in a particular year, then short duration monitoring approaches, such as flow-duration curves and sediment transport studies can provide some information on HMP effectiveness on shorter timescales.

Spatial Variability. Sampling an adequate variety of channel susceptibility types, along with a reasonable number of replicates within for each susceptibility type, is important to capture the range of watershed conditions present in the permit coverage area. Other important factors that affect stream responses to hydromodification include channel grade, watershed area, vegetated cover, and stream sinuosity. In addition to channel and watershed features, location within the watershed is an important consideration. Monitoring stations should be located in the watershed headwaters just downstream of a development project of sufficient size, so that hydromodification effects from the proposed development can be isolated for comparison purposes to the maximum extent practicable. Upper watershed sites provide more definitive measures of HMP effectiveness because they can more directly correlate effects to specific development projects. Middle watershed and lower watershed sites would be influenced by confounding variables such as mass wasting and impacts from natural tributary confluences and other existing development projects, including phased developments over many years, in the watershed. Therefore, middle and lower watershed

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monitoring sites would require much more time to assess overall program effectiveness. However, the Copermittees will attempt to utilize data from concurrent water quality monitoring programs to develop a database of middle/lower watershed flow data. Specifically, monitoring station located in middle to lower watershed locations will be identified for the two proposed channel susceptibility types. While the San Diego HMP has been written to require onsite hydromodification flow controls at each applicable new development and redevelopment site, thus minimizing the potential for cumulative watershed impacts as a result of new development and redevelopment, monitoring station locations will be selected, where possible, to include the effects of multiple upstream developments. The concept of providing hydromodification effectiveness measurements in the watershed headwaters is supported by SCCWRP. Research by SCCWRP has shown that hydromodification effects of a development project become muted with increasing distance from the development site (defined by SCCWRP as the Domain of Effect). To the extent practicable, monitoring locations detailed in the Monitoring Plan will be distributed throughout the Permit coverage area Hydrologic Units to provide for geographic and climatic variability across San Diego County.

8.3 Recommended Approaches to Assess Effectiveness

Selection of HMP effectiveness assessment monitoring techniques is subject to two primary constraints. The schedule constraint involves the RWQCB's desire to have information on HMP effectiveness prior to re-issuance of the Municipal Separate Storm Sewer System (MS4) Permit for San Diego County, currently scheduled for 2012. This schedule constraint creates an added "practicality" issue, since it is unlikely that meaningful data can be acquired in such an abbreviated timeline. While the monitoring plan detailed in this memorandum extends for five years, interim data may be provided to the Regional Board to assist with development of the next Permit.

The budget constraint involves the San Diego County Copermittees' limited resources for monitoring. Given the fact that the Copermittees are currently committed to a $2,500,000 annual regional water quality monitoring plan effort, and given the current economic climate in which multiple local municipalities have been forced to reduce both budget and staff, expansion of existing monitoring mandates requires significant financial consideration and analysis. Thus, the Copermittees are compelled to evaluate how to develop the best possible monitoring approach to evaluate HMP effectiveness within the available budget.

Details of the monitoring plan are above and beyond details of the existing regional water quality monitoring effort. Wherever possible, the Copermittees will seek opportunities to utilize relevant data from the existing water quality monitoring efforts to achieve an economy of scale. The Copermittees will also ensure there is no duplication of effort between the two monitoring programs.

This monitoring plan focuses on using continuous monitoring data to obtain the maximum amount of data regarding sediment transport and flow duration monitoring. It is the opinion of the Copermittees that acquisition of continuous data at a statistically justified number of monitoring locations is more valuable (from a data analysis standpoint) as compared to obtaining a finite number of isolated runoff events from more monitoring locations.

Considering the constraints and technical approach detailed above, the following approaches are recommended for the revised HMP Monitoring Plan.

- **Monitor effectiveness using Sediment Transport and Flow Duration Studies.** As noted above, continuous sediment transport and flow duration studies can provide direct measures of HMP effectiveness on a relatively short timescale. These studies are important to verify HMP assumptions about the lower flow thresholds and to verify flow duration design criteria is being achieved. Development of the sediment transport studies would also provide stream cross section data, as well as photographic evidence, that could serve as a baseline for future stream morphology comparisons.

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- **Monitor the Upper Watershed.** Upper watershed monitoring is recommended to eliminate confounding lower watershed variables that would skew the analysis and minimize the potential for reaching meaningful conclusions.
- **Monitor Replicates of Two Channel Susceptibility Types.** In the development of the San Diego County HMP, receiving streams will be classified into one of three channel types, pursuant to a State Board-funded study conducted by SCCWRP. The stream classification system is consistent with the analysis, findings, and tools developed in the SCCWRP study and classifies streams into the following stream susceptibility categories:
  - HIGH susceptibility
  - MEDIUM susceptibility
  - LOW susceptibility

  Monitoring locations should be selected from HIGH and MEDIUM susceptibility channel segments.
- **Monitor three replicates and one reference station for each susceptibility type.** Providing three replicates of each channel susceptibility type would begin the characterization of the range of conditions present in San Diego County. The reference monitoring station associated with each channel susceptibility type would be located in a watershed for which no upstream development (existing or future) is anticipated. Data from the reference stations can be used to supplement pre-project condition data obtained at the replicate sites, since the amount of pre-project condition data that can be obtained at such sites is dependent on the land development process. Providing three replicate stations balances the need to characterize spatial variability against the cost of monitoring and provides the data needed to estimate the median and range of the lower flow threshold for a given susceptibility type, or to estimate the standard deviation of an average value.
- **Monitor the Middle Watershed.** Middle watershed monitoring will be provided at two monitoring locations, both of which will be located downstream of existing urbanized areas with watershed impervious areas greater than 40 percent.

8.4 Summary and Conclusions

The revised Monitoring Plan, scheduled for implementation over a 5-year period, will recommend the following specific activities:

Baseline Monitoring Plan Requirements:

- Development of QAPP
- Rainfall gauge analysis and installation
- Rainfall gauge, stream gauge, and HMP facility outflow station inspection and maintenance (Fiscal Year 2012 through 2016)
- Annual data analysis (2012 – 2016)
- Reevaluation of the Monitoring Plan after review of findings from Statewide HMP Monitoring Technical Advisory Group and review of final SCCWRP Hydromodification Monitoring Report (2013)
- Report preparation (final report to be prepared in 2016)

Channel Assessments:

- Initial geomorphic assessment at each monitoring location (to determine stream susceptibility type – 2011-2012)
- Baseline cross section surveys at each monitoring location (2011-2012)

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- Annual geomorphic assessments at each monitoring location (to assess channel condition and response - 2012 – 2016)
- Cross section surveys (after 5 years) at each monitoring location (2016)

Sediment Transport Analysis:

- Flow and sediment monitoring station installation
- Continuous pre-project, post-project and reference station flow, sediment and rainfall data collection (2012 – 2016)

Flow Duration Analysis:

- HMP facility outflow monitoring station installation
- Continuous post-project HMP facility outflow data collection (2013 – 2016)

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9. CONCLUSIONS

Implementation of this HMP satisfies Provision D.1.g of Board Order R9-2007-0001. Adherence to guidelines outlined in the HMP is required "to manage increases in runoff discharge rates and durations for all Priority Development Projects, where such increased rates and durations are likely to cause increased erosion of channel beds or banks, sediment pollutant generation, or other impacts to beneficial uses and stream habitat due to increased erosive force."

Order R9-2007-0001 contains requirements that strongly influence the methodology contained in this HMP. As recommended in the HMP, post-project flows must match pre-project flows within the prescribed geomorphically significant flow range.

Flow control options to meet the criteria include LID facilities, which promote infiltration and filtration to attain the required flow mitigation, and extended flow duration control detention basins. Continuous hydrologic modeling is required to prove conformance with the standards presented in this HMP.

Specific permit requirements, detailed below, have been addressed by this HMP.

- Provide performance criteria for Priority Development Projects (Chapter 6)
- Include a protocol to evaluate potential hydrograph change impacts to downstream watercourses from PDPs (Chapter 6).
- Provide a description of how the Copermittees will incorporate the HMP requirements into their local approval processes (Chapter 1).
- Include a description of pre- and post-project monitoring and other program evaluations to be conducted to assess the effectiveness of implementation of the HMP (Chapter 8).
- Include mechanisms for addressing cumulative impacts within a watershed on channel morphology (Chapter 5).
- Utilize a continuous rainfall record to identify the geomorphically significant flow range (Chapter 5).
- Include a pertinent literature review (Chapter 4)
- Include criteria on management practices designed to mitigate increases to peak flows and durations (Chapter 7)
- Include information on the evaluation of channel form and condition (Chapter 5)

The Copermittees will incorporate HMP requirements into the local approval processes via incorporation of HMP criteria into their local SUSMPs. The San Diego region's updated Model SUSMP will incorporate the Final HMP criteria. HMP criteria will be incorporated into the local SUSMP and municipal ordinances no later than 180 days following RWQCB adoption of the HMP.

Information presented in the HMP has been prepared in association with the County of San Diego, San Diego Storm Water Copermittees, the Technical Advisory Committee, and the consultant team.

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10. LIMITATIONS

Report Limitations

This document was prepared solely for the County of San Diego in accordance with professional standards at the time the services were performed and in accordance with the contract between the County of San Diego and Brown and Caldwell dated September 6, 2007. This document is governed by the specific scope of work authorized by the County of San Diego; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on rainfall data provided by the County of San Diego and other parties and have made no independent investigation as to the validity or accuracy of such data.

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APPENDIX A

Flow Threshold Report

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Flow Control Threshold Analysis
for the
San Diego Hydrograph Modification Management Plan

Prepared for

San Diego County and Copermittees

Prepared by

Philip Williams & Associates, Ltd.

December 23rd 2009

PWA REF. # 1915

Services provided pursuant to this Agreement are intended solely for the use and benefit of San Diego County and the Hydromodification Management Plan Copermitees. No other person or entity shall be entitled to rely on the services, opinions, recommendations, plans or specifications provided pursuant to this agreement without the express written consent of Philip Williams & Associates, Ltd., 550 Kearny Street, Suite 900, San Francisco, CA 94108.

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1. INTRODUCTION AND BACKGROUND

1.1 PURPOSE OF THE REPORT

San Diego County and its copermittees are required to develop a Hydromodification Management Plan (HMP) under their National Pollutant Discharge Elimination System (NPDES) MS4 permit. The purpose and requirements of the HMP are described in a 2007 Regional Water Quality Control Board (RWQCB) order renewing the NPDES permit (Order No. R9-2007-0001). The purpose of the HMP is to identify guidelines for managing 'geomorphically-significant' flows that, if not controlled, would cause increased erosion of receiving waters. Specifically, the HMP must identify a low and high flow threshold between which flows should be controlled so that the post-project flow rates and durations do not exceed pre-project levels between these two flow magnitudes. The lower flow threshold is required to correspond to critical flow producing critical shear stress in the channel. The flow control language in the Board Order is as follows:

> Utilize continuous simulation of the entire rainfall record to identify a range of runoff flows[8] for which Priority Development Project post-project runoff flow rates and durations shall not exceed pre-project runoff flow rates and durations, where the increased flow rates and durations will result in increased potential for erosion or other significant adverse impacts to beneficial uses, attributable to changes in the flow rates and durations. The lower boundary of the range of runoff flows identify shall correspond with the critical channel flow that produces the critical shear stress that initiates channel bed movement or that erodes the toe of channel banks. The identified range of runoff flows may be different for specific watersheds, channels or channel reaches.
>
> [8] The identified range of runoff flows to be controlled should be expressed in terms of peak flow rates of rainfall events, such as "10% of the pre-project 2-year peak flow up to the pre-project 10-year peak flow."

1.2 CONCEPTS BEHIND 'GEOMORPHICALLY-SIGNIFICANT FLOWS', CRITICAL FLOWS AND FLOW CONTROL

For the purposes of this project 'hydrograph modification' or 'hydromodification' is understood to mean changes to the frequency, duration and magnitude of surface runoff that, when untreated, cause an increase in erosion of the receiving water body. Hydromodification occurs when urbanization replaces areas of vegetated, uncompacted soil with impermeable surfaces such as buildings, roads and compacted fill. The reduction in permeability results in increased volumes of runoff, and faster and more concentrated delivery of this water to receiving waters. These changes have the potential to cause creeks to erode faster than before development.[1]

[1] Although the focus of hydromodification management plans has been on increased erosion it should be noted that in rivers that are depositional hydromodification can cause creeks to regain some transport equilibrium.

Stream flows are often expressed in terms of the frequency with which a particular flow occurs. For example, Q_2 refers to the flow rate that occurs once every two years, on average over the long term. Flow frequencies are a function of rainfall and watershed characteristics, and are unique to each stream channel (and location along the channel). The effects of urbanization tend to increase the magnitude of the flow associated with a given frequency (e.g. post-development Q_2 higher than pre-development Q_2). Similarly, urbanization tends to increase the frequency with which any given flow rate occurs. The purpose of the HMP is to control runoff from new developments so that flow magnitudes and frequencies match pre-development conditions within a critical range of flows.

Not all runoff causes erosion: runoff in receiving channels below a critical discharge (Q_{crit}) does not exert sufficient force to overcome the erosion resistance of the channel banks and bed materials. Flows greater than Q_{crit} cause erosion, with larger flows causing proportionally greater erosion. It has been determined by calculations and field measurements that most erosion in most natural creeks is caused by flows between some fraction of Q_2 and Q_{10} (see for example Leopold, 1964). Flows in this range are referred to as 'geomorphically-significant' because they cause the majority of erosion and sediment transport in a channel system.

Flows greater than Q_{10}, though highly erosive *per event*, occur too infrequently to do as much work as smaller but more frequent flows (see Figure 1). Hydromodification also has less impact on flows greater than Q_{10} since at such high rainfall intensities the soil becomes saturated and the infiltration capacity of undeveloped landscapes is rapidly exceeded. When the soil is saturated, runoff rates become more similar to those from impervious surfaces. For these reasons, HMPs have focused on identifying a low flow threshold that is close to Q_{crit} for most receiving channels, and controlling flows between that value and Q_{10} (see for example the HMPs completed in Santa Clara, Contra Costa, Alameda and San Mateo Counties). By requiring treatment (storage and either infiltration or detention) of excess runoff within the control range, and by limiting the release of excess water to Q_{crit} or less, HMPs seek to prevent additional erosion in receiving channels.

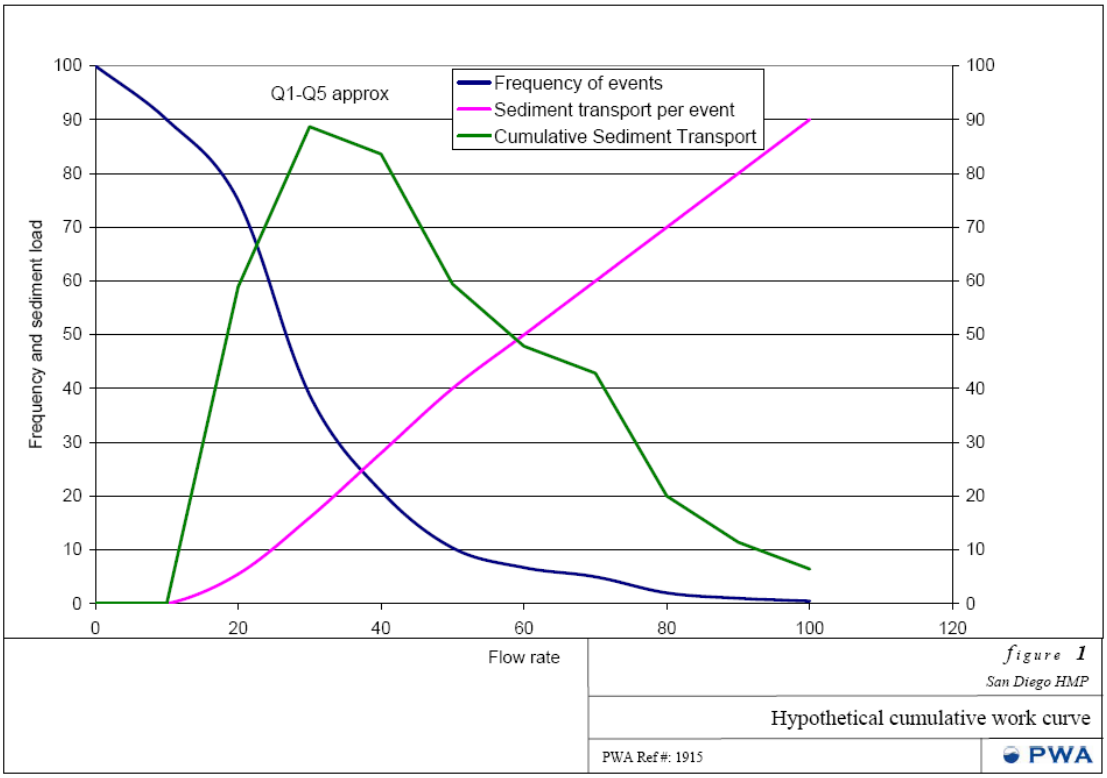

figure 1
San Diego HMP
Hypothetical cumulative work curve
PWA Ref #: 1915
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2. IDENTIFYING A HIGH FLOW THRESHOLD

Previous HMPs have focused considerable attention on the low flow threshold, but little on the high flow threshold. The use of an upper flow threshold is based on two assumptions:

1. Flows above this level cause relatively little cumulative erosion in receiving waters due to their low recurrence
2. Flows above this level are relatively unaffected by hydromodification because at such high rainfall intensities and durations the pre-development ground cover become saturated and most rain runs off, similar to in a post development condition.

The five HMPs developed to date in California have all adopted a value of Q_{10} as the upper threshold. We propose adopting the same value for the San Diego HMP.

3. IDENTIFYING A LOW FLOW THRESHOLD

Erosion occurs when the shear stress exerted on the channel by flowing water (*boundary shear stress*) exceeds the resistance of the channel (*critical shear stress*). Critical shear stress varies by several orders of magnitude for different channel materials (Table 1). *Critical flow* (Q_{crit}) is the channel flow which produces boundary shear stress equal to the critical shear stress for a given channel. That is, the flow rate that can initiate erosion in a channel. Q_{crit} is a function not only of the critical shear stress of the channel materials, but also channel size, and channel geometry. A particular flow rate (expressed as a number of cubic feet per second) in a small, steep, confined channel will create more shear stress than the identical flow rate in a large, flat, wide open channel. Thus Q_{crit} can be extremely variable depending on channel and watershed characteristics and will be different in each channel, and in each watershed.

Boundary Category	Boundary Type	Permissible Shear Stress (lb/sq ft)
Soils	Fine colloidal sand	0.02 - 0.03
	Sandy loam (noncolloidal)	0.03 - 0.04
	Alluvial silt (noncolloidal)	0.045 - 0.05
	Silty loam (noncolloidal)	0.045 - 0.05
	Firm loam	0.075
	Fine gravels	0.075
	Stiff clay	0.26
	Alluvial silt (colloidal)	0.26
	Graded loam to cobbles	0.38
	Graded silts to cobbles	0.43
	Shales and hardpan	0.67
Gravel/Cobble	1-in.	0.33
	2-in.	0.67
	6-in.	2.0
	12-in.	4.0
Vegetation	Class A turf	3.7
	Class B turf	2.1
	Class C turf	1.0
	Long native grasses	1.2 – 1.7
	Short native and bunch grass	0.7 - 0.95
	Reed plantings	0.1-0.6
	Hardwood tree plantings	0.41-2.5
Temporary Degradable RECPs	Jute net	0.45
	Straw with net	1.5 – 1.65
	Coconut fiber with net	2.25
	Fiberglass roving	2.00
Non-Degradable RECPs	Unvegetated	3.00
	Partially established	4.0-6.0
	Fully vegetated	8.00
Riprap	6 – in. d_{50}	2.5
	9 – in. d_{50}	3.8
	12 – in. d_{50}	5.1
	18 – in. d_{50}	7.6
	24 – in. d_{50}	10.1
Soil Bioengineering	Wattles	0.2 – 1.0
	Reed fascine	0.6-1.25
	Coir roll	3 - 5
	Vegetated coir mat	4 - 8
	Live brush mattress (initial)	0.4 – 4.1
	Live brush mattress (grown)	3.90-8.2
	Brush layering (initial/grown)	0.4 – 6.25
	Live fascine	1.25-3.10
	Live willow stakes	2.10-3.10
Hard Surfacing	Gabions	10
	Concrete	12.5

[1] Ranges of values generally reflect multiple sources of data or different t

A. Chang, H.H. (1988).
B. Florineth. (1982)
C. Gerstgraser, C. (1998).
D. Goff, K. (1999).
E. Gray, D.H., and Sotir, R.B. (1996).
F. Julien, P.Y. (1995).
G. Kouwen, N.; Li, R. M.; and Simons, D.B., (1980).
H. Norman, J. N. (1975).
I. Schiechtl, H. M. and R. Stern. (1996).
J. Schoklitsch, A. (1937).

Table 1. Range of critical shear stresses (τ_{cr}) for different materials. From Fischenich, 2001.

It was the original intent of the HMP project team to identify a single low flow threshold for the entire county (per previous HMPs). However, an extensive assessment of channel and runoff conditions led the team to conclude that there was a very wide range in critical flows, based largely on channel material but also on channel dimensions, rainfall, and watershed area[2]. Adopting a single standard that is conservative for the most vulnerable channels would result in controls that were excessively conservative for more resilient channels, while adopting an 'average' value would leave some channels unprotected. As the ongoing SCCWRP Hydromod project is showing, individual creeks have different risk categories and respond in different ways to the same level of hydromodification. Because of this natural variability, we pursued an analytical approach for estimating Q_{crit} as a function of parameters such as channel materials, channel dimensions and watershed area. The following sections of this report describe an analysis of Q_{crit} as a fraction of Q_2 for the range of channel conditions in San Diego County. This is followed by a description of a calculator tool developed by PWA that may be used to calculate Q_{crit} for a specific channel based on parameters that may be readily measured in the field. The analyses described in this report provide background for the selection of low flow thresholds identified in the HMP.

[2] These early analyses are summarized in Appendix D of the Final Hydromodification Management Plan.

4. CRITICAL FLOW ANALYSIS

4.1 BACKGROUND

PWA conducted a sensitivity analysis in which a wide range of channel sizes and geometries, rainfalls, watershed areas and channel materials were modeled in a flow-erosion model to identify Q_{crit} as a function of Q_2. In all, 170 combinations of channel, rainfall and watershed conditions were assessed (described below). Based on the results of this sensitivity analysis, a range of Q_{crits} were identified for several categories of channel materials.

The steps used to conduct the sensitivity analysis:

1. Identify the typical range of rainfall conditions for the HMP area (west San Diego County)
2. Identify the range of typical watershed areas likely to be developed
3. Identify a range of typical receiving channel dimensions for each watershed area
4. Identify a range of typical channel materials for receiving channels
5. Simulate a range of flows and develop rating curves (relationships between discharge and boundary shear stress)
6. Identify the flow rate at which boundary shear stress exceeds critical shear stress for the channel and material
7. Express this flow rate as a function of Q_2
8. Group critical flow rates by channel materials.

Steps 1 through 4 were used to define the range of parameters to use in the sensitivity testing. The intent was to identify a typical range of conditions likely to occur in the HMP area (west San Diego County), rather than provide an exhaustive description of possible watershed and channel conditions. Sensitivity testing on many combinations of parameters within this typical range allows identification of the range of channel responses and critical flows.

Each step in the critical flow analysis is explained in detail in the following sections.

4.2 IDENTIFY THE TYPICAL RANGE OF RAINFALL CONDITIONS FOR THE HMP AREA (WEST SAN DIEGO COUNTY)

Mean annual rainfall was used to estimate receiving channel size, Q_2, Q_5 and Q_{10} (methods described in subsequent sections). Figure 2 shows mean annual rainfall for San Diego County. Based on the map, three mean annual rainfalls were selected to represent the range of rainfall conditions for the simulations: 10”, 20” and 30”.

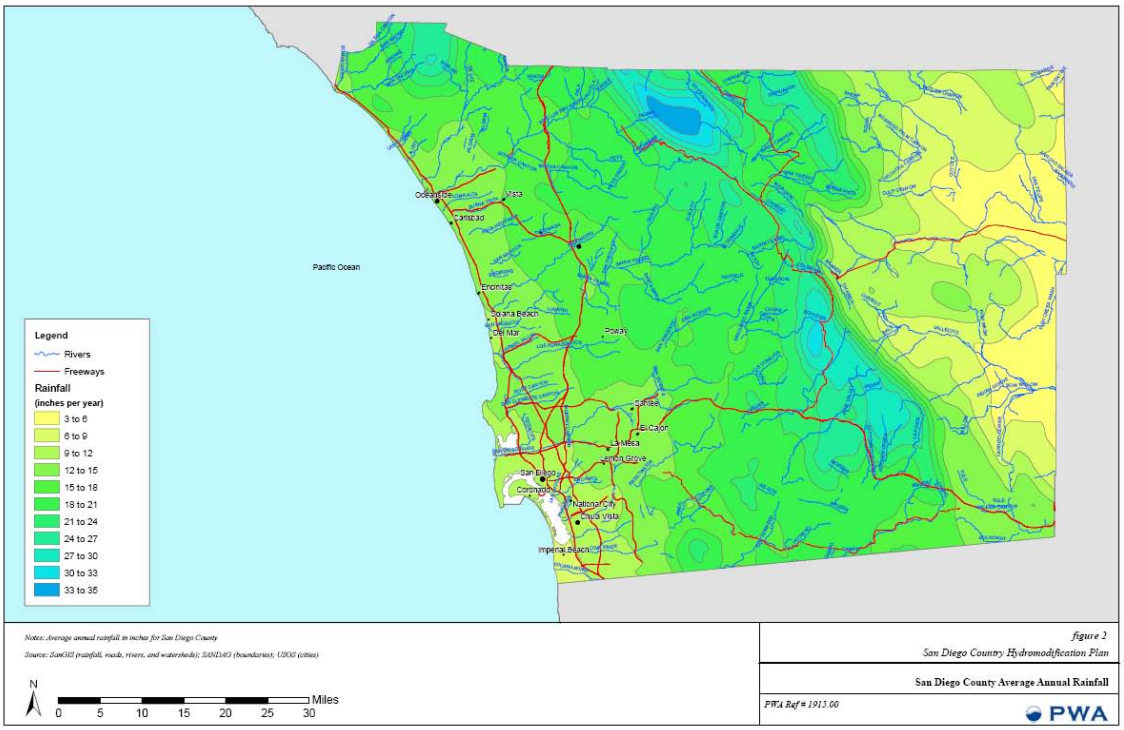


Figure 2. Rainfall distribution in San Diego County

4.3 IDENTIFY THE RANGE OF TYPICAL WATERSHED AREAS LIKELY TO BE DEVELOPED

Based on discussions with the Technical Advisory Committee, a range of representative watershed areas for development projects was identified. These were: 0.1 sq mi, 0.5 sq mi, 1 sq mi, 2 sq mi. We assumed that in project watersheds larger than 2 sq mi the development would either require site specific continuous simulation modeling, or be broken into multiple smaller sub watersheds with individual points of compliance.

4.4 IDENTIFY A RANGE OF TYPICAL RECEIVING CHANNEL DIMENSIONS FOR EACH WATERSHED AREA

Empirical relationships have been developed to express channel dimensions (width, depth and, to a lesser extent, gradient) as a function of dominant discharge. Dominant discharge for a creek channel is the flow rate that transports the majority of sediment and creates/maintains the characteristic size and shape of the channel over time. Dominant discharge may also be referred to as bankfull flow. For undeveloped channels in semi arid parts of the US, dominant discharge is approximately equivalent to Q_5. For example, Coleman et. al. (2005) found dominant discharge for streams in Southern California to average $Q_{3.5}$ (range = $Q_{2.1}$ – $Q_{6.7}$.) Goodwin (1998) found dominant discharge to vary from Q_2 to Q_{10} for semi arid regions.

To capture natural variability in channel geometry, we used three different empirical channel geometry relationships to estimate receiving channel dimensions for the range of watershed areas and rainfall characteristics used in this study. The relationships were:

Coleman et. al. 2005 (modified by Stein – personal communication) – derived from undeveloped channels in Southern California, tends to predict narrow, deep, steep dimensions.

$$\text{Width (ft)} = 0.6012 * Q_{bf}^{0.6875}$$

$$\text{Depth (ft)} = 0.3854 * Q_{bf}^{0.3652}$$

Where Q_{bf} is in cfs.

Parker et al. 2007 – suitable for gravel channels, tends to predict wide, shallow, flat braided dimensions.

$$\text{Width (m)} = 4.63 * (Q_{bf}^{2/5}) / (9.81^{1/5}) * (Q_{bf} / \texttt{Sqrt}\ (9.81 * d50) * d50^2))^{0.0667}$$

$$\text{Depth (m)} = 0.382*((Qbf^{2/5})/(9.81^{1/5})))$$

Where Q_{bf} is bankfull discharge in m^3/sec and d50 (diameter of median channel material) is in m.

The Parker equation was only used to assess gravel and cobble channel conditions.

Hey and Thorne 1986 tends to predict medium width, depth, and gradient channels.

$$\text{Width (m)} = 2.73*Q_{bf}^{0.5}$$

$$\text{Depth (m)} = 0.22 * \text{Width}^{0.37} * d50^{-0.11}$$

Where Q_{bf} is in m^3/sec and d50 is in m.

(Note that we have used the original combinations of English and metric units described in the source papers rather than standardized these equations in one set of measurements.)

The three equations cover a wide range of likely field conditions, from deeply incised channels (Coleman et al, 2005) to wide, braided conditions (Parker, 2007). Note that for the sensitivity analysis we set d50 in the Parker et al. equation to the d50 of the channel material being tested, and did not use the equation for channels where the material was sand or silt.

The equations produce estimations of width and depth. To estimate a slope for each combination of channel dimensions we calculated the velocity associated with each cross section (by dividing

discharge by width multiplied by depth) and calculated the slope that corresponded with that velocity using Manning's equation.

$$\text{Velocity (ft/sec)} = 1.486 \frac{HR^{0.66} * s^{0.5}}{n}$$

Where HR is channel hydraulic radius, s is slope, and n is Manning's roughness coefficient (see definitions). For the purposes of the sensitivity analysis a value of n 0.035 was assumed, corresponding to a non vegetated, straight channel with no riffles and pools. This is a reflection of the small, ephemeral receiving channels which are most prevalent in Southern California developments. A relatively low value was used at the request of the San Diego RWQCB so that the values erred on the conservative side.

These equations all require a value for bankfull discharge. Bankfull discharge (assumed to be approximately Q_5) was estimated using the USGS regional regression for undeveloped watersheds in the South Coast region (Waananen and Crippen, 1977). This equation calculates Q_5 as a function of watershed area and mean annual precipitation, based on empirical observations of USGS gages. The relationship is:

$$Q_5 \text{ (cfs)} = 0.4 * \text{Watershed Area}^{0.77} * \text{Mean Annual Precipitation}^{1.69}$$

Where watershed area is in square miles and precipitation is in inches.

For each combination of typical watershed area (Section 2.2) and mean annual rainfall (Section 2.3) we calculated Q_5 using the USGS regression, then calculated three sets of channel dimensions based on the three channel equations. This provided the range of channel conditions to simulate for the critical flow analysis. The total number of channel conditions was as follows:

3 rainfalls (10, 20, 30 inches per year)
4 watershed areas (0.1, 0.5, 1, 2 square miles)
3 channel width, depth and slope combinations (narrow/deep, medium, wide/shallow)
= 36 combinations of receiving channel geometry

4.5 IDENTIFY A RANGE OF TYPICAL CHANNEL MATERIALS FOR RECEIVING CHANNELS

We identified a range of typical channel materials based on feedback from the TAC and experience gained working in San Diego County. The identified materials are not intended as a comprehensive list of possible channel materials, but to cover the range of critical shear stresses likely to be encountered in typical western San Diego County channels. The identified range is as follows:

Material	Critical shear stress (lb/sq ft)
Coarse unconsolidated sand	0.025
alluvial silt (non coloidal)	0.045
medium gravel	0.12
alluvial silt/clay	0.26
2.5 inch cobble	1.1

Combining the 5 channel material types with the 36 combinations of channel geometry produces 180 potential combinations of receiving channel characteristics. Ten sets of combinations were omitted from the analysis because they produced physically unrealistic conditions, such as slopes that were too steep to be developed. Exclusion of these results did not significantly affect the overall results.

4.6 DEVELOP SHEAR STRESS RATING CURVES

Rating curves for the 36 different combinations of receiving channel characteristics were developed using the same Excel worksheet that forms the basis for the Qcrit calculator developed for Track 2 (described in later sections). Using channel cross section, roughness and gradient input by the user, the tool calculates the average boundary shear stress associated with a range of different flow depths to construct a rating curve (discharge on the x axis versus shear stress on the y axis). It then identifies the flow rate where average boundary shear stress equals critical shear stress for the channel materials. This is the critical flow (Q_{crit}). By dividing this number by Q_2 we identify the critical flow for each simulation as a function of Q_2 (e.g. $0.1Q_2$ where the critical flow is one tenth of the Q_2 flow).

The tool calculates a shear stress rating curve for a range of flows between 1% and 100% of the bankfull flow depth. Bankfull flow depth is defined as the flow depth that corresponds to the dominant discharge for a given channel. The range 1% to 100% of bankfull is used because critical flow rarely falls outside these values. The tool then calculates an equation that allows for interpolation between the points. For each of the depths, the tool calculates discharge and average boundary shear stress exerted on the bed, as described below.

4.6.1 Calculating Average Boundary Shear Stress

Average boundary shear stress is the force that flowing water exerts on channel materials. For a given channel cross-section, it is calculated as follows:

$$\tau_b = \gamma * HR * s$$

where τ_b = average boundary shear stress (lb/ft^2)
γ = unit weight water (62.4 lb/ft^3)
HR = Hydraulic radius (cross section area / wetted perimeter)
S = channel slope (ft/ft)

For each depth increment between 1% and 100% of bankfull, cross section area, wetted perimeter, HR and τ_b are calculated. Slope is a constant for the cross section. These calculations produce a rating curve for boundary shear as a function of flow depth.

4.6.2 Calculating Flow Rate

This step converts flow depth to flow rate (Q) so that the rating curve may be expressed as a function of Q. For each depth increment between 1% and 100% of bankfull, the flow rate is calculated using Manning's equation:

$$\text{Velocity (ft/sec)} = 1.486 \frac{HR^{0.66} * s^{0.5}}{n}$$

where V = velocity (ft/sec)
n = Manning's roughness coefficient

For the sensitivity analysis Manning's n was assumed to be 0.035, which is typical for a non-vegetated ephemeral channel. We assumed that for most developments covered by the HMP the receiving channels would be relatively high in the watershed and would have received little summer flow. In interim sensitivity analysis found that relative to other factors such as critical shear stress, the range of roughness factors found in receiving channels had little effect on the estimated critical shear flow rate.

Discharge is calculated as velocity multiplied by cross section area (calculated for each cross section, above). The result of these calculations is a rating curve showing boundary shear stress for the receiving channel as a function of discharge, with the highest point representing bankfull depth (see Figure 3 below). Rating curves were created for each of the 36 combinations of channel characteristics.

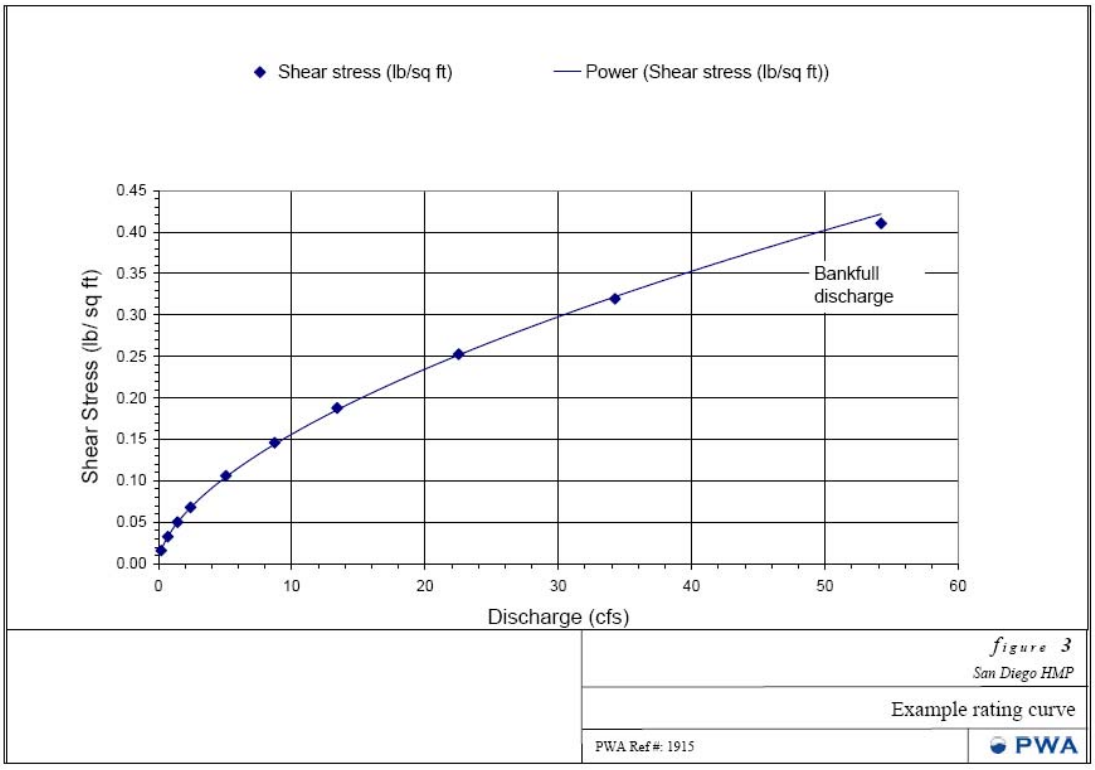


Figure 3. Shear stress rating curve for an example channel (0.5%, 10 feet wide, 2 feet deep). These curves were created for 36 different combinations of channel characteristics.

4.7 IDENTIFY CRITICAL FLOW FOR THE CHANNEL AND MATERIAL

Q_{crit} is the flow rate at which boundary shear stress equals critical shear stress. The tool uses a power function to interpolate the discharge versus boundary shear stress rating curve, to allow calculation of an intercept between the rating curve and critical shear stress. The critical shear stress for each channel material was plotted horizontally from the Y axis until it intercepted the rating curve. The intercept point was extended vertically to the X axis, showing the Q_{crit} (see Figure 4 below). In this way, Q_{crit} was calculated for each of the five channel materials using each of the 36 rating curves representing different channel dimensions. As mentioned above, 10 combinations unlikely to occur in nature were eliminated, resulting in a total of 170 Q_{crit} calculations.

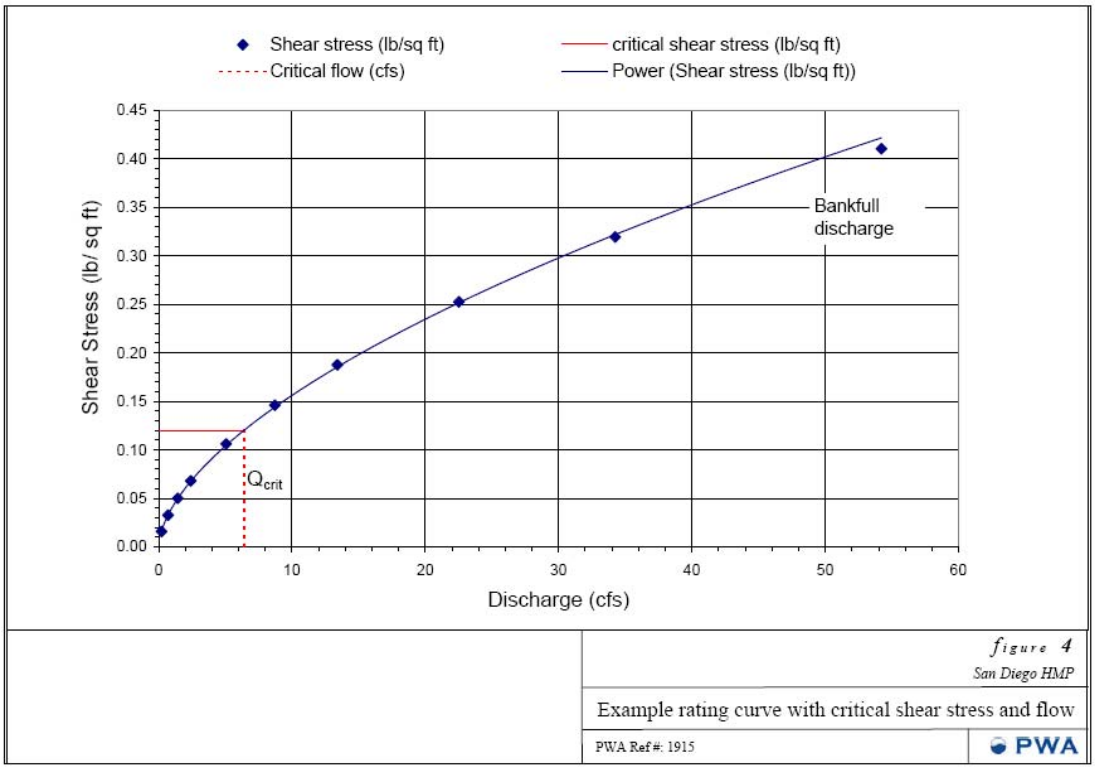


Figure 4. Example of a rating curve with critical shear stress for medium sized gravel. In this example critical shear stress = 0.12 lb/sq ft and critical flow Q_{crit} = 6.4 cfs.

4.8 EXPRESS CRITICAL FLOW AS A FUNCTION OF Q_2

As described above, each rating curve represents a particular combination of watershed area and channel dimensions. Q_2 was calculated for each combination using the USGS regional regression for Q_2 as described in section 4.4. By dividing the calculated Q_{crit} by the appropriate Q_2, Q_{crit} as a proportion of Q_2 was calculated for the 170 scenarios. These Q_{crits} were then plotted by material type, showing mean and one standard deviation either side of the mean. Note that although we assume that Q_5 is bankfull discharge, we express the critical flow as a function of Q_2 as has become standard for HMPs.

4.9 CRITICAL FLOW ANALYSIS RESULTS

The results show the high degree of variability in Q_{crit} based on different channel materials. It is important to note that in field conditions many of the most extreme cases shown in the figure (examples with very high or very low thresholds) would tend to evolve to conditions that yielded critical flows closer to the bankfull discharge because channels have a tendency to self equilibrate. For example, channels with materials that have very low critical flows such as

unconsolidated sand tend to erode and either flatten (lowering shear stress, and so increasing critical flow rate) or armor (increasing flow resistance, and increasing critical flow rate). Likewise, channels with materials that have very high thresholds tend to either become steeper due to deposition (increasing shear stress and lowering critical flow rate) or fill in with finer material (reducing resistance and lowering critical flow rate).

4.10 DISCUSSION

As the results of this analysis demonstrate, critical flow is extremely variable among channel materials and, for a given channel material, can vary significantly with channel configuration (slope, width/depth ratio etc.). Unconsolidated fine sediments can be mobilized by extremely low flows in the absence of clays or other consolidating elements with the structure of the channel. This result is based on literature values for critical shear stress for unconsolidated materials and may not be realistic for natural channels. Therefore in setting flow thresholds this result should be balanced with the recognition that natural channels are likely to include some consolidating fraction within their structure, as well as practical considerations associated with controlling trickle flows that represent the smaller fractions of Q_2 analyzed in this study.

5. TOOL FOR CALCULATING SITE-SPECIFIC CRITICAL FLOW

5.1 BACKGROUND

PWA developed a tool for calculating a site-specific critical flow (Q_{crit}) based on local conditions. Q_{crit} for the receiving channel is calculated based on channel geometry (width, depth and gradient), channel materials, and watershed area.

The approach taken was to develop an Excel spreadsheet model to calculate the boundary shear stress associated with a range of flows up to Q_5 for a given channel width, depth and slope, then plot the critical shear stress for the channel material on this rating curve over to identify the flow where boundary shear stress equals critical shear stress (see example graph below).

The development steps were as follows:

1. Develop simplified channel cross section and gradient inputs
2. Calculate a shear stress rating curve
3. Characterize channel materials in terms of critical shear stress
4. Plot critical shear stress of the receiving channel on the rating curve to determine Q_{crit}
5. Divide the critical low flow by the project areas as a proportion of the receiving water watershed area to determine the allowable flow at the point of compliance

5.2 SIMPLIFIED CHANNEL CROSS SECTION AND GRADIENT INPUTS

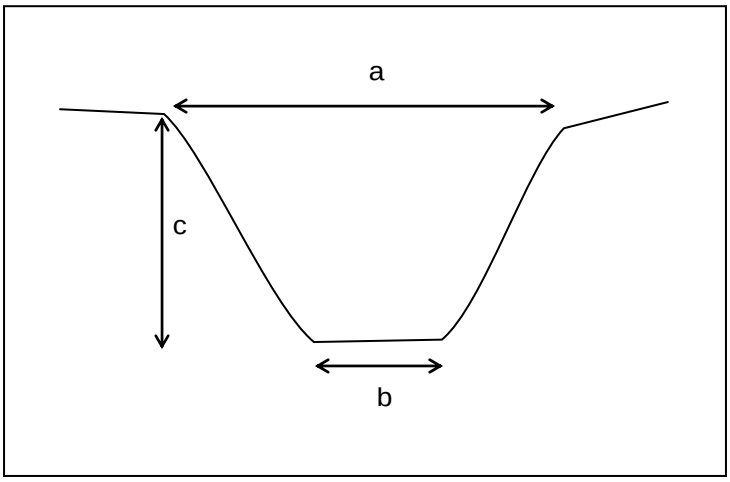
The tool generates a flow rating curve based on user inputs describing the receiving channel dimensions (cross section) and gradient. The first step in developing the tool was to create a template for inputting the required channel parameters. The template assumes a simple trapezoidal cross section, with the following elements:

1. Channel width at a well defined break point corresponding to top of bank (a)
2. Channel width at the toe of the bank (b)
3. Channel depth (elevation difference between bank top and channel bed) (c)

Assumptions:

1. Receiving channels can be reasonably represented by a simple trapezoidal cross section
2. The top of bank corresponds reasonably to the level inundated by the dominant discharge (approximately equal to Q_5)

If top of bank is much higher than the dominant discharge flow depth (e.g. in an incised channel) the applicant should adjust the cross section to represent the lower part of the channel so that depth (c) corresponds approximately to the Q_5 depth.



5.3 DEVELOP A SHEAR STRESS RATING CURVE

The tool creates a shear stress rating curve for a range of flows between 1% of the bankfull flow depth and bankfull depth (flow at depth (c).) The range 1% to 100% of bankfull is used because critical flow rarely lies outside these values. The tool then calculates a power function between the points to allow for interpolation. For each of the flows the tool calculates average boundary shear stress exerted on the bed, and discharge, as described below.

5.3.1 Calculating Average Boundary Shear Stress

Average boundary shear stress is the force that erodes channel materials. It is calculated as follows:

$$\tau_{crit} = \gamma * HR * s$$

where τ_{crit} = average boundary shear stress (lb/ft^2)
γ = unit weight water (62.4 lb/ft^3)
HR = Hydraulic radius (cross section area / wetted perimeter)
S = channel slope (ft/ft)

For each depth increment between 1% of bankfull and bankfull, cross section area, wetted perimeter, HR and τ_{crit} are calculated. Slope is assumed to be constant for the cross section; therefore multiple calculations may be required for variable slope conditions. These calculations produce a rating curve for boundary shear stress as a function of flow depth.

5.3.2 Calculating Discharge

For each depth increment between 1% of bankfull and bankfull discharge is calculated using Manning's equation:

$$V = 1.486 \frac{HR^{0.66} * S^{0.5}}{n}$$

where V = velocity (ft/sec)
n = Manning's roughness coefficient

Manning's n is entered by the user from a drop down dialogue box ranging from 0.03 (smooth, straight earth channel with no vegetation) to 0.12 (windy, rough bed channel with dense vegetation).

Discharge is calculated as velocity multiplied by cross section area. The product of these calculations is a rating curve showing boundary shear stress for the receiving channel as a function of discharge, with the highest point representing bankfull flow (see Figure 7 below).

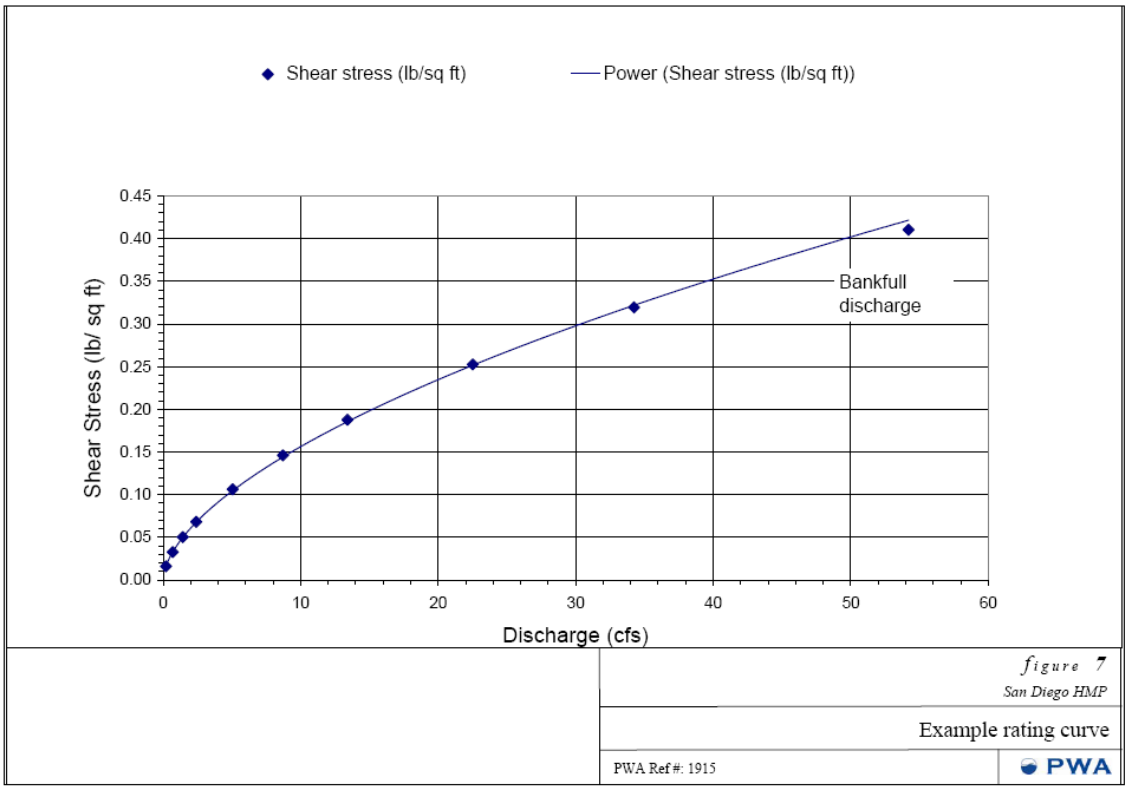


Figure 7. Shear stress rating curve for an example channel (0.5%, 10 feet wide, 2 feet deep)

5.4 CHARACTERIZE RECEIVING CHANNEL MATERIALS IN TERMS OF CRITICAL SHEAR STRESS

The critical shear stress of the channel materials is estimated using a look-up table based on values published by the USACE (Fischenich, 2001). The tool provides values of critical shear stress for a wide range of channel materials in a drop down box so the user can select from the list, or select a median particle size (d50). The values are shown in Table 1. The calculator also allows the user to input a vegetated channel material when this is appropriate (when the channel is completely lined in vegetation). The process for identifying representative materials is covered in the implementation chapter.

5.5 CALCULATING CRITICAL FLOW FOR THE RECEIVING WATER

Critical flow is the discharge at which boundary shear stress equals critical shear stress. The tool uses a power function to interpolate the discharge versus boundary shear stress rating curve. The critical shear stress for the weaker of the bed or banks is plotted horizontally from the Y axis until it intercepts the rating curve. The intercept point is extended vertically to the X axis, showing the critical flow (see Figure 8 below). This represents Q_{crit} for the receiving water. Note that the creation of a site-specific rating curve allows Q_{crit} to be expressed as a specific flow rate (Q) rather than a fraction of Q_2.

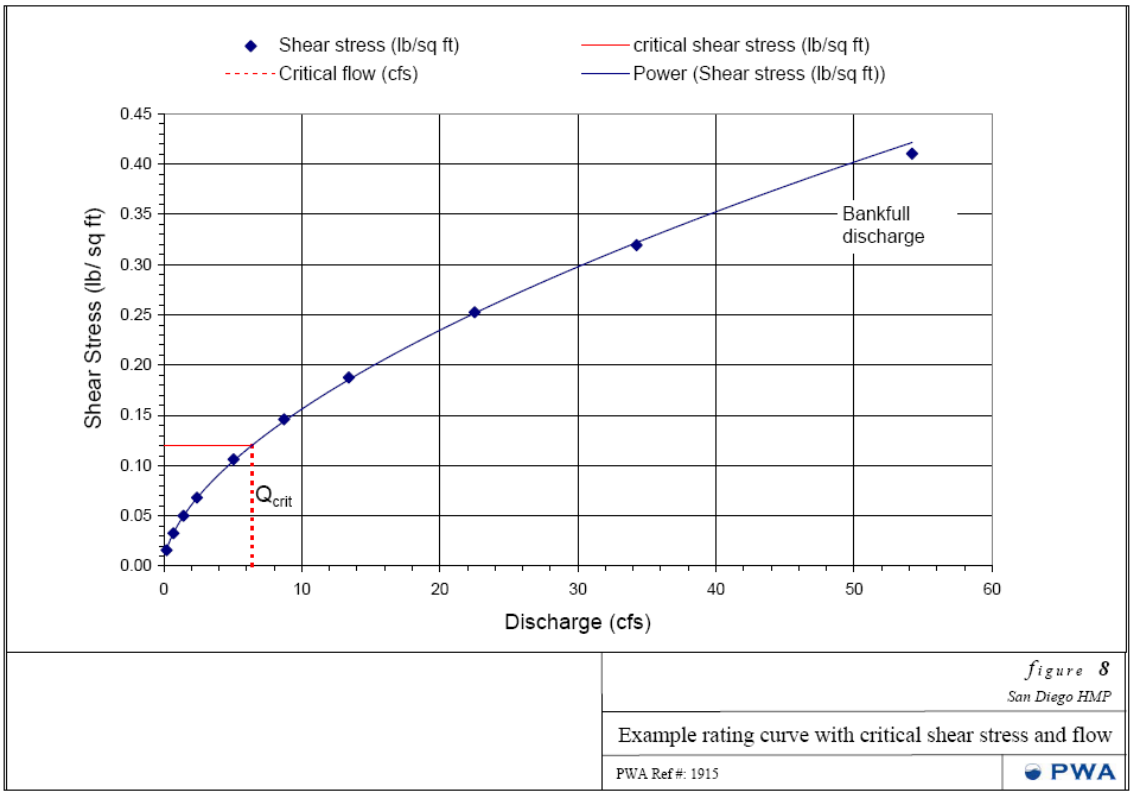


Figure 8. Example of a rating curve with critical shear stress for medium sized gravel. In this example critical shear stress = 0.12 lb/sq ft and critical flow Q_{crit} = 6.4 cfs.

5.6 CALCULATING CRITICAL FLOW AT THE POINT OF COMPLIANCE

The tool calculates critical flow based on the characteristics of the receiving water. Where the project watershed does not make up the entire watershed area for the receiving water, it is necessary to divide the estimated Qcrit based on the percentage of the watershed that is occupied by the project site[3]. For example, if a project occupies one tenth of the receiving water's watershed at the point of compliance and the critical flow level is 50 cfs, the project's 'share' of the non-erosive flow is 5 cfs (50 x 1/10). This prevents the cumulative impact of future developments from exceeding critical flow in the receiving water, since the critical flow is apportioned according to watershed area.

$$\text{Critical flow at Point of Compliance} = \text{Critical flow at receiving water} \times \frac{\text{project area}}{\text{watershed area}}$$

[3]. It is not necessary to adjust the "off-the-shelf" thresholds developed for Track 1 for point of compliance, since they are expressed as a fraction of Q2 for the relevant project area.

5.7 CONVERSION OF CRITICAL FLOW TO FLOW CLASS

To avoid having an infinite range of flow control standards the calculator assigns the discharge into one of three classes based on its value as a function of the estimated Q_2. These classes are: $0.1Q_2$, $0.3Q_2$, $0.5Q_2$. For example, a channel where the critical flow is $0.15Q_2$ would be assigned a flow threshold of $0.1Q_2$. Channels with critical flows less than $0.1Q_2$ are assigned to the $0.1Q_2$ class. The class flow rate is calculated (i.e. the critical flow corresponding to the assigned fraction of Q_2 and expressed as the final output of the tool.

6. GLOSSARY

Bankfull depth
The water depth between the deepest part of the channel and the water surface, during bankfull discharge. Also the vertical distance between the uppermost 'bankfull indicators' and the deepest part of the channel.

Bankfull discharge
The flow rate at which the actively scoured portion of the creek channel is filled with water. In southern California bankfull discharge has typically been found to be between Q2 and Q7, with an average of approximately Q5.

Bankfull indicators
Morphological evidence for the portion of a creek channel that is subject to active scour and sediment transport processes. Typical indicators include scour lines along a bank, the highest vertical level on point bars, base of undercut tree roots.

Bankfull width
The width of the channel at the water surface during bankfull discharge. Also the horizontal distance between 'bankfull indicators' across a channel.

Critical flow
The discharge corresponding to Critical Shear Stress. Varies with channel geometry and materials.

Critical shear stress
The shear stress at which a given channel material is eroded. In non cohesive sediments larger particles have higher critical shear stresses. In cohesive sediments (those smaller than 0.063 mm) sediment has higher critical shear stresses than fine, non cohesive materials

d50
The median sediment particle size in a sample of material taken from a creek bed (diameter of the 50th percentile)

Geomorphically-significant flows
The range of flows that, over a period of several decades, erode and transport the majority of the sediment in a creek system. The mid range of this flow range tends to be similar to "bankfull" discharge, leading people to infer that these flows shape the channel as well as moving most sediment. Calculated by integrating the flow frequency curve with the sediment rating curve.

Point of Compliance
The point at which collected stormwater from a development is delivered from a constructed or modified drainage system into the natural creek receiving water. Note that the HMP applies only to discharge into a natural creek of receiving water, and does not apply to sheet flow or overland flow from a developed site.

Q2
The discharge that recurs on average every 2 years, and that has a 50% probability of occurring in any single year.

Q10
The discharge that recurs on average every 10 years, and that has a 10% probability of occurring in any single year.

Shear stress (also known as boundary shear stress or average boundary shear stress)
The average force exerted by flowing water on the channel boundary. Shear stress is the force responsible for eroding sediment from the channel boundary. It is a function of water surface gradient (related to channel gradient), water depth, and water density.

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APPENDIX B

SCCWRP Channel Screening Report

Use of contents on this sheet is subject to the limitations specified at the end of this document.
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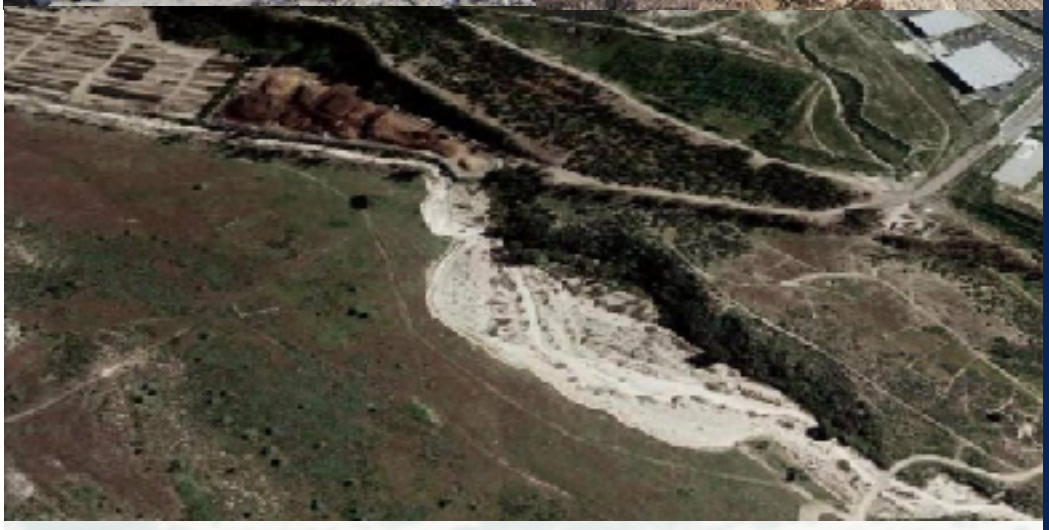
HYDROMODIFICATION SCREENING TOOLS: FIELD MANUAL FOR ASSESSING CHANNEL SUSCEPTIBILITY







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Technical Report 606 - March 2010

Hydromodification Screening Tools: Field Manual for Assessing Channel Susceptibility

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Technical Report 606

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EXECUTIVE SUMMARY

Managing the effects of hydromodification (physical response of streams to changes in catchment runoff and sediment yield) has become a key element of most stormwater programs in California. Although straightforward in intent, hydromodification management is difficult in practice. Shifts in the flow of water and sediment, and the resulting imbalance in sediment supply and capacity can lead to changes in channel planform and cross-section via wide variety of mechanisms. Channel response can vary based on factors such as boundary materials, valley shape and slope, presence of in-stream or streamside vegetation, or catchment properties (e.g., slope, land cover, geology).

Management prescriptions should be flexible and variable to account for the heterogeneity of streams; a given strategy will not be universally well-suited to all circumstances. Management decisions regarding a particular stream reach(s) should be informed by an understanding of susceptibility (based on both channel and catchment properties), resources potentially at risk (e.g., habitat, infrastructure, property), and the desired management endpoint (e.g., type of channel desired, priority functions; see Figure ES1).

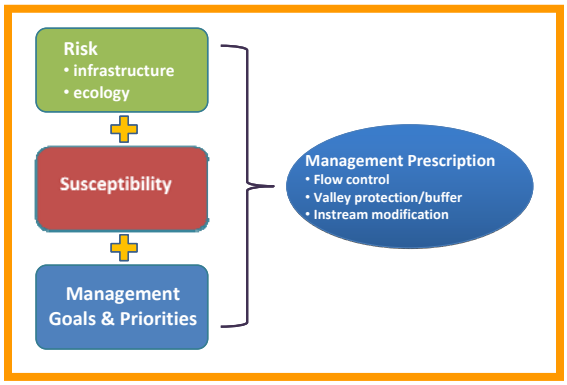

Figure ES1: Decision nodes that influence the management prescription for a particular stream reach.

We have produced a series of documents that outline a process and provide tools aimed at addressing the decision node associated with assessing channel susceptibility. The three corresponding hydromodification screening tool documents are:

1. *GIS-based catchment analyses of potential changes in runoff and sediment discharge* which outlines a process for evaluating potential change to stream channels resulting from watershed-scale changes in runoff and sediment yield.
2. *Field manual for assessing channel susceptibility* which describes an in-the-field assessment procedure that can be used to evaluate the relative susceptibility of channel reaches to deepening and widening.
3. *Technical basis for development of a regionally calibrated probabilistic channel susceptibility assessment* which provides technical details, analysis, and a summary of field data to support the field-based assessment described in the field manual.

The catchment analyses and the field manual are designed to support each other by assessing channel susceptibility at different scales and in different ways. The GIS-based catchment analyses document is a planning tool that describes a process to predict likely effects of hydromodification based on potential change in water and sediment discharge as a consequence of planned or potential landscape alteration (e.g., urbanization). Data on geology, hillslope, and land cover are compiled for each watershed of interest, overlaid onto background maps, grouped into several discrete categories, and classified independently across the watershed in question.

The classifications are used to generate a series of Geomorphic Landscape Units (GLUs) at a resolution defined by the coarsest of the three data sets (usually 10 to 30 m). Three factors: geology, hillslope, and land cover are used because the data are readily available; these factors are important to controlling sediment yield. The factors are combined into categories of High, Medium, or Low relative sediment production. The current science of sediment yield estimation is not sophisticated enough to allow fully remote (desktop) assignment of these categories. Therefore initial ratings must be verified in the field.

Once the levels of relative sediment production (i.e., Low, Medium, and High) are defined across a watershed under its current configuration of land use, those areas subject to future development are identified, and corresponding sediment-production levels are determined by substituting Developed land cover for the original categories and modifying the relative sediment production as necessary (Figure ES2). Conversely, relative sediment production for currently developed watershed areas can be altered to estimate relict sediment production for an undeveloped land use and used to assess the impact of watershed development on pre-development sediment production. The resultant maps can be used to aid in planning decisions by indicating areas where changes in land use will likely have the largest (or smallest) effect on sediment yield to receiving channels.

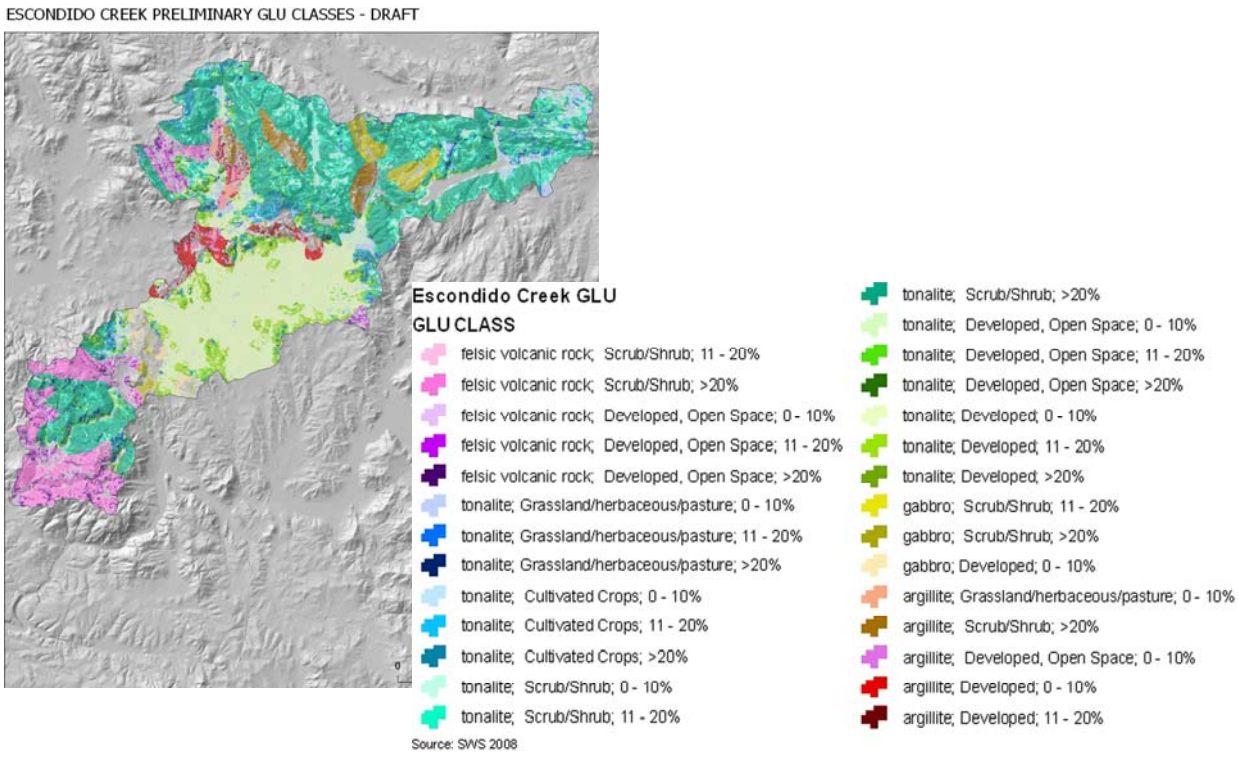

Figure ES2: Example of Geomorphic Landscape Units for the Escondido Creek Watershed.

The field assessment procedure is intended to provide a rapid assessment of the relative susceptibility of a specific stream reach to effects of hydromodification. The intrinsic sensitivity of a channel system to hydromodification as determined by the ratio of disturbing to resisting forces, proximity to thresholds of concern, probable rates of response and recovery, and potential for spatial propagation of impacts. A combination of relatively simple, but quantitative, field indicators are used as input parameters for a set of decision trees. The decision trees follow a logical progression and allow users to assign a classification of Low, Medium, High, or Very High susceptibility rating to the reach being assessed. Ratings based on likely response in the vertical and lateral directions (i.e., channel deepening and widening) are assigned separately. The screening rating foreshadows the level of data collection, modeling, and ultimate mitigation efforts that can be expected for a particular stream-segment type and geomorphic setting. The field assessment is novel in that it incorporates the following combination of features:

- Integrated field and office/desktop components
- Separate ratings for channel susceptibility in vertical and lateral dimensions
- Transparent flow of logic via decision trees
- Critical nodes in the decision trees are represented by a mix of probabilistic diagrams and checklists
- Process-based metrics selected after exhaustive literature review and analysis of large field dataset
- Metrics balance process fidelity, measurement simplicity, and intuitive interpretability
- Explicitly assesses proximity to geomorphic thresholds delineated using field data from small watersheds in southern California
- Avoids bankfull determination, channel cross-section survey, and sieve analysis, but requires pebble count in some instances
- Verified predictive accuracy of simplified logistic diagrams relative to more complex methods, such as dimensionless shear-stress analyses and Osman and Thorne (1988) geotechnical stability procedure
- Assesses bank susceptibility to mass wasting; field-calibrated logistic diagram of geotechnical stability vetted by Colin Thorne (personal communication)
- Regionally-calibrated braiding/incision threshold based on surrogates for stream power and boundary resistance
- Incorporates updated alternatives to the US Geological Survey (USGS; Waananen and Crippen 1977) regional equations for peak flow (Hawley and Bledsoe In Review)
- Does not rely on bank vegetation given uncertainty of assessing the future influence of root reinforcement (e.g., rooting depth/bank height)
- Channel evolution model underpinning the field procedure is based on observed responses in southern California using a modification of Schumm *et al*. (1984) five-stage model to represent alternative trajectories

The probabilistic models of braiding, incision, and bank instability risk embedded in the screening tools were calibrated with local data collected in an extensive field campaign. The models help users directly assess proximity to geomorphic thresholds and offer a framework for gauging susceptibility that goes beyond expert judgment. The screening analysis represents the first step toward determining appropriate management measures and should help inform decisions about subsequent more detailed analysis.

The GIS-based catchment-scale analysis and the field screening procedure are intended to be used as a set of tools to inform management decisions (Figure ES3). The catchment-scale analysis provides an overall assessment of likely changes in runoff and sediment discharge that can be used to support larger-scale land use planning decisions and can be applied prospectively or retrospectively. The field screening procedure provides more precise estimates of likely response of individual stream reaches based on direct observation of indicators. The field assessment procedure also provides a method to evaluate the extent of potential upstream and downstream propagation of effects (i.e., the analysis domain). In concept, the catchment-scale analysis would be completed for a watershed of interest before conducting the field analysis. However, this is not required and the two tools can be used independent of each other. It is not presently possible to describe a mechanistic linkage between the magnitude of the *drivers* of hydromodification (i.e., changes in the delivery of water and sediment to downstream channels), the *resistance* of channels to change, and the net expression on channel form. For this reason, the results of the catchment and field analyses must be conducted independently and the results cannot be combined to produce an overall evaluation of channel susceptibility to morphologic change (Figure ES3).

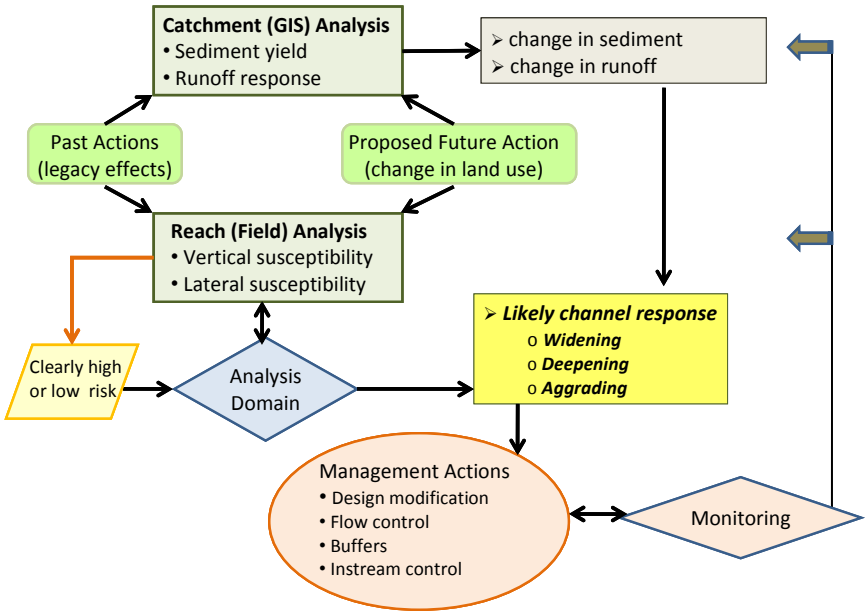

Figure ES3: Relationship of catchment and field screening tools to support decisions regarding susceptibility to effects of hydromodification.

Finally, it is important to note that these tools should be used as part of larger set of considerations in the decision making process (see Figure ES1). For example, the tools do not provide assessments of the ecological or economic affects of hydromodification. Similarly, they do not allow attribution of current conditions to past land use actions. Although the screening tool is designed to have management implications via a decision framework, policy/management decisions must be made by local stakeholders in light of a broader set of considerations.

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INTRODUCTION

Hydromodification, the response of streams to changes in flow and sediment input, is an area of active investigation and emerging regulation. Previous research that led to screening tool development has concluded that 1) urbanization markedly affects the flow regimes of streams in southern California, 2) the corresponding imbalances in sediment-transport capacity result in substantial geomorphic instabilities across most stream settings, 3) channels in southern California may be more sensitive than streams in other regions of the United States (US) for equivalent flows, bed-material sizes, valley slopes, and bank heights/angles, and 4) widely varying degrees of susceptibility to hydromodification are clearly reflected across the field study sites as an interaction between flow energy and the resistance of channel boundaries to lateral and vertical adjustments (Hawley 2009).

Many management schemes currently use a one-size-fits-all approach to managing hydromodification effects, whereby a single criterion is applied to all streams within a given area. However, factors such as dominant bed material, channel planform, grade control, vegetation, and existing infrastructure can influence the rate and manner in which streams respond to changes in flow and sediment. Consideration of these differences in management programs requires a tool to rate stream reaches in terms of their relative susceptibility to hydromodification effects.

This document provides the steps and process to apply a process-based hydromodification susceptibility screening tool. The tool builds on studies conducted in other regions, as summarized by Bledsoe *et al*. (2008), to provide a means to rank stream reaches in terms of their relative likelihood of response to hydromodification. The screening tool consists of two elements: 1) Geographic Information System (GIS) based landscape-scale analyses of relative runoff and sediment yield to stream channels, and 2) field-based assessment of channel condition. Together these two elements can be used to assess susceptibility of a specific stream reach based on both landscape and local influences (**Figure 1**). The GIS based analysis is intended mainly as a planning tool to allow potential changes in runoff and sediment yield to be considered during the siting and design of new developments. This tool is presented in the companion to this document. The field-based tool is intended to provide a rapid assessment of the relative susceptibility of a specific stream reach to effects of hydromodification. This tool is presented in this document.

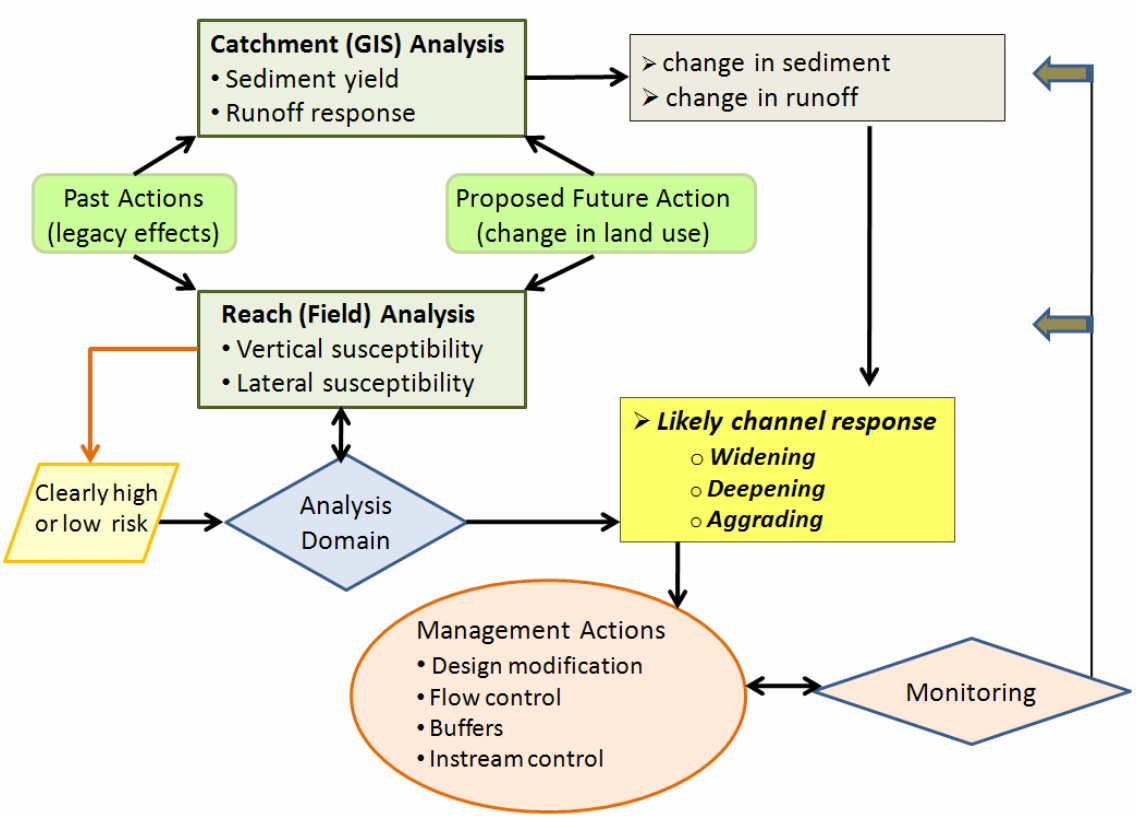


Figure 1. Conceptual application of GIS- and field-based screening tools.

General features of the field screening tool:

- Integrated field and office/desktop components
- Separate ratings for channel susceptibility in vertical and lateral dimensions
- Transparent flow of logic via decision trees
- Critical nodes in the decision trees are represented by a mix of probabilistic diagrams and checklists
- Process-based metrics selected after exhaustive literature review and analysis of large field dataset
- Metrics balance process fidelity, measurement simplicity, and intuitive interpretability
- Explicitly assesses proximity to geomorphic thresholds delineated using field data from small watersheds in southern California
- Avoids bankfull determination, channel cross-section survey, and sieve analysis, but requires pebble count in some instances

- Verified predictive accuracy of simplified logistic diagrams relative to more complex methods, such as dimensionless shear-stress analyses and Osman and Thorne (1988) geotechnical stability procedure
- Assesses bank susceptibility to mass wasting; field-calibrated logistic diagram of geotechnical stability vetted by Colin Thorne (personal communication)
- Regionally-calibrated braiding/incision threshold based on surrogates for stream power and boundary resistance
- Incorporates updated alternatives to the US Geological Survey (USGS; Waananen and Crippen 1977) regional equations for peak flow (Hawley and Bledsoe, In Review)
- Does not rely on bank vegetation given uncertainty of assessing the future influence of root reinforcement (e.g., rooting depth/bank height)
- Channel evolution model (CEM) underpinning the field procedure is based on observed responses in southern California using a modification of Schumm *et al*. (1984) five-stage model to represent alternative trajectories

The Field Screening Tool <u>DOES NOT</u>:

⊗ **Make policy/management decisions**: although the screening tool is designed to have management implications via a decision framework, policy/management decisions must be made by local stakeholders

⊗ **Incorporate ecological/economic considerations**: the screening tool is exclusively focused on geomorphic stability and does not include ecological/economic aspects that stakeholders may consider

⊗ **Assess historical attribution**: the screening tool is designed to assess the current susceptibility of a channel, independent of attributing degraded conditions to historical land users, and policies.

OFFICE AND FIELD COMPONENTS FOR FIELD SCREENING TOOL

Office Components

The screening tool presented in this report is predominantly designed for field-based assessment. The field tool requires some preparatory office work to provide context and familiarity with the site prior to conducting the field evaluation. The following addresses:

- Examination of Overall Setting (using Google Earth or equivalent aerials)
- Quantification of important remotely-sensed parameters (using GIS software)
- Identification of Analysis Domain (tentatively defining upstream and downstream extents of field reconnaissance, locations of likely grade control, and valley transitions)

Overall Setting

Using satellite imagery/aerial photography, gather a baseline understanding of the watershed. Consider aspects such as development extent, fires and vegetation coverage, sediment sources and bottlenecks, ecologically-sensitive areas, etc. Examine the valley setting near the project in greater detail, identifying tributary confluences, potential grade control (e.g., road crossings), and infrastructure (e.g., stormwater outfalls, drainage 'improvements', etc.) *sensu* Chin and Gregory (2005). Specifically consider:

- Geologic setting, basin type, valley context, and tributaries
- Recent watershed history – urbanization and fire
- Obvious grade-control locations, human influences, and existing infrastructure

Printed screen shots of aerials, specifically near the project site, may be helpful in the field. In addition, the results from the GIS-based assessment (if completed) should be reviewed prior to beginning the field assessment.

GIS Metrics

Using publicly available GIS data, measure four readily quantifiable watershed- and valley-scale variables that will be used to compute the simple, but statistically-significant, screening indices (i.e., flow, screening index, and valley width index). Measurement details in Form 1 (**Figure 2**).

- Spatial: contributing drainage area
- Topographic: valley slope at site(s)
- Precipitation: mean annual area-weighted precipitation
- Geomorphic Confinement: valley bottom width at site(s)

These variables are explained in more detail in Form 1 Table 1 (**Figure 2**). A digital data entry form is available as well (Data Entry Form.xls).

Analysis Domain

The effects of hydromodification may propagate for significant distances downstream (and sometimes upstream) from a point of impact such as a stormwater outfall. Accordingly, it may

be necessary to conduct geomorphic screening reconnaissance across a domain spanning multiple channel types/settings and property owners.

The maximum spatial unit for assigning a susceptibility rating is defined as a *ca.* 20 channel width reach not to exceed 200 m. Before conducting the field screening, the analyst should identify the following attributes as part of the office analysis to estimate the maximum extent of the analysis domain for field refinement.

Begin by defining the points or zones along the channel reach(es) where changes in discharge or channel type are likely to occur (e.g., potential locations of outfalls or tributary inputs). Document any observed outfalls for final desktop synthesis and define the upstream and downstream extents of analysis as follows:

- **Downstream** – until reaching the closest of the following:
  - at least one reach downstream of the first grade-control point (but preferably the second downstream grade-control location)
  - tidal backwater/lentic waterbody
  - equal order tributary (Strahler 1952)[1]
  - a 2-fold increase in drainage area[2]

OR demonstrate sufficient flow attenuation through existing hydrologic modeling

- **Upstream** – extend the domain upstream for a distance equal to 20 channel widths OR to grade control in good condition – whichever comes first. Within that reach, identify hard points that could check headward migration, evidence that head cutting is active or could propagate unchecked upstream

Within the analysis domain there may be several reaches that should be assessed independently based on either length or change in physical characteristics. In more urban settings, segments may be logically divided by road crossings (Chin and Gregory 2005), which may offer grade control, cause discontinuities in the conveyance of water or sediment, etc. In more rural settings, changes in valley/channel type, natural hard points, and tributary confluences may be more appropriate for delineating assessment reaches. In general, the following criteria should trigger delineation of a new reach and hence a separate susceptibility assessment:

- 200 m or ca. 20 bankfull widths – it is difficult to integrate over longer distances
- Distinct or abrupt change in grade or slope due to either natural or artificial features
- Distinct or abrupt change in dominant bed material or sediment conveyance
- Distinct or abrupt change in valley setting or confinement
- Distinct or abrupt change in channel type, bed form, or planform

[1] In the absence of proximate downstream grade control or backwater, the confluence of an 'equal order tributary' should correspond to substantial increases in flow and channel capacity that should, in theory, correspond to significant flow attenuation; however, there is no scientific basis to assume that downstream channels of higher stream order are less susceptible than their upstream counterparts. This (practically-driven) guidance should not supersede the consideration of local conditions and sound judgment. Stakeholders may elect to use a more regionally-preferred guidance.

[2] An increase in drainage area greater than or equal to 100% would roughly correspond to the addition of an equal-order tributary

FORM 1: INITIAL DESKTOP ANALYSIS

Complete all shaded sections.

IF required at multiple locations, circle one of the following site types:

Applicant Site / Upstream Extent / Downstream Extent

Location: Latitude: _____ Longitude: _____

Description (river name, crossing streets, etc.): _____

GIS Parameters: The International System of Units (SI) is used throughout the assessment as the field standard and for consistency with the broader scientific community. However, as the singular exception, US Customary units are used for contributing drainage area (A) and mean annual precipitation (P) to apply regional flow equations after the USGS. See SCCWRP Technical Report 607 for example measurements and "Screening Tool Data Entry.xls" for automated calculations.

Form 1 Table 1. Initial desktop analysis in GIS.

	Symbol	Variable	Description and Source	Value
Watershed properties (English units)	A	Area (mi^2)	Contributing drainage area to screening location via published Hydrologic Unit Codes (HUCs) and/or ≤ 30 m National Elevation Data (NED), USGS seamless server	
	P	Mean annual precipitation (in)	Area-weighted annual precipitation via USGS delineated polygons using records from 1900 to 1960 (which was more significant in hydrologic models than polygons delineated from shorter record lengths)	
Site properties (SI units)	S_v	Valley slope (m/m)	Valley slope at site via NED, measured over a relatively homogenous valley segment as dictated by hillslope configuration, tributary confluences, etc., over a distance of up to ~500 m or 10% of the main-channel length from site to drainage divide	
	W_v	Valley width (m)	Valley bottom width at site between natural valley walls as dictated by clear breaks in hillslope on NED raster, irrespective of potential armoring from floodplain encroachment, levees, etc. (imprecise measurements have negligible effect on rating in wide valleys where VWI is >> 2, as defined in lateral decision tree)	

Form 1 Table 2. Simplified peak flow, screening index, and valley width index. Values for this table should be calculated in the sequence shown in this table, using values from Form 1 Table 1.

Symbol	Dependent Variable	Equation	Required Units	Value
Q_{10cfs}	10-yr peak flow (ft^3/s)	$Q_{10cfs} = 18.2 * A^{0.87} * P^{0.77}$	A (mi^2) P (in)	
Q_{10}	10-yr peak flow (m^3/s)	$Q_{10} = 0.0283 * Q_{10cfs}$	Q_{10cfs} (ft^3/s)	
INDEX	10-yr screening index ($m^{1.5}/s^{0.5}$)	$INDEX = S_v * Q_{10}^{0.5}$	Sv (m/m) Q_{10} (m^3/s)	
W_{ref}	Reference width (m)	$W_{ref} = 6.99 * Q_{10}^{0.438}$	Q_{10} (m^3/s)	
VWI	Valley width index (m/m)	$VWI = W_v/W_{ref}$	W_v (m) W_{ref} (m)	

(Sheet 1 of 1)

Figure 2. Form 1: Initial Desktop Analysis. Complete set of assessment forms in Appendix B.

Conceptual Basis for 10-yr Flow Analysis

The geomorphic thresholds presented in the field-screening sections below correspond to the 10-yr peak flow calculated using the regional hydrologic model presented in Form 1 Table 2 (**Figure 2**; Hawley and Bledsoe, In review). This peak flow model is substantially more accurate for small watersheds in southern California than previously published regional regression equations. The 10-yr flow was selected for several reasons. First, it better represents a channel-filling flow than alternative return intervals such as Q_2. Second, it typically requires a 10-yr instantaneous peak flow to create a geomorphically significant *duration* at the 2-yr flow magnitude (i.e., the 10-yr instantaneous peak flow typically corresponds to a daily-mean flow equal to a 2- to 3-yr peak magnitude). Finally, the 10-yr hydrologic models had the best prediction accuracy of all return intervals. Out of 5 peak-flow model forms (Hawley and Bledsoe, In review), the model based on drainage area and precipitation had the best cross-validation performance. With respect to modeling Q_{10}, the standard error as percentage of mean for validation samples was 41% (arithmetic space), with an R^2 during final calibration of 0.81 (geometric space). Because of the relatively-robust model performance and overall simplicity, we selected the model form of Q = f (A, P) for use in this screening tool.

Field Components

After completing the Initial Desktop Analysis (**Figure 2**), the user should have a first-order estimate of an appropriate analysis domain, a baseline understanding of the watershed, and critical indices to use during the field assessment(s). At this juncture it is essential to examine the stream (and its valley setting) in greater detail. Minimally, the following items should be taken to the field, although Form 2: Pebble Count (**Figure 4**) is not needed in every case:

- Assessment forms and/or field book for sketches/notes
- Digital camera for photographic documentation
- Pocket rod and/or tape for some basic measurements and reference/scale in photographs
- Protractor (e.g., gravity-driven) for measuring bank angle (**Figure 3a**)
- Gravelometer (i.e., US SAH-97 half-phi template) for standardized pebble count (**Figure 3b**)

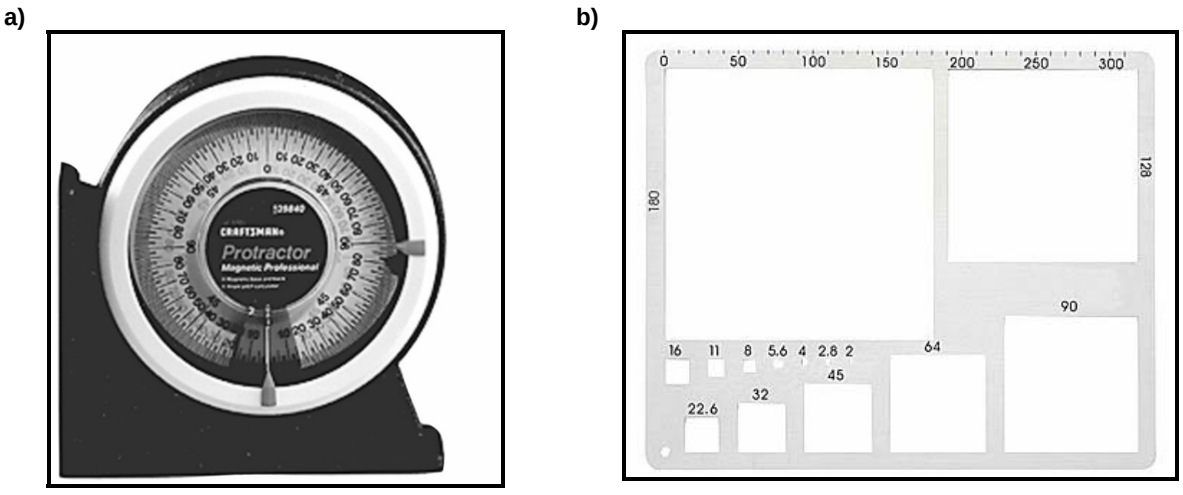


Figure 3. Craftsman magnetic protractor (a) and US SAH-97 half-phi template gravelometer (b).

FORM 2: PEBBLE COUNT

If it is necessary to estimate d_{50}, perform a pebble count, after Bunte and Abt (2001a,b), using a minimum of 100 particles and a standard half-phi template, or by measuring along the intermediate axis of each pebble. Use a grid and tape for equally spaced samples over systematic/complete transects across riffle sections (i.e., if the 100th particle is in the middle of a transect, complete the full transect before stopping the count; if more than 125 particles, record data near the bottom of Sheet 2 of 2). If the source of fines (sand/silt d <2 mm; see Form 2 Table 2 below) is less than ½ inch thick (approximately one finger width) at the sampling point, sample the coarser buried substrate; otherwise record observation of fines. Take photographs to support observations (Detailed instructions in Appendix A.3).

Form 2 Table 1. 100-pebble count tabulation for Vertical Susceptibility. Record station (Sta) and diameter (d) in millimeters.

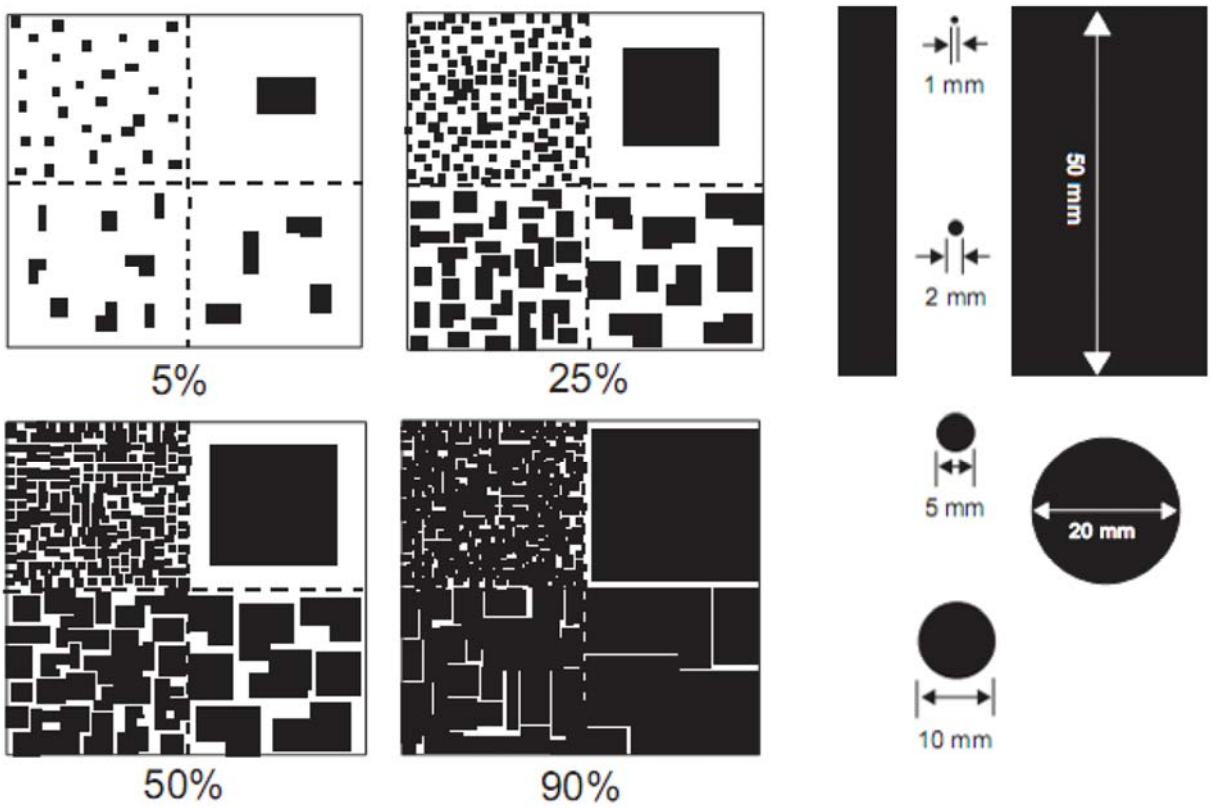
#	Sta	d (mm)	#	Sta	d (mm)	#	Sta	d (mm)	#	Sta	d (mm)	#	Sta	d (mm)
1			26			51			76			101		
2			27			52			77			102		
3			28			53			78			103		
4			29			54			79			104		
5			30			55			80			105		
6			31			56			81			106		
7			32			57			82			107		
8			33			58			83			108		
9			34			59			84			109		
10			35			60			85			110		
11			36			61			86			111		
12			37			62			87			112		
13			38			63			88			113		
14			39			64			89			114		
15			40			65			90			115		
16			41			66			91			116		
17			42			67			92			117		
18			44			68			93			118		
19			44			69			94			119		
20			45			70			95			120		
21			46			71			96			121		
22			47			72			97			122		
23			48			73			98			123		
24			49			74			99			124		
25			50			75			100			125		

Form 2 Table 2. d_{50} for Screening Index Threshold.

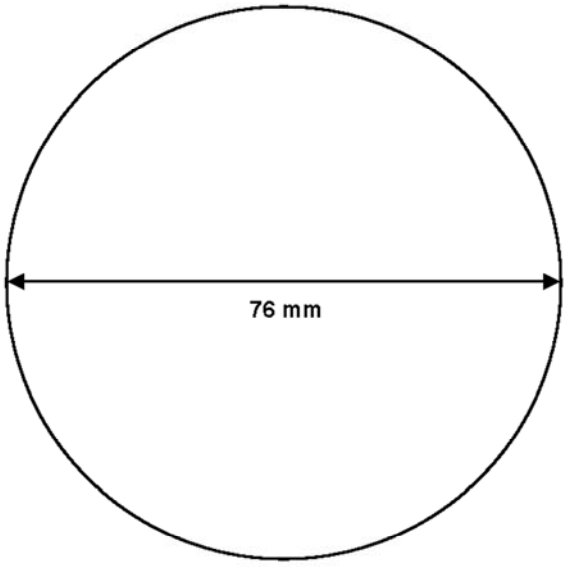
Class Name	Diameter (mm)	Helpful Descriptions for Field Identification
Boulder	> 256	Difficult to lift by hand
Cobble	> 64	Typically able to lift
Gravel	> 2	Fits in one hand
Sand	> 0.0625	Can feel between fingers
Silt	> 0.004	Can feel with tongue
Clay	≤ 0.004	Can not feel individual particle

(Sheet 1 of 2)

Figure 4. Form 2: Pebble Count. Complete set of assessment forms in Appendix B.



Note: Each quadrant within each box contains the same total area covered using different sized objects.



Form 2 Figure 1. Examples of % coverage by volume and substrate sizing adapted from *NRCS Field Book for Describing and Sampling Soils* (Schoeneberger *et al.* 2002) and Julien (1998).

(Sheet 2 of 2)

Figure 4. Continued

Susceptibility Rating Definitions

The field screening tool uses a combination of relatively simple, but quantitative, field indicators as input parameters to a set of decision trees. The decision trees follow a logical progression and allow users to assign a classification of Low, Medium, High, or Very High susceptibility rating (Table 1) to the reach being assessed.

Table 1. Vertical and Lateral Susceptibility rating definitions.

Susceptibility Rating	Definitions of Susceptibility
LOW	• Low ratio of disturbing forces to resisting forces
	• Far from geomorphic thresholds of concern (based on explicit quantification of probability if feasible – < 1% probability of exceedance)
	• Relatively rapid relaxation time
	• Low potential for positive feedbacks, nonlinear response, sensitivity to initial conditions
	• Very limited or no spatial propagation (*ca.* 10 m)
MEDIUM	• Moderate ratio of disturbing forces to resisting forces
	• Not proximate to geomorphic thresholds of concern (based on explicit quantification of probability if feasible – e.g., < 10% probability of exceedance)
	• Moderately rapid relaxation time
	• Low to moderate potential for positive feedbacks, nonlinear response, sensitivity to initial conditions
	• Local spatial propagation, contained within *ca.* 100 m
HIGH	• High ratio of disturbing forces to resisting forces
	• Proximate to geomorphic thresholds of concern (based on explicit quantification of probability if feasible – e.g., > 10 to 50% probability of exceedance)
	• Relaxation time may be relatively long given magnitude and spatial extent of change
	• Moderate to high potential for positive feedbacks, nonlinear response, sensitivity to initial conditions
	• Potential spatial propagation – headcutting/base-level change upstream and downstream but contained within *ca.* 100 to 1,000 m domain of control
VERY HIGH	• High ratio of disturbing forces to resisting forces
	• At geomorphic thresholds of concern (based on explicit quantification of probability if feasible – e.g., ≥ 50% probability of exceedance)
	• Relaxation time may be relatively long given magnitude and spatial extent of change
	• High potential for positive feedbacks, nonlinear response, sensitivity to initial conditions
	• Potential widespread spatial propagation – headcutting/base-level change upstream and downstream uncontained within *ca.* 1,000 m domain of control
	• Specifically, the VERY HIGH rating is reserved for the following geomorphic thresholds/states (clear and present danger): o **Vertical** ▪ Currently unstable (Channel Evolution Model (CEM) Type III or IV) with incision past critical bank height for mass wasting and active bank failure ▪ Currently stable (CEM Type I or II) with banks less than critical height, but p ≥ 50% for incision or braiding in labile bed (d_{50} <16 mm) with ineffective/absent grade control o **Lateral** ▪ Currently unstable with active braiding/extensive mass wasting/fluvial erosion (> 50% of banks) in a wide valley ▪ Currently stable consolidated bank in wide valley with High Vertical rating combined with p > 10% for mass wasting ▪ Currently stable unconsolidated banks with fine toe material in wide valley with High Vertical rating

Recall that it may be necessary to perform the field assessment at several locations based on an analysis domain that could span multiple stream reaches up and downstream (see Analysis Domain above). At each distinct reach type, the user will follow the guidelines below to separately assess susceptibility in vertical and lateral dimensions. Although vertical and lateral responses are often interdependent, vertical and lateral susceptibility are assessed separately for several reasons. First, vertical and lateral responses are primarily controlled by different types of resistance, which, when assessed separately, may improve ease of use and lead to increased repeatability among users compared to an integrated, cross-dimensional assessment. Second, the mechanistic differences between vertical and lateral responses point to different modeling tools and potentially different management strategies. Having separate screening ratings may better direct users and managers to the most appropriate tools for subsequent analyses.

The field screening tool uses combinations of decision trees, checklists, tables and calculations. We attempt to employ decision trees when a question can be answered fairly definitively and/or quantitatively (e.g., median grain diameter (d_{50}) < 16 mm; see Form 2 (**Figure 4**)). Alternatively, checklists are used in places where answers are relatively qualitative (e.g., grade control).

The tool is designed to first classify the current state of the assessment area. Next, the user identifies the type and number of risk factors that are present; risk factors are then combined with current state to determine a final rating. Users should take photographs to support their assessment. If uncertain about a given decision node, the user should use the more precautionary pathway that results in a higher rating of susceptibility. The field-assessment process is described in detail below:

- Decision Trees
  - Vertical Susceptibility
  - Lateral Susceptibility

- Design/Setup
  - Assess the Analysis Domain (defined above), which may include multiple stream types and settings; conduct separate analyses for reaches distinguished by distance, change in valley type, dominant bed material, and other significant geomorphic considerations
  - Assign susceptibility ratings of Low, Medium, High, and Very High (as defined in Table 1 above) independently to the vertical and lateral conditions of each channel reach

- Consult susceptibility decision trees and photographic supplements for rating guidance; to clearly highlight rating endpoints within the decision trees, non-terminal and terminal nodes in the decision trees have been color coded (**Figure 5**) to prompt users to proceed to another step

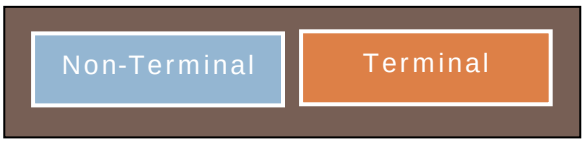


Figure 5. Color scheme for non-terminal and terminal nodes in susceptibility decision trees.

- Overall logic of susceptibility decision trees (**Figure 6**)

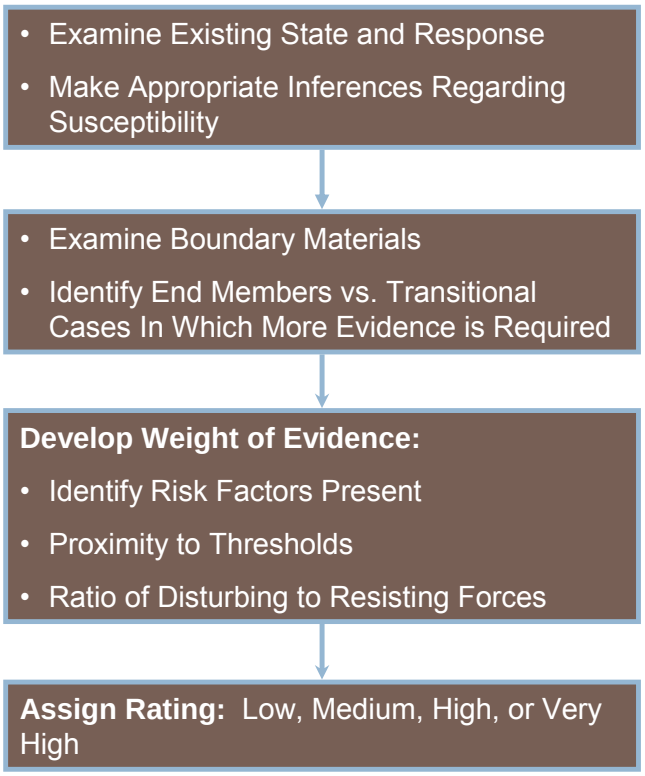


Figure 6. Logical flow of susceptibility decision trees.

CHANNEL SUSCEPTIBILITY DECISION TREES AND FORMS

Vertical Susceptibility

In the Vertical Susceptibility decision tree, there are three potential states of bed material based on broad classes of armoring potential. These states are listed below from most susceptible to least with definitions and photographic examples provided in Form 3 (**Figure 7**):

- Labile Bed – sand-dominated bed, little resistant substrate
- Transitional/Intermediate Bed – bed typically characterized by gravel/small cobble, intermediate level of resistance of the substrate and uncertain potential for armoring
- Threshold Bed (Coarse/Armored Bed) – armored with large cobbles or larger bed material or highly-resistant bed substrate (i.e., bedrock)

Threshold beds composed of boulders and large cobbles and/or highly-resistant bedrock are the region's most resistant channel beds with geologic grade control and a natural capacity to armor (see Form 3 (**Figure 7**)). Consequently, threshold beds correspond to a vertical rating of low. Conversely, labile beds have little to no capacity to self-armor and have a high probability of vertical adjustments in response to hydromodification. Depending on two additional decision tree questions that consider the current state of incision and grade control, labile beds receive a rating of High or Very High. Finally, transitional/intermediate beds are involved in a wide range of potential susceptibility responses and must be assessed in greater detail in order to develop weight of evidence for appropriate screening ratings. Three primary risk factors used to assess vertical susceptibility for channels with transitional/intermediate bed materials:

- Armoring Potential – Form 3 Checklist 1 (**Figure 7**)
- Grade Control – Form 2 Checklist 1 (**Figure 7**)
- Probability of Incision/Braiding based on a Regionally-Calibrated Screening Index – Form 3 Figure 1/Table 1 (**Figure 7**)

These risk factors are assessed using checklists and a diagram, then calculated using the instructions and equation at the bottom of Form 3 Sheet 4 of 4 (**Figure 7**) to provide an overall vertical susceptibility rating for the intermediate/transitional bed-material group.

Vertical Susceptibility Decision Tree

The purpose of the vertical susceptibility decision tree is to assess the state of the channel bed with a particular focus on the risk of incision (i.e., down cutting). Vertical stability is a prerequisite for lateral stability because a stream that incises can increase bank heights to the point of collapse and channel widening. Accordingly, vertical susceptibility is assessed first because it affects the lateral rating in most instances.

Conceptual Basis

Channel bed material is one of the main factors controlling vertical stability. Bed material is assessed using the photographic supplement Form 3 Figure 1 (**Figure 7**), with Form 2 Figure 1 (**Figure 4**) provided as a reference for some particle sizes and to assist with estimating the

percentage of surface sand. Some reaches may require a pebble count, Form 2 (**Figure 4**), for a more definitive assessment of bed material size.

For threshold (coarse/armored) beds, document the channel substrate with photographs, and a supporting pebble count[3] if d_{50} is near 128 mm. For labile beds, use supplemental photographs in Form 3 Figure 1 (**Figure 7**) and the diagram of the five-stage CEM presented in Appendix A, Figure A.3, to assess the current state of channel incision. For intermediate/transitional beds, assess: armoring potential using Form 3 Checklist 1 (**Figure 7**), grade-control condition using Form 3 Checklist 1 (**Figure 7**), and risk of incision/braiding using Form 3 Table 1 (**Figure 7**).

Form 3 Checklist 1 (**Figure 7**): Armoring potential is assessed because it is a primary mechanism in which a channel can self-check channel incision/headcutting. Coarser particles naturally provide greater resistance and, therefore, yield a lower susceptibility rating. Additionally, the tighter the particles are packed, the more resistant the armor layer, which can also influence the rating. Finally, the amount of sand-sized particles can adversely affect the resistance of an armor layer (Wilcock and Kenworthy, 2002; Wilcock and Crowe, 2003).

Form 3 Checklist 2 (**Figure 7**): Grade control is another way in which incision/headcutting can be arrested. When channels adjust their slope, the incision typically hinges around a hard point such as a natural or artificial grade control. Grade control has been clearly demonstrated to be a statistically-significant predictor of channel enlargement in southern California (Hawley 2009). Adjustments may also revolve around channel base-level, which could be set by an estuary, large waterbody (such as a lake or reservoir), or confluence with a larger river.

Form 3 Figure 4 (**Figure 7**): Risk of incising or braiding is based on the potential specific stream power of the valley relative to d_{50}. Beyond armoring potential and grade control, channels with intermediate/transitional beds may also have a relatively-energetic valley setting that creates an inherently higher risk for incision than lower energy settings. The threshold is based on regional data from unconfined, unconstructed valley settings and modeled after similar analyses from various regions (e.g., Chang (1988), van den Berg (1995), and Bledsoe and Watson (2001)).

Hawley (2009) performed separate logistic regression analyses on incising and braiding systems relative to their stable, unconfined counterparts that returned similar thresholds. In developing this revised screening tool, we combined unstable states of braided or incising into one model for parsimony. Well over 100 total model variations were developed that segregated unstable (braided or incising) channels from stable, single-thread, unconfined, unconstructed channels, using different measures of erosive energy (i.e., dimensionless shear stress, specific stream power, and screening index) and different hydrologic models to estimate the 2- and 10-yr instantaneous peak flow events.

In addition, a large body of previous fluvial geomorphic research suggests that the behavior and response potential of coarse versus fine-grained systems is markedly different (e.g., Chang (1988), Montgomery and MacDonald (2002), and Simons and Simons (1987)). We assessed both combined and separated models, based on different grain-size discriminators between sand-

[3] If d_{50} is clearly greater than 128 mm, there is no need to conduct a pebble count, only visual documentation with photographs and general description of substrate type is recommended.

dominated gravels and gravel/cobble armored systems. Out of 108 total models, all but 6 were significant ($p < 0.05$) with the simplified specific stream power and grain-size surrogate(screening index) regularly performing similarly or superior to the more rigorous indices. Indeed, 5 of the 12 models of the screening index for coarse-size fractions offered complete segregation of unstable/stable sites (i.e., 100% correctly classified). Although that clearly delineates a threshold (Form 3 Table 1 (**Figure 7**)) it precludes using the logistic model to represent risk levels in terms of a range of probabilities. This explains why the 90% and 10% lines converge to the 50% risk level for $d_{50} > 16$ mm in Form 3 Figure 4 (**Figure 7**).

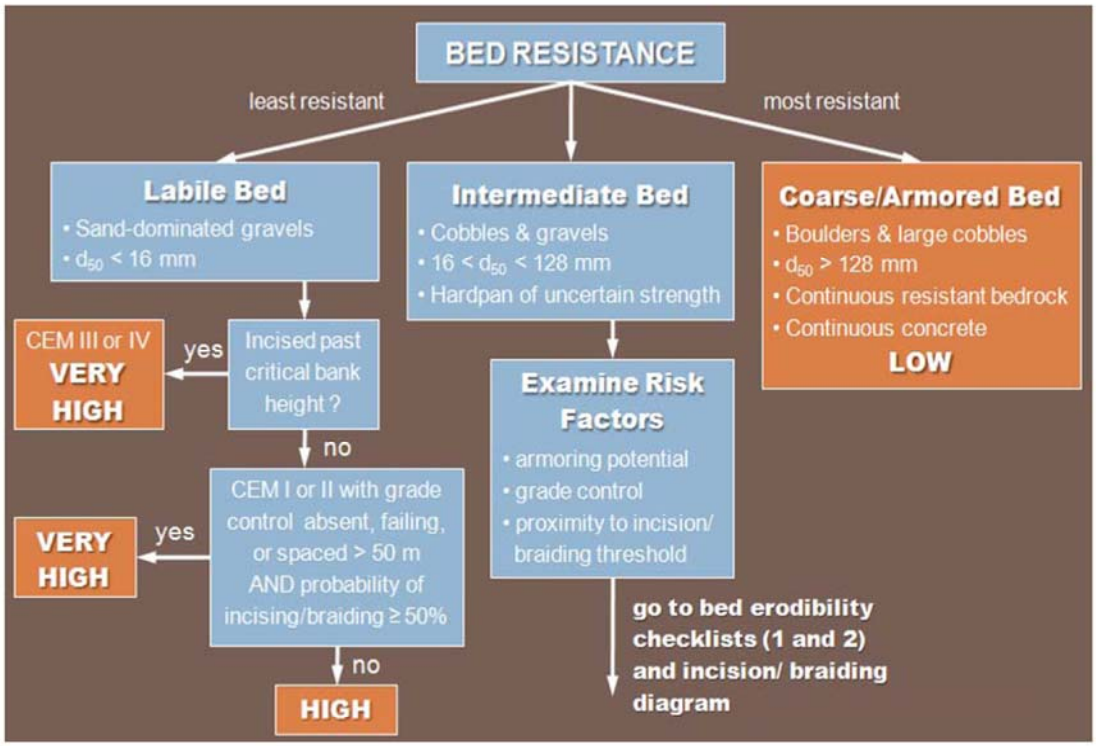
Vertical Flow and Forms

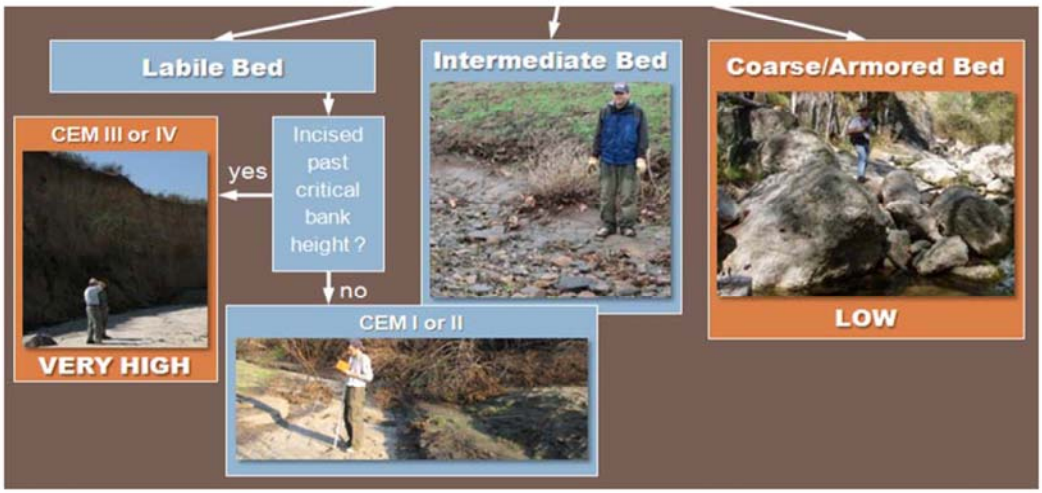
Forms 3: Vertical Susceptibility Field Sheet (**Figure 7**) is used to assess vertical susceptibility. The logical flow of this form is summarized through a series of decisions outlined below:

1) Assess the initial 'state': which of the following (a, b, or c) best describes the bed condition/material
    a. If the bed is Coarse/Armored with $d_{50} > 128$ mm or continuous bedrock/concrete, then Vertical Rating = Low; see Form 3 Figure 1 (**Figure 7**)
    b. If the bed is labile with sand dominated gravels and $d_{50} < 16$ mm, then assess level of incision:
        i. If channel is incised past critical bank height for mass wasting (CEM III or IV), Vertical Rating = Very High; see Form 3 Figure 1 (**Figure 7**) and Form 2 (**Figure 4**)
        ii. If channel is not incised past critical bank height (CEM I or II), assess Grade Control using Form 3 Checklist 2 (**Figure 7**) and Probability of Incision/Braiding using Form 3 Table 1 (**Figure 7**)
            1. If CEM I or II with grade control absent, failing, or spaced at intervals larger than 50 m, AND probability of incising/braiding ≥50%, Vertical Rating = Very High; see Form 3 Figure 1 (**Figure 7**)
            2. If CEM I or II with grade control in good condition and spaced at intervals less than 50 m, OR probability of incising/braiding < 50%, Vertical Rating = High; see Form 3 Figure 1 (**Figure 7**)
    c. If the bed is Intermediate with cobbles and gravels and $16 < d_{50} < 128$ mm or hardpan of uncertain strength, proceed to Form 3 Checklist 1 and 2 (**Figure 7**) to assess Armoring Potential and Grade Control, respectively, and Form 3 Figure 4 (**Figure 7**) to estimate Probability of Incising/Braiding.

FORM 3: VERTICAL SUSCEPTIBILITY FIELD SHEET

Circle appropriate nodes/pathway for proposed site.





Form 3 Figure 1. Vertical Susceptibility photographic supplement to be used in conjunction with Form 3 Bed Resistance above.

(Sheet 1 of 4)

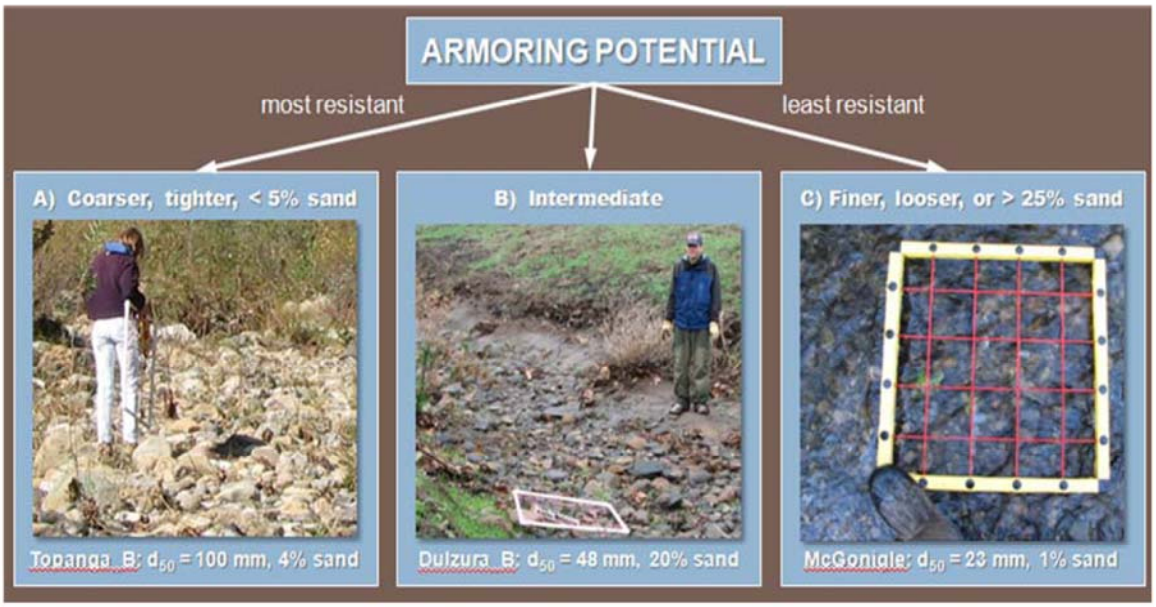
Figure 7. Form 3: Vertical Susceptibility Field Sheet. Complete set of assessment forms in Appendix B.

Form 3 Support Materials

Form 3 Checklists 1 and 2, along with information recording in Form 3 Table 1, are intended to support the decisions pathways illustrated in Form 3 Overall Vertical Rating for Intermediate/Transitional Bed.

Form 3 Checklist 1: Armoring Potential

☐	A	A mix of coarse gravels and cobbles that are tightly packed with <5% surface material of diameter <2 mm
☐	B	Intermediate to A and C or hardpan of unknown resistance, spatial extent (longitudinal and depth), or unknown armoring potential due to surface veneer covering gravel or coarser layer encountered with probe
☐	C	Gravels/cobbles that are loosely packed or >25% surface material of diameter <2 mm



Form 3 Figure 2. Armoring potential photographic supplement for assessing intermediate beds ($16 < d_{50} < 128$ mm) to be used i**n conjunction with Form 3 Checklist 1.**

(Sheet 2 of 4)

Figure 7. Continued

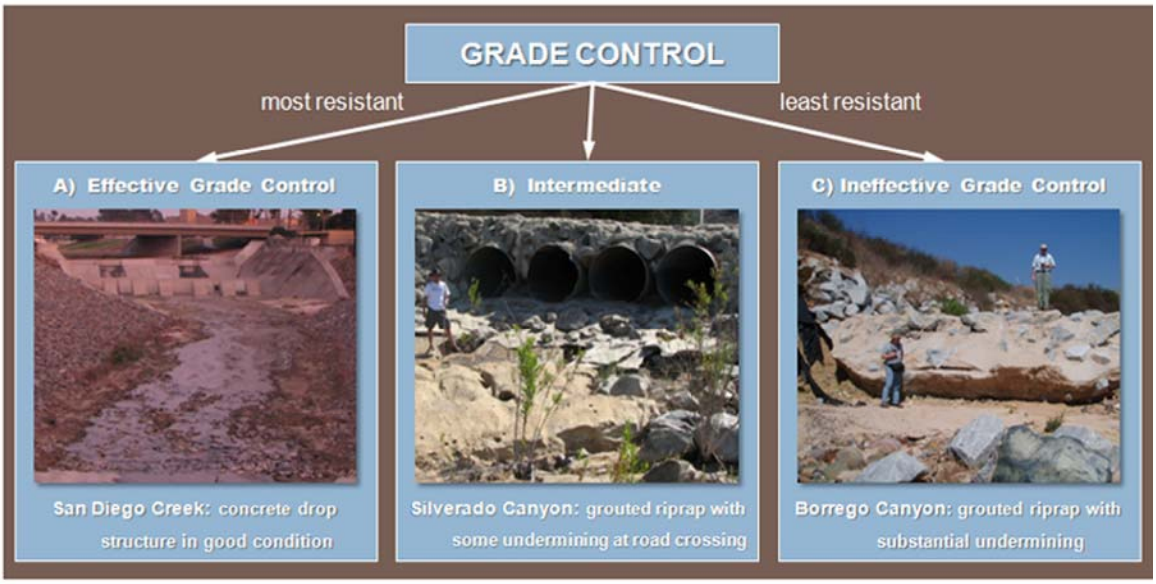
Form 3 Checklist 2: Grade Control

☐ A Grade control is present with spacing <50 m or $2/S_v$ m

- No evidence of failure/ineffectiveness, e.g., no headcutting (>30 cm), no active mass wasting (analyst cannot say grade control sufficient if mass-wasting checklist indicates presence of bank failure), no exposed bridge pilings, no culverts/structures undermined
- Hard points in serviceable condition at decadal time scale, e.g., no apparent undermining, flanking, failing grout
- If geologic grade control, rock should be resistant igneous and/or metamorphic; For sedimentary/hardpan to be classified as 'grade control', it should be of demonstrable strength as indicated by field testing such as hammer test/borings and/or inspected by appropriate stakeholder

☐ B Intermediate to A and C – artificial or geologic grade control present but spaced 2/Sv m to 4/Sv m or potential evidence of failure or hardpan of uncertain resistance

☐ C Grade control absent, spaced >100 m or $>4/S_v$ m, or clear evidence of ineffectiveness



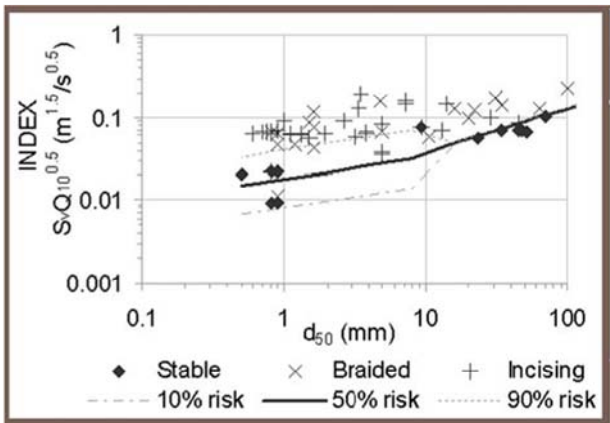
Form 3 Figure 3. Grade-control (condition) photographic supplement for assessing intermediate beds ($16 < d_{50} < 128$ mm) to be used in conjunction with Form 3 Checklist 2.

(Sheet 3 of 4)

Figure 7. Continued

Regionally-calibrated Screening Index Threshold for Incising/Braiding

For transitional bed channels (d_{50} between 16 and 128 mm) or labile beds (channel not incised past critical bank height), use Form 3 Figure 3 to determine Screening Index Score and complete Form 3 Table 1.



Model Type	d_{50} (mm)	50% Risk $S_vQ_{10}^{0.5}$ ($m^{1.5}/s^{0.5}$)
Logistic Regression $d_{50} \geq 16$ mm	128	0.145
	96	0.125
	80	0.114
	64	0.101
	48	0.087
	32	0.070
	16	0.049
Logistic Reg. $d_{50} < 16$ mm	8	0.031
	4	0.026
	2	0.022
	1	0.018
	0.5	0.015

Form 3 Figure 4. Probability of incising/braiding based on logistic regression of Screening Index and d_{50} to be used in conjunction with Form 3 Table 1.

Form 3 Table 1. Values for Screening Index Threshold (probability of incising/braiding) to be used in conjunction with Form 3 Figure 4 (above) to complete Form 3 Overall Vertical Rating for Intermediate/Transitional Bed (below).. Screening Index Score: A = <50% probability of incision for current Q_{10}, valley slope, and d_{50}; B = Hardpan/d_{50} indeterminate; and C = ≥50% probability of incising/braiding for current Q_{10}, valley slope, and d_{50}.

d_{50} (mm) *From Form 2*	$S_v{*}Q_{10}^{0.5}$ ($m^{1.5}/s^{0.5}$) *From Form 1*	$S_v{*}Q_{10}^{0.5}$ ($m^{1.5}/s^{0.5}$) *50% risk of incising/braiding from table in Form 3 Figure 3 above*	Screening Index Score (A, B, C)

Overall Vertical Rating for Intermediate/Transitional Bed

Calculate the overall Vertical Rating for Transitional Bed channels using the formula below. Numeric values for responses to Form 3 Checklists and Table 1 as follows: A = 3, B = 6, C = 9.

$$Vertical\ Rating = \sqrt{\{(\sqrt{armoring * grade\ control}) * screening\ index\ score\}}$$

Vertical Susceptibility based on Vertical Rating: <4.5 = LOW; 4.5 to 7 = MEDIUM; and >7 = HIGH.

(Sheet 4 of 4)

Figure 7. Continued

Lateral Susceptibility

In terms of lateral stability, there are five primary states of bank characteristics. These states are listed below, roughly in order of most susceptible to least:

- Mass wasting or fluvial erosion/braiding existing and extensive
- Poorly consolidated or unconsolidated with fine/nonresistant toe material
- Poorly consolidated or unconsolidated with coarse/resistant toe material
- Consolidated
- Fully-armored bedrock/engineered reinforcement or fully confined by hillslope

In addition to the present channel state/response and bank materials, there are three primary risk factors used to develop a weight of evidence for lateral susceptibility:

- Valley width index (VWI) from Form 1 (**Figure 2**): a measure of valley bottom width versus reference channel width (calculated in the office) used to assess the potential for lateral movement of the channel; see Forms 4 and 5 (**Figures 12 and 13**, respectively)
- Proximity to a regionally-calibrated bank stability threshold: geotechnical probability diagram based on bank height and angle; see Form 6 (**Figure 14**)
- The Vertical Susceptibility Rating: from Form 3 Sheet 4 of 4 (**Figure 7**)

Lateral Susceptibility Decision Tree

The purpose of the lateral decision tree is to assess the state of the channel banks with a particular focus on the risk of widening. Channels can widen from either bank failure or through fluvial processes such as chute cutoffs, avulsions, and braiding (see Figure A.2 in Appendix A). Widening through fluvial avulsions/active braiding is a relatively straightforward observation. If braiding is not already occurring, the next logical question is to assess the condition of the banks. Banks fail through a variety of mechanisms (see Figures A.4a and A.4b in Appendix A); however, one of the most important distinctions is whether they fail in mass (as many particles) or by fluvial detachment of individual particles. Although much research is dedicated to the combined effects of weakening, fluvial erosion, and mass failure (Beatty 1984, Hooke 1979, Lawler 1992, Thorne 1982), we found it valuable to segregate bank types based on the inference of the dominant failure mechanism (as the management approach may vary based on the dominant failure mechanism).

Conceptual Basis

Cohesive banks have been documented in both flume and field experiments as being much more resistant to fluvial entrainment than non-cohesive banks (Thorne 1982). Despite the fact that most of the banks that observed in southern California had relatively low amounts of cohesion when compared to other US regions, it is generally acknowledged that truly non-cohesive banks are rare in nature given the effective cohesion introduced by pore-water suction even in banks formed in coarse materials (Lawler *et al*. 1997). Furthermore, there was clear evidence of mass wasting at a large number of sites, including the presence of tension cracks and discrete failure surfaces deep within the banks exhibiting corresponding planar, slab, and rotational failures.

Because cohesivity is difficult to assess in the field, Hawley (2009) segregated banks by relative degree of consolidation. Failure in banks composed of recently deposited alluvium with little time to consolidate (i.e., <~10 yrs, unconsolidated) was generally dominated by the resistance of individual particles. Banks composed of much older fluvial deposits with more time to both acquire more cohesive particles and become more consolidated (i.e., well-consolidated) were controlled by mass failure. Intermediate poorly- and moderately-consolidated bank types were generally found to be controlled by mass wasting with the latter and fluvial entrainment with the former; however, the segregation is both subjective and somewhat difficult to determine, especially in stable banks. For the present study, in addition to the current bank condition, we considered key risk factors including 1) the potential for lateral instability triggered by vertical instability, and 2) potential severity of the lateral response based on the available valley width (i.e., how large of a valley bottom is there for the channel to access?).

Lateral Susceptibility Definitions and Forms

- Channel Banks – vertically inclined surfaces that are generally perpendicular to flow and contain approximately the 10-year flow (i.e., the 'walls' of the active channel)

- *Extensive mass wasting* – >50% of banks exhibiting planar, slab, or rotational failures, and/or scalloping, undermining, and/or tension cracks (**Figure 8**)

a) **b)**



Figure 8. Planar/Slab failure with tension cracks, exhibiting cohesive consolidated banks, at San Timetao, San Bernardino County, CA (a) and Acton, Los Angeles County, CA (b).

- *Extensive fluvial erosion* – significant and frequent bank cuts (> 50% of banks) and not limited to bends and constrictions (**Figure 9**)



Figure 9. Bank failure at Hicks Canyon, Orange County, CA, exhibiting combinations of fluvial erosion, shallow slips, and mass failure in weakly cohesive, poorly consolidated banks.

- *Moderately to highly consolidated* – hard when dry with little evidence of crumbling. Bank appears as a composite of tightly-packed particles that are difficult to delineate even with close inspection of the bank; moderately dry block/ped sample (1 in^2) is not crushable between fingers and bank material stratification not prevalent or contributing to failure (**Figure 10**)

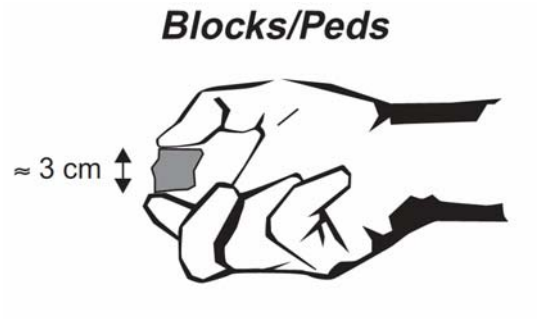


Figure 10. Moderately dry block/ped sample. Figure adapted from Schoeneberger *et al. (*2002); Not to scale.

- *Poorly consolidated to unconsolidated* – relatively weak with evidence of crumbling (**Figure 11**). Bank appears as a loose pile of recently deposited alluvium and block/ped samples (if attainable) can be crushed between fingers

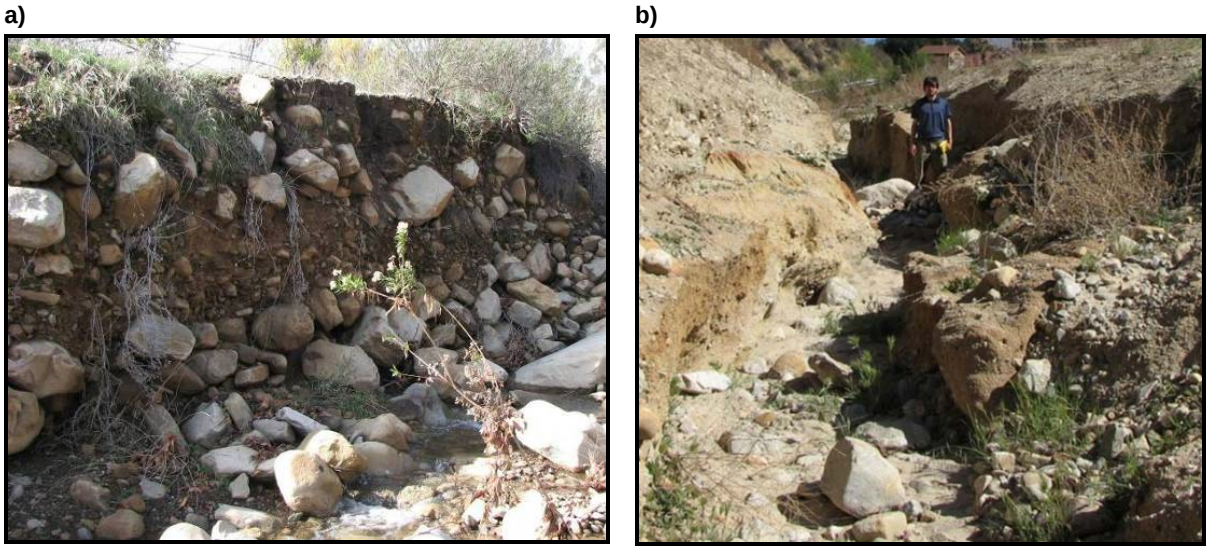


Figure 11. Failure of poorly consolidated banks with some cohesivity, but bank stability largely controlled by resistance of the individual particles of the bank toe in Stewart Canyon, Ventura County, CA, (a) and Hasley Canyon, Los Angeles County, CA (b).

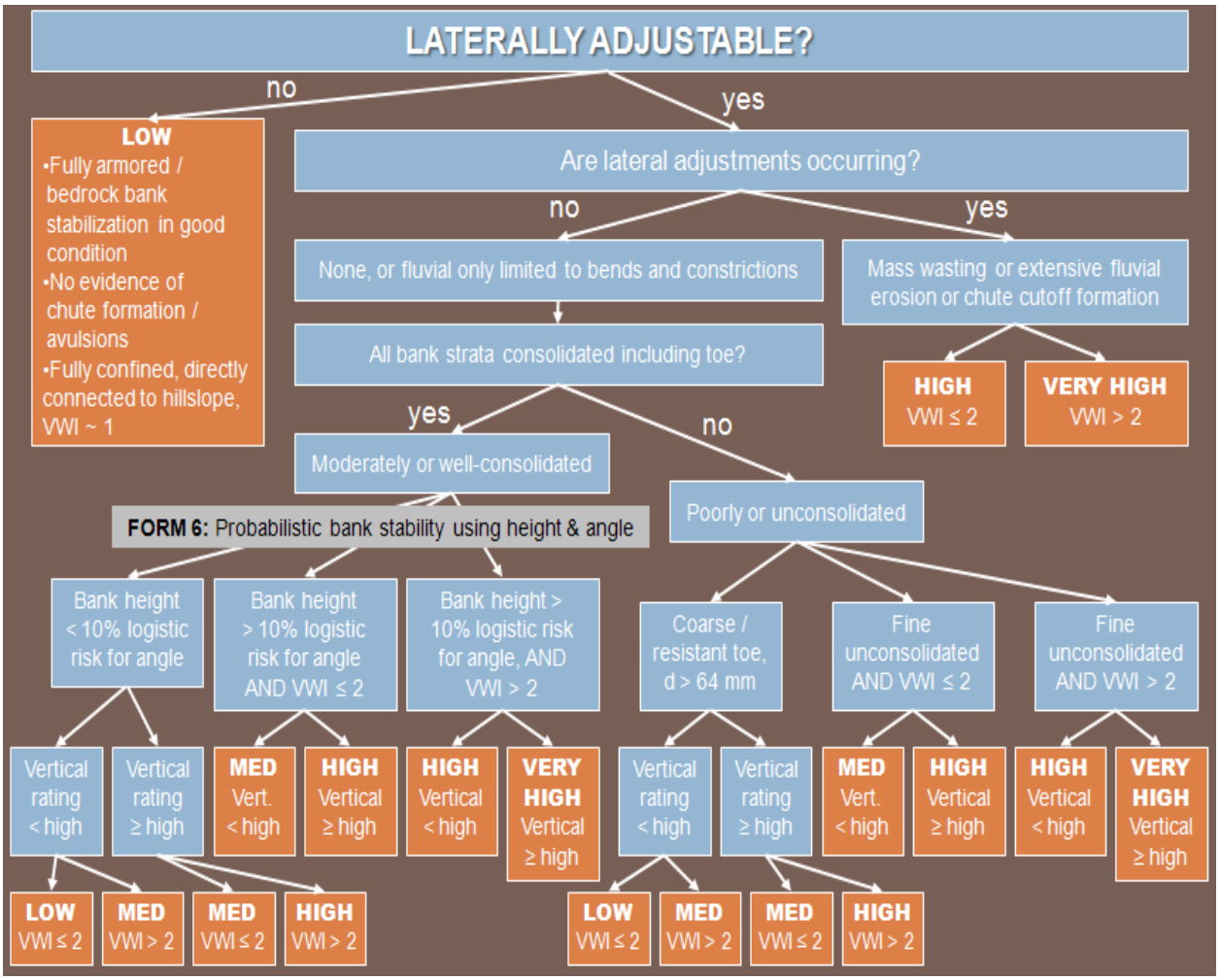
In assessing the potential for incision-induced bank failure we selected a vertical rating of high as a key discriminator. This decision was made primarily because such an approach inherently captures braiding risk as channels with high amounts of erosive energy relative to their bed material and >50% risk of incision/braiding using Form 3 Table 1 (**Figure 7**) would most likely result in a vertical rating of high unless exceptionally resistant and well-protected by armoring. We also defined a VWI of 2 as a key discriminator because doing so successfully distinguished between channels with valley bottoms 'confined by bedrock or hillslope' versus unconfined channels in the field data set. Unconfined valley settings were typically well above a VWI of 2.

The Lateral Susceptibility decision tree in Form 4 (**Figure 12**) and the series of questions in Form 5 (**Figure 13**) are provided for use in conducting the lateral susceptibility assessment. Either may be used depending on the user's preference. Definitions and photographic examples above are intended to support the lateral susceptibility assessment.

Additionally, Hawley (2009) performed logistic regression analysis of stable versus mass wasting in moderately- to well-consolidated banks using bank height and angle, consistent with geotechnical stability theory presented by Osman and Thorne (1988). The model was highly significant ($p < 0.0001$) and correctly classified unstable and stable states with ~95% accuracy, as shown in Form 6 (**Figure 14**), using a shape that was analogous to the Culmann relationship. As an alternative, by including the poorly consolidated sites, the model accuracy was ~90% with a lower 50% threshold and a much broader 10 to 90% risk range.

FORM 4: LATERAL SUSCEPTIBILTY FIELD SHEET

Circle appropriate nodes/pathway for proposed site
OR use sequence of questions provided in Form 5.



(Sheet 1 of 1)

Figure 12. Form 4: Lateral Susceptibility Field Sheet. Complete set of assessment forms in Appendix B.

FORM 5: SEQUENCE OF LATERAL SUSCEPTIBILITY QUESTIONS OPTION

Enter Lateral Susceptibility (Very High, High, Medium, Low) in shaded column.
Mass wasting and bank instability from Form 6, VWI from Form 4, and Vertical Rating from Form 3.

			Lateral Susceptibility
Channel fully confined with VWI ~1 – connected hillslopes OR fully-armored/engineered bed and banks in good condition?	If YES, then LOW		
If NO, Is there active **mass wasting** or extensive fluvial erosion (> 50% of bank length)?	If YES, VWI ≤ 2 = HIGH, VWI > 2 = VERY HIGH		
If NO, Are both banks consolidated?	If YES, How many risk factors present? **Risk Factors:** o Bank instability p > 10% o VWI > 2 o Vertical rating ≥ High	• All three = VERY HIGH • Two of three = HIGH • One of three = MEDIUM • None = LOW	
If NO, Are banks either consolidated or unconsolidated with coarse toe of d > 64 mm?	If YES, How many risk factors present? **Risk Factors:** o VWI > 2 o Vertical rating ≥ High	• Two = HIGH • One = MEDIUM • None = LOW	
If NO, At least one bank is unconsolidated with toe of d < 64 mm	How many risk factors present? **Risk Factors:** o VWI > 2 o Vertical rating ≥ High	• Two = VERY HIGH • One = HIGH • None = MEDIUM	

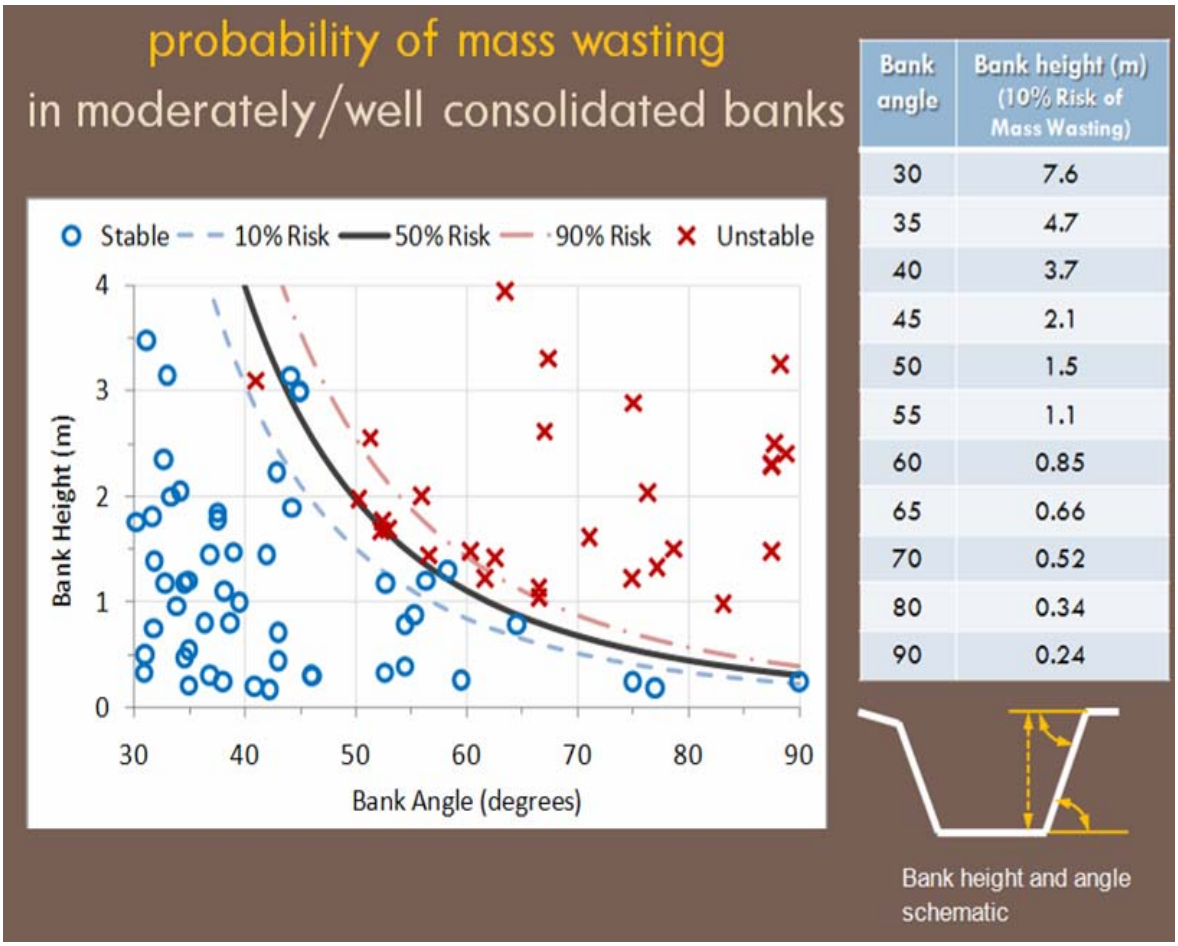
(Sheet 1 of 1)

Figure 13. Form 5: Sequence of Lateral Questions Option for lateral susceptibility assessment. Complete set of assessment forms in Appendix B.

FORM 6: PROBABILITY OF MASS WASTING BANK FAILURE

If mass wasting is not currently extensive and the banks are moderately- to well-consolidated, measure bank height and angle at several locations (i.e., at least three locations that capture the range of conditions present in the study reach) to estimate representative values for the reach. Use Form 6 Figure 1 below to determine if risk of bank failure is >10% and complete Form 6 Table 1. Support your results with photographs that include a protractor/rod/tape/person for scale.

	Bank Angle (degrees) *(from Field)*	**Bank Height (m)** *(from Field)*	**Corresponding Bank Height for 10% Risk of Mass Wasting (m)** *(from Form 6 Figure 1 below)*	**Bank Failure Risk** *(<10% Risk)* *(>10% Risk)*
Left Bank				
Right Bank				



Form 6 Figure 1. Probability Mass Wasting diagram, Bank Angle:Height/% Risk table, and Band Height:Angle schematic.

(Sheet 1 of 1)

Figure 14. Form 6: Probability of Mass Wasting Bank Failure for lateral susceptibility assessment. Complete set of assessment forms in Appendix B.

SUMMARY AND CONCLUSIONS

After completing the initial desktop and field components, the user should return to the office to summarize the reconnaissance information. Some values that were measured in the field may require (or be simplified by) computer assistance (e.g., sorting and ranking the pebble count data to determine the median particle size). A data entry spreadsheet (Data Entry Form.xls) has been provided to automate the necessary calculations from your field data.

At a minimum, we suggest outlining the following aspects from the field reconnaissance:

- Aerial photo of analysis domain with demarcation of reaches assessed and locations of critical features such as hard points, outfalls, changes in valley type, etc.
- A minimum of four photos from each assessed reach
    - Overview/cross-section
    - Representative bed material
    - Representative bank from right and left side of channel
- Applicable Vertical Susceptibility forms and final rating from each assessed reach
- Applicable Lateral Susceptibility forms and final rating from each assessed reach

In depth information describing the development and scientific basis of the field screening tool is provided in SCCWRP Technical Report 607, available at www.sccwrp.org We expect that the field screening tool presented herein will be systematically improved over time through a variety of monitoring and adaptive management activities, as well as through user feedback. Accordingly, comments, questions, and suggestions are welcome and may be submitted to Eric Stein at SCCWRP (**erics@sccwrp.org**) and Brian Bledsoe at CSU (brian.bledsoe@colostate.edu).

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APPENDIX A: GENERAL DEFINITIONS

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APPENDIX A: GENERAL DEFINITIONS

A.1 SUSCEPTIBILITY/SENSITIVITY DEFINITIONS

What is susceptibility?

The *intrinsic* sensitivity of a channel system to hydromodification as determined by the ratio of disturbing to resisting forces, proximity to thresholds of concern, probable rates of response and recovery, and potential for spatial propagation of impacts.

What is sensitivity?

Schumm defined *sensitivity* as:

"One aspect of (landform) singularity that must be treated separately is the sensitivity of landscape components... The reason for such variable response… is the existence of threshold conditions, which when exceeded produce a large change. In contrast, apparently similar landforms may show little or no response to a similar change. Thus, within a landscape composed of singular landforms there will be sensitive and insensitive landforms." Schumm (1985, page 13)

"Sensitivity refers to the propensity of a system to respond to a minor external change. The changes occur at a threshold, which when exceeded produces a significant adjustment. If the system is sensitive and near a threshold it will respond to an external influence; but if it is not sensitive it may not respond." Schumm (1991, page 78)

Downs and Gregory (1995) illustrated *sensitivity* as:

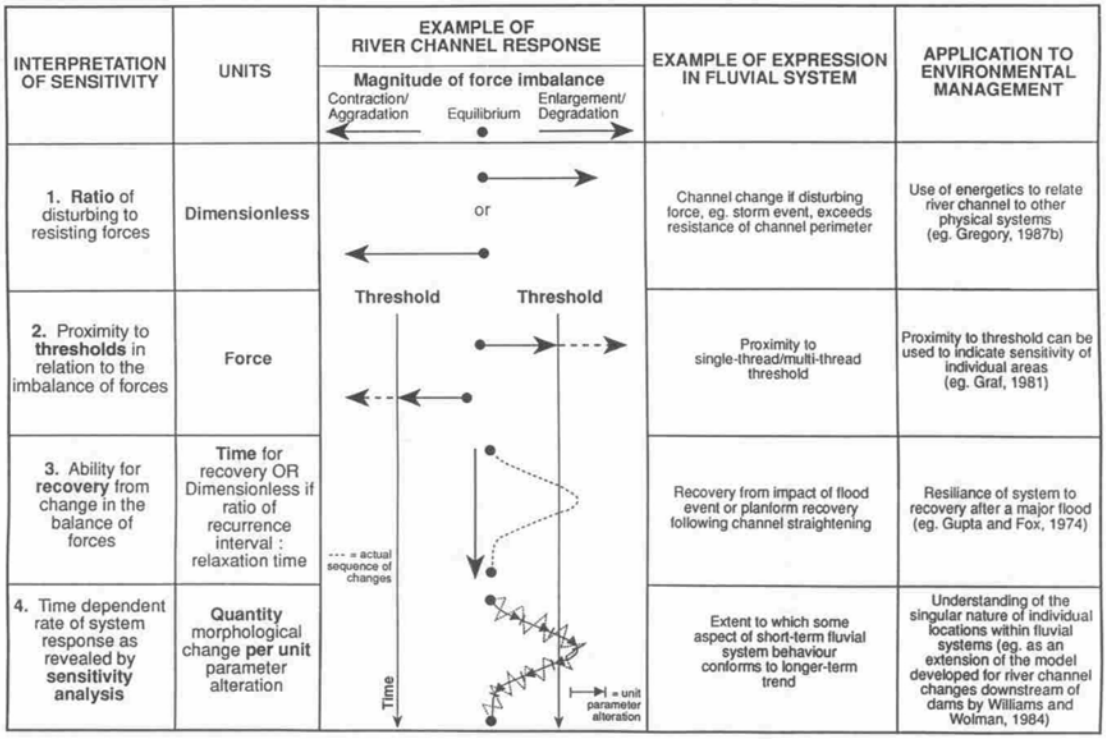


Figure A.1: Interpretation of sensitivity from Downs and Gregory (1995)

We add to this, the potential spatial extent of impacts over a common engineering time scale of *ca*. 50 yrs. That is, some effects may propagate throughout drainage networks relatively quickly and result in headcutting, base-level lowering of tributaries, complex response, etc.

A.2 Braiding Definitions

- Broadest definition: multi-channel patterns (Leopold and Wolman 1957)
- Definition illustrations of sinuosity, braiding, and anabranching (Figure A.2), incision-driven CEM (Figure A.3), bank failure (Figures A.4a and A.4b)
- Flow separated by bars within a defined channel, where bars (Knighton 1998):
    - o may be inundated at higher flows, appearing as a single channel at/near 'bankfull'
    - o tend to be unvegetated, temporary, with little cohesion
- Characterized by repeated division and joining of channels (i.e., divergence and convergence of flow) resulting in high rates of fluvial activity relative to other rivers (Knighton 1998)

- Non-cohesive floodplains with braid-channel accretion as the main sediment accretion mechanism (Nanson and Croke 1992)

- Informed by the aforementioned definitions, we classify ‘braided’ channels for the purposes of this screening tool as:

  ➔ ***Multiple flow paths through over 50% of the reach length at low to moderate flows (see 35 – 65% ‘degree of braiding’, Figure A.2)***

  ➔ ***OR, if stakeholders are not concerned about ‘anastomosing’/ ‘anabranching’ systems, augment above with: where paths are temporary and the result of dynamic, mostly unvegetated/non-cohesive bars***

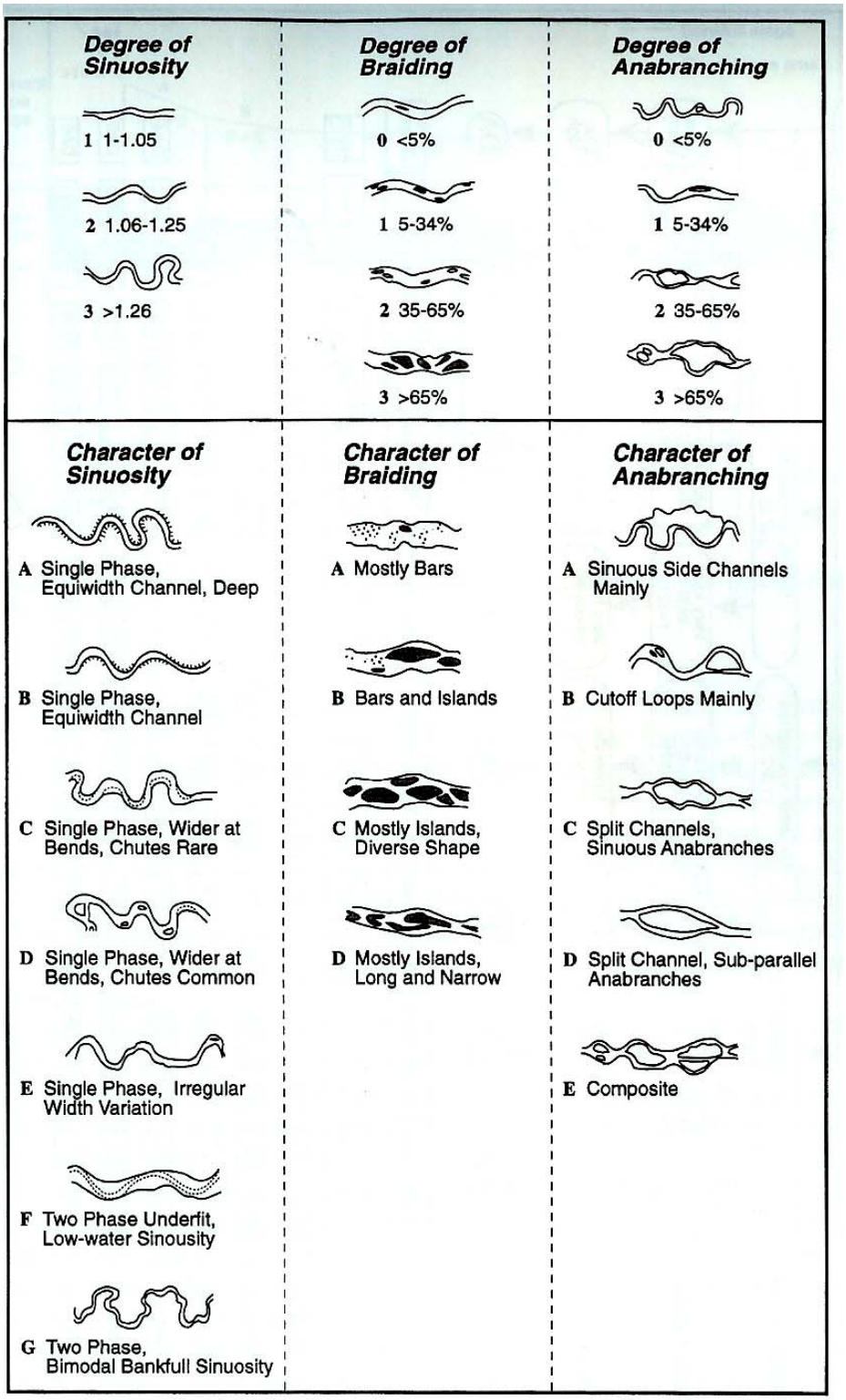
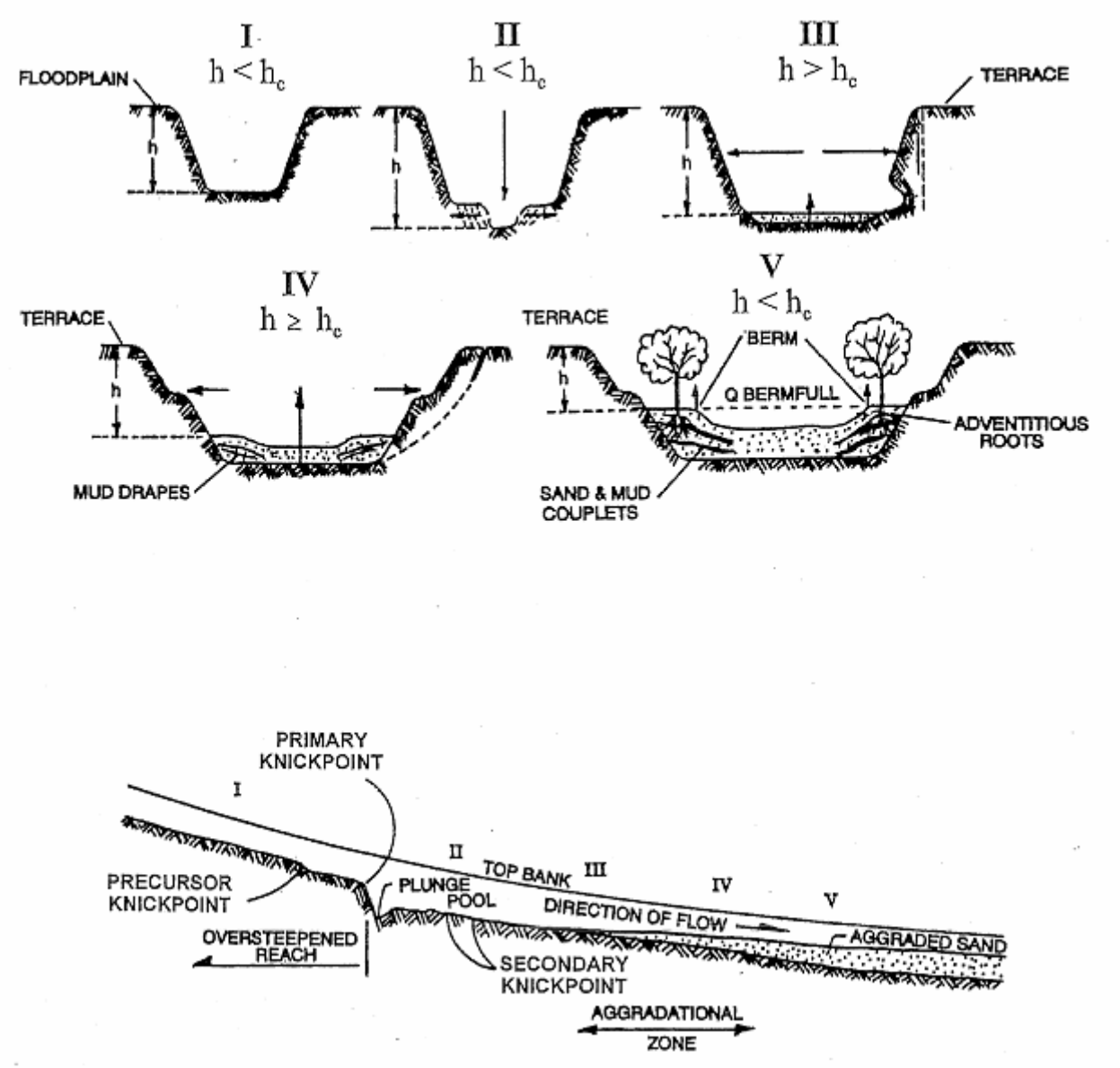


Figure A.2: Illustration of sinuosity, braiding, and anabranching (from Brice (1960, 1964))



h_c = critical bank height for mass failure

Figure A.3: Incision-driven CEM after Schumm *et al.* (1984); figure adapted from Watson *et al*. (2002)

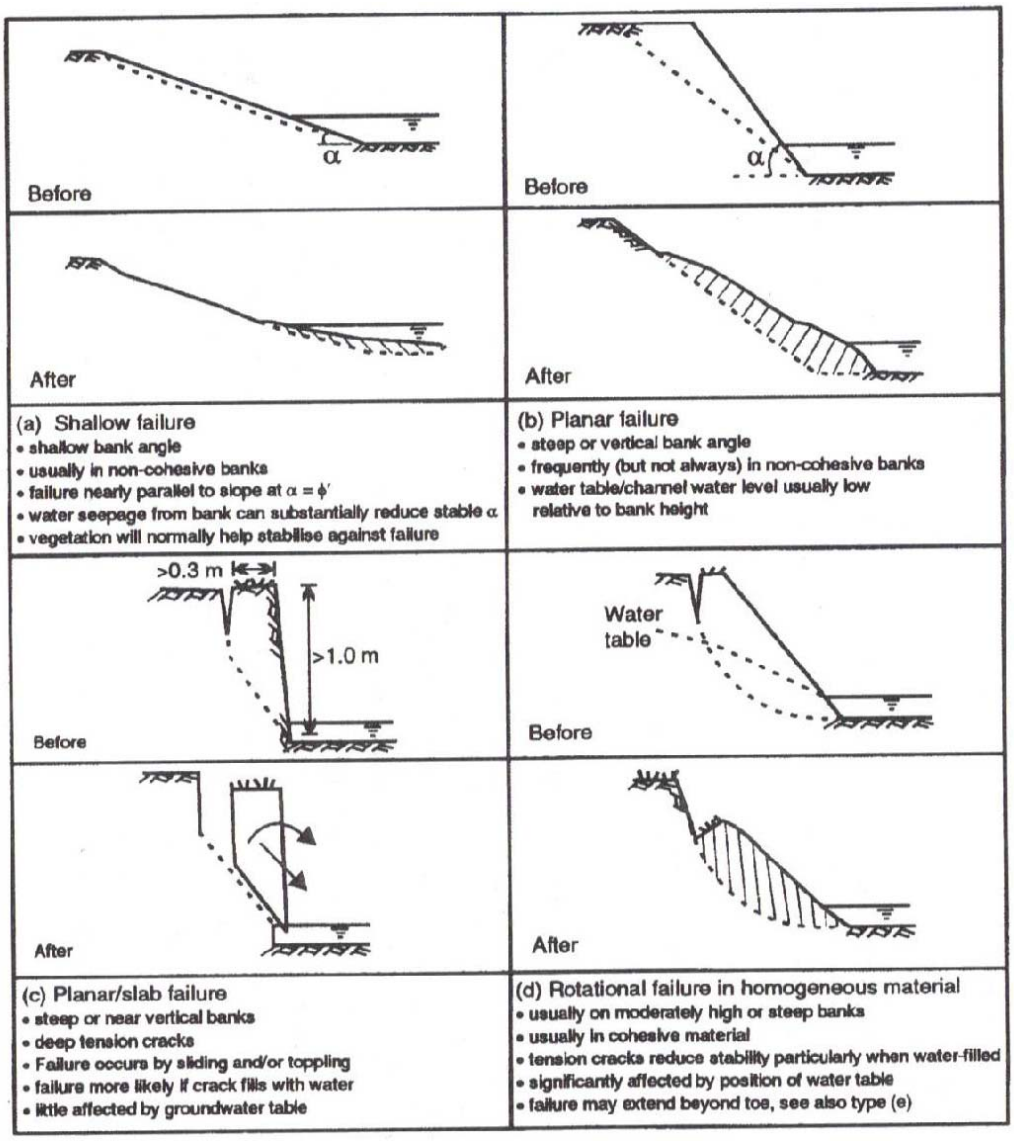


Figure A.4a: Bank-failure illustrations (a through d) after Hey *et al.* (1991); figure adapted from Lawler *et al.* (1997)

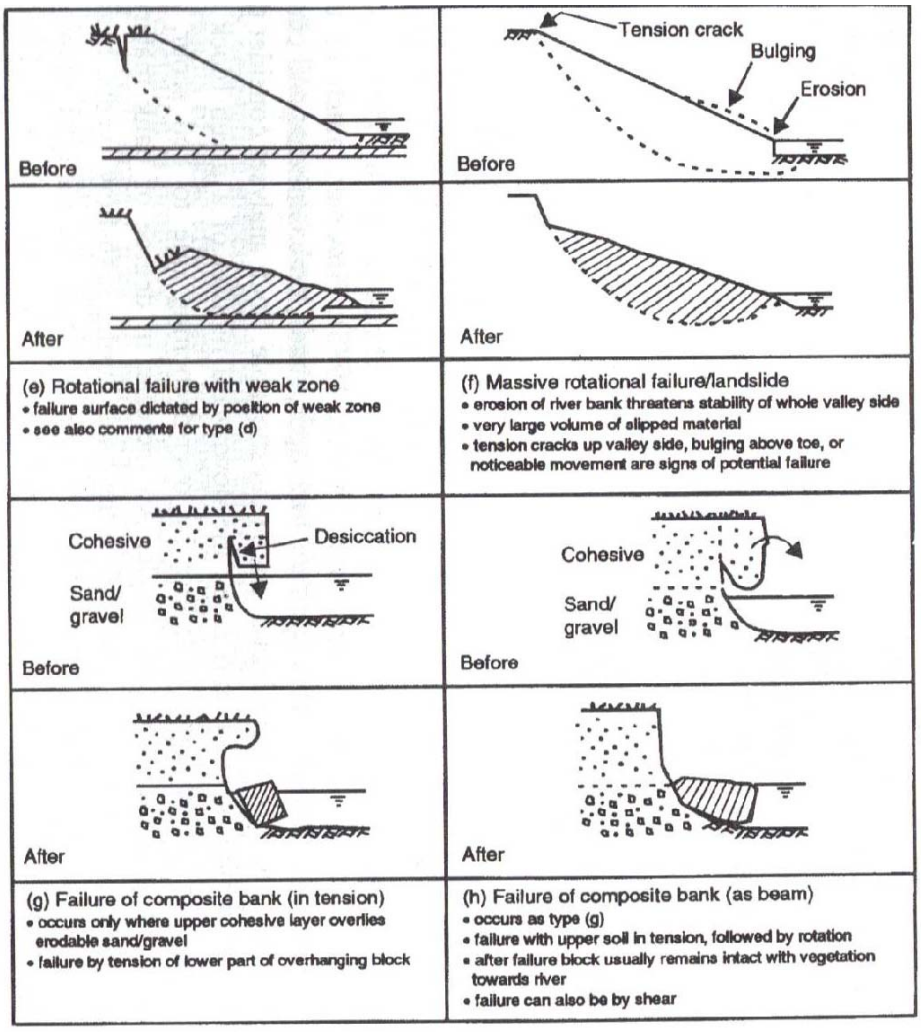


Figure A.4b: Bank-failure illustrations (e through h) after Hey *et al.* (1991); figure adapted from Lawler *et al.* (1997)

A.3 PEBBLE COUNT INSTRUCTIONS

Sampling with a frame – Excerpt from Bunte and Abt, 2001b:

"A tape measure is stretched from bank to bank. The sampling frame is placed onto the stream bottom so that one of the corners aligns with even-spaced marks on the tape, e.g., every three feet or one meter. Grid points derived by the elastic bands are used to visually define the particle to be selected. If the flow is deep and fast, and vision is blurred, looking at the grid intersection can help identify the particle to be included in the sample. If, for example, the grid intersection is between two cobbles, the operator knows that a small interstitial particle should be selected, but neither of the cobbles.

If flow is too deep or too fast to see the particle under the grid intersection, the particle to be included in the sample has to be identified by touch. A pointed index finger is placed in a corner of the grid intersection, and vertically lowered onto the sediment surface. The grid intersection serves as a guide for the position of the finger as it is lowered to the bed surface. Using the grid intersection as a reference point as opposed to the tip of the boot helps the operator select a particle more representatively because the operator works in a more comfortable posture when bending down to the sampling frame as opposed to bending down to the tip of the boot. The elastic bands in the sampling frame do not hinder the removal of a particle from the streambed. Particles are collected from under all four grid points, measured with a template, and placed back approximately into the same position from which they were taken. The frame is then moved to the next position along the tape. For many coarse gravel-bed rivers, a 30-cm grid within a 60 by 60 cm frame placed at 1 m, or 3 feet increments along the tape will be adequate. The sampling frame can be used on both sides of a transect. Individual transects should be 3 - 4 m apart to avoid overlap between sampled areas."

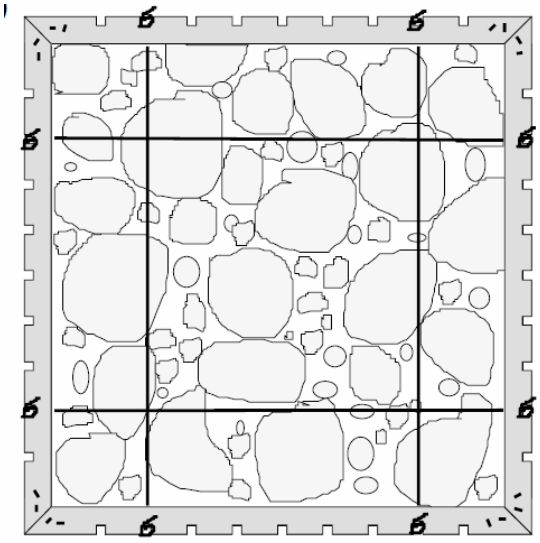


Figure A.5: Pebble Count Sampling Frame and Instructions from Bunte and Abt (2001b)

APPENDIX B: ASSESSMENT FORMS

Click here to open pdf version of Appendix B

APPENDIX B: ASSESSMENT FORMS

Overview

This appendix compiles the field forms necessary to conduct the field susceptibility analysis. The field assessment uses a combination of relatively simple, but quantitative field, indicators as input parameters to a set of decision trees. The decision trees follow a logical progression and allow users to assign a classification of Low, Medium, High, or Very High susceptibility rating to the reach being assessed. Each stream reach is assessed independently in terms of its vertical and lateral susceptibility.

The susceptibility assessment consists of the following steps:

1. Determine the **Analysis Domain**
2. Conduct the initial **Office Assessment**
3. Rate the **Vertical Susceptibility** of the stream reach
4. Rate the **Horizontal Susceptibility** of the stream reach

The following forms and instructions provided to conduct these assessments include:

- Instruction on determining Analysis Domain
- Office Assessment Forms
    - Form 1: Initial Desktop Analysis
    - Form 2: Pebble Count
        - Example coverage and substrate sizing guidance
    - Form 3: Vertical Susceptibility Field Sheet
        - Checklist 1: Armoring Potential
        - Checklist 2: Grade Control
        - Probability of Incising/Braiding Diagram and Screening Index Threshold Calculations
        - Overall Vertical Susceptibility Decision Tree
    - Form 4: Lateral Susceptibility Field Sheet
    - Form 5: Sequence of Lateral Susceptibility Questions Option
    - Form 6: Probability of Mass Wasting Bank Failure

In order to complete the field assessment, the following items should be taken to the field:

- Additional forms and/or field book for sketches/notes
- Digital camera for photographic documentation
- Pocket rod and/or tape for some basic measurements and reference/scale in photographs
- Protractor (e.g., gravity-driven) for measuring bank angle
- Gravelometer (i.e., US SAH-97 half-phi template) for standardized pebble count

Analysis Domain

Prior to initiating the assessment, it is necessary to define the domain of analysis that will be covered. The maximum spatial unit for assigning a susceptibility rating is defined as a *ca.* 20 channel width 'reach' not to exceed 200 m. Before conducting the field screening, the analyst should identify the following attributes as part of the office analysis to estimate the maximum extent of the analysis domain for field refinement.

Begin by defining the points or zones along the channel reach(es) where changes in discharge or channel type are likely to occur (e.g., potential locations of outfalls or tributary inputs). Document any observed outfalls for final desktop synthesis and define the upstream and downstream extents of analysis as follows:

- **Downstream** – until reaching the closest of the following:
  - at least one reach downstream of the first grade-control point (but preferably the second downstream grade-control location)
  - tidal backwater/lentic waterbody
  - equal order tributary (Strahler 1952)[1]
  - a 2-fold increase in drainage area[2]

OR demonstrate sufficient flow attenuation through existing hydrologic modeling

- **Upstream** – extend the domain upstream for a distance equal to 20 channel widths OR to grade control in good condition – whichever comes first. Within that reach, identify hard points that could check headward migration, evidence that head cutting is active or could propagate unchecked upstream

Within the analysis domain there may be several reaches that should be assessed independently based on either length or change in physical characteristics. In more urban settings, segments may be logically divided by road crossings (Chin and Gregory, 2005), which may offer grade control, cause discontinuities in the conveyance of water or sediment, etc. In more rural settings, changes in valley/channel type, natural hard points, and tributary confluences may be more appropriate for delineating assessment reaches. In general, the following criteria should trigger delineation of a new reach and hence a separate susceptibility assessment:

- 200 m or ca. 20 bankfull widths – it is difficult to integrate over longer distances
- Distinct or abrupt change in grade or slope due to either natural or artificial features
- Distinct or abrupt change in dominant bed material or sediment conveyance
- Distinct or abrupt change in valley setting or confinement
- Distinct or abrupt change in channel type, bed form, or planform

Assessment Forms

Assessment Forms 1 - 6, beginning on the next page, have been collected for printing as a group.

[1] In the absence of proximate downstream grade control or backwater, the confluence of an 'equal order tributary' should correspond to substantial increases in flow and channel capacity that should, in theory, correspond to significant flow attenuation; however, there is no scientific basis to assume that downstream channels of higher stream order are less susceptible than their upstream counterparts. This (practically-driven) guidance should not supersede the consideration of local conditions and sound judgment. Stakeholders may elect to use a more regionally-preferred guidance.

[2] An increase in drainage area greater than or equal to 100% would roughly correspond to the addition of an equal-order tributary (see above).

FORM 1: INITIAL DESKTOP ANALYSIS

Complete all shaded sections.

IF required at multiple locations, circle one of the following site types:

Applicant Site / Upstream Extent / Downstream Extent

Location: Latitude: _____ Longitude: _____

Description (river name, crossing streets, etc.): _____

_____

GIS Parameters: The International System of Units (SI) is used throughout the assessment as the field standard and for consistency with the broader scientific community. However, as the singular exception, US Customary units are used for contributing drainage area (A) and mean annual precipitation (P) to apply regional flow equations after the USGS. See SCCWRP Technical Report 607 for example measurements and "Screening Tool Data Entry.xls" for automated calculations.

Form 1 Table 1. Initial desktop analysis in GIS.

Symbol		Variable	Description and Source	Value
Watershed properties (English units)	**A**	Area (mi^2)	Contributing drainage area to screening location via published Hydrologic Unit Codes (HUCs) and/or ≤ 30 m National Elevation Data (NED), USGS seamless server	
	P	Mean annual precipitation (in)	Area-weighted annual precipitation via USGS delineated polygons using records from 1900 to 1960 (which was more significant in hydrologic models than polygons delineated from shorter record lengths)	
Site properties (SI units)	**S_v**	Valley slope (m/m)	Valley slope at site via NED, measured over a relatively homogenous valley segment as dictated by hillslope configuration, tributary confluences, etc., over a distance of up to ~500 m or 10% of the main-channel length from site to drainage divide	
	W_v	Valley width (m)	Valley bottom width at site between natural valley walls as dictated by clear breaks in hillslope on NED raster, irrespective of potential armoring from floodplain encroachment, levees, etc. (imprecise measurements have negligible effect on rating in wide valleys where VWI is >> 2, as defined in lateral decision tree)	

Form 1 Table 2. Simplified peak flow, screening index, and valley width index. Values for this table should be calculated in the sequence shown in this table, using values from Form 1 Table 1.

Symbol	Dependent Variable	Equation	Required Units	Value
Q_{10cfs}	10-yr peak flow (ft^3/s)	$Q_{10cfs} = 18.2 * A^{0.87} * P^{0.77}$	A (mi^2) P (in)	
Q_{10}	10-yr peak flow (m^3/s)	$Q_{10} = 0.0283 * Q_{10cfs}$	Q_{10cfs} (ft^3/s)	
INDEX	10-yr screening index ($m^{1.5}/s^{0.5}$)	$INDEX = S_v * Q_{10}^{0.5}$	Sv (m/m) Q_{10} (m^3/s)	
W_{ref}	Reference width (m)	$W_{ref} = 6.99 * Q_{10}^{0.438}$	Q_{10} (m^3/s)	
VWI	Valley width index (m/m)	$VWI = W_v/W_{ref}$	W_v (m) W_{ref} (m)	

(Sheet 1 of 1)

FORM 2: PEBBLE COUNT

If it is necessary to estimate d_{50}, perform a pebble count, after Bunte and Abt (2001a,b), using a minimum of 100 particles and a standard half-phi template, or by measuring along the intermediate axis of each pebble. Use a grid and tape for equally spaced samples over systematic/complete transects across riffle sections (i.e., if the 100th particle is in the middle of a transect, complete the full transect before stopping the count; if more than 125 particles, record data near the bottom of Sheet 2 of 2). If the source of fines (sand/silt d <2 mm; see Form 2 Table 2 below) is less than ½ inch thick (approximately one finger width) at the sampling point, sample the coarser buried substrate; otherwise record observation of fines. Take photographs to support observations (Detailed instructions in Appendix A.3).

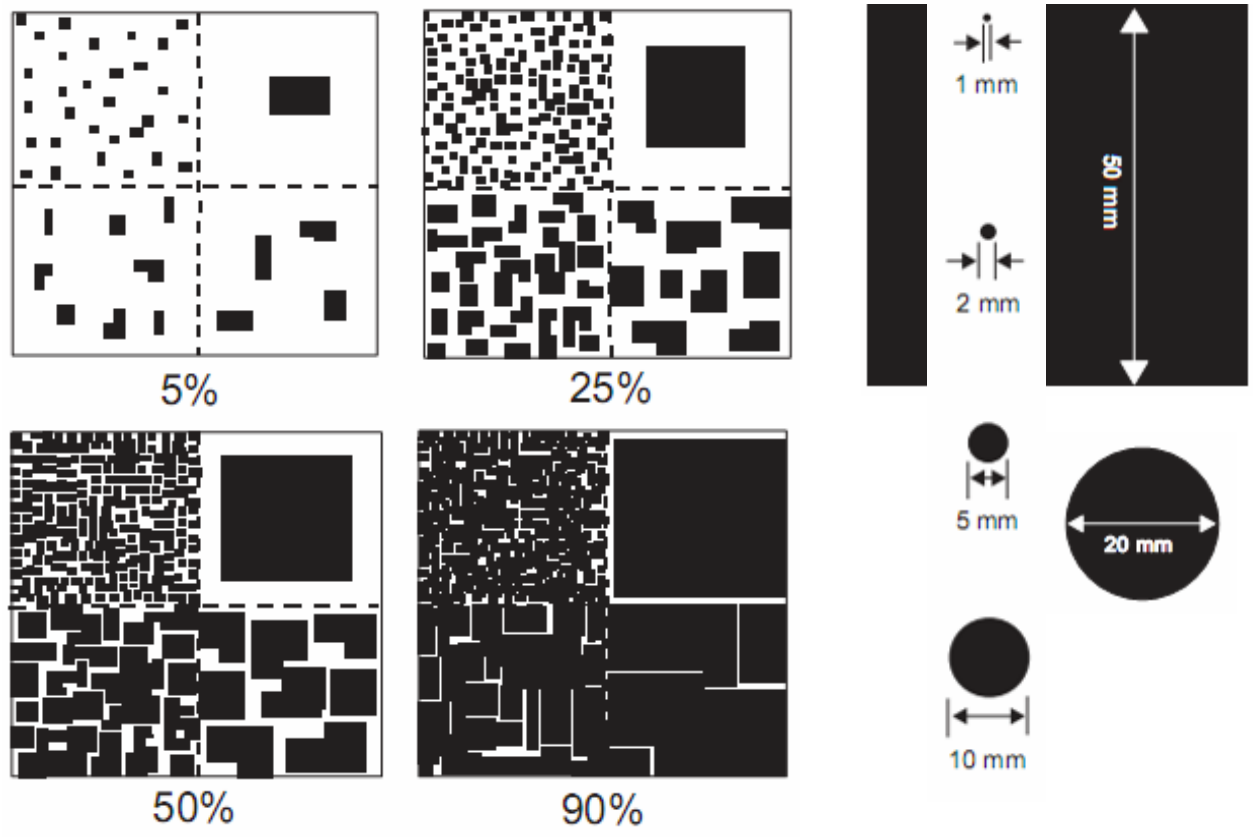
Form 2 Table 1. 100-pebble count tabulation for Vertical Susceptibility. Record station (Sta) and diameter (d) in millimeters.

#	Sta	d (mm)	#	Sta	d (mm)	#	Sta	d (mm)	#	Sta	d (mm)	#	Sta	d (mm)
1			26			51			76			101		
2			27			52			77			102		
3			28			53			78			103		
4			29			54			79			104		
5			30			55			80			105		
6			31			56			81			106		
7			32			57			82			107		
8			33			58			83			108		
9			34			59			84			109		
10			35			60			85			110		
11			36			61			86			111		
12			37			62			87			112		
13			38			63			88			113		
14			39			64			89			114		
15			40			65			90			115		
16			41			66			91			116		
17			42			67			92			117		
18			44			68			93			118		
19			44			69			94			119		
20			45			70			95			120		
21			46			71			96			121		
22			47			72			97			122		
23			48			73			98			123		
24			49			74			99			124		
25			50			75			100			125		

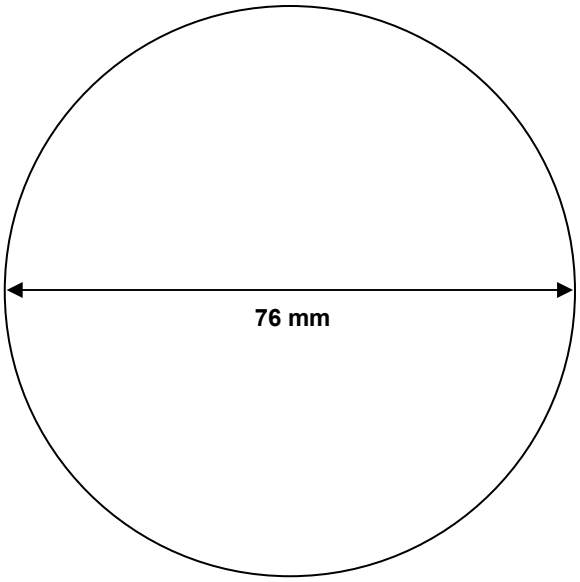
Form 2 Table 2. d_{50} for Screening Index Threshold.

Class Name	Diameter (mm)	Helpful Descriptions for Field Identification
Boulder	> 256	Difficult to lift by hand
Cobble	> 64	Typically able to lift
Gravel	> 2	Fits in one hand
Sand	> 0.0625	Can feel between fingers
Silt	> 0.004	Can feel with tongue
Clay	≤ 0.004	Can not feel individual particle

(Sheet 1 of 2)



Note: Each quadrant within each box contains the same total area covered using different sized objects.

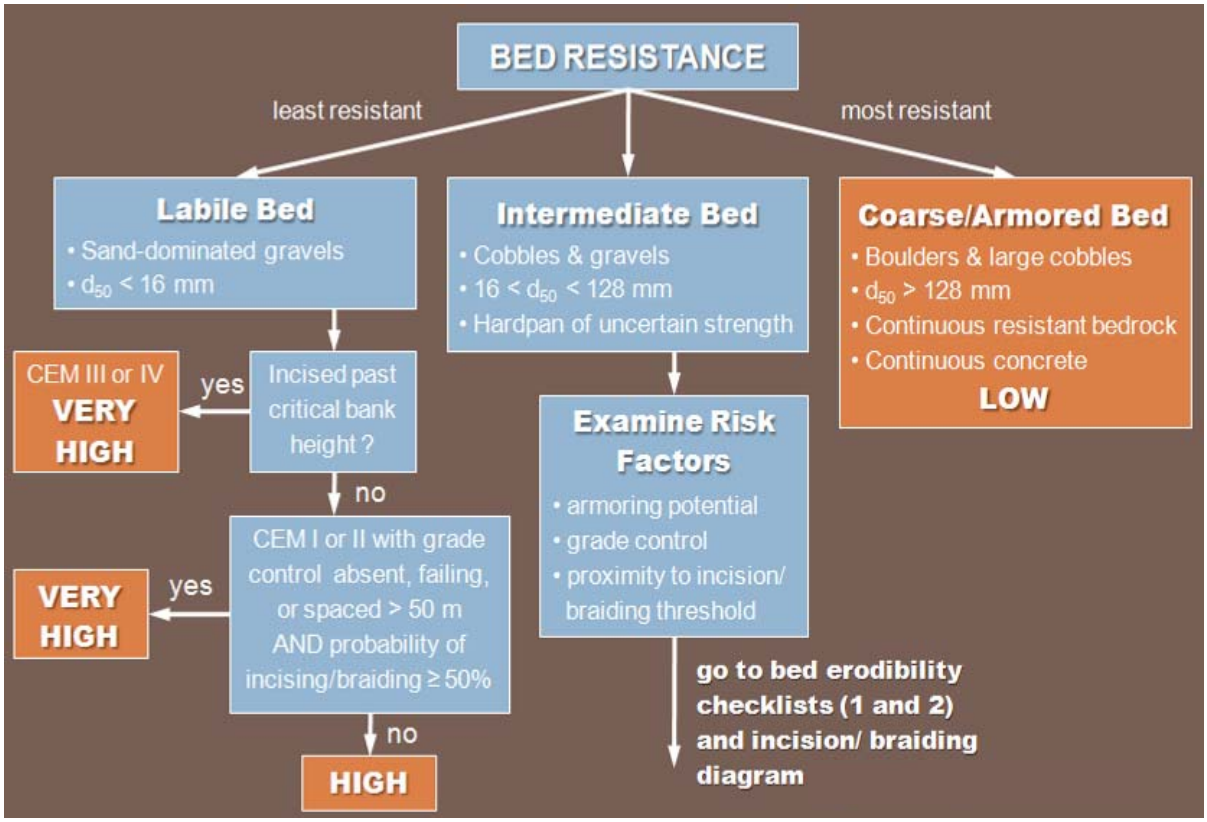


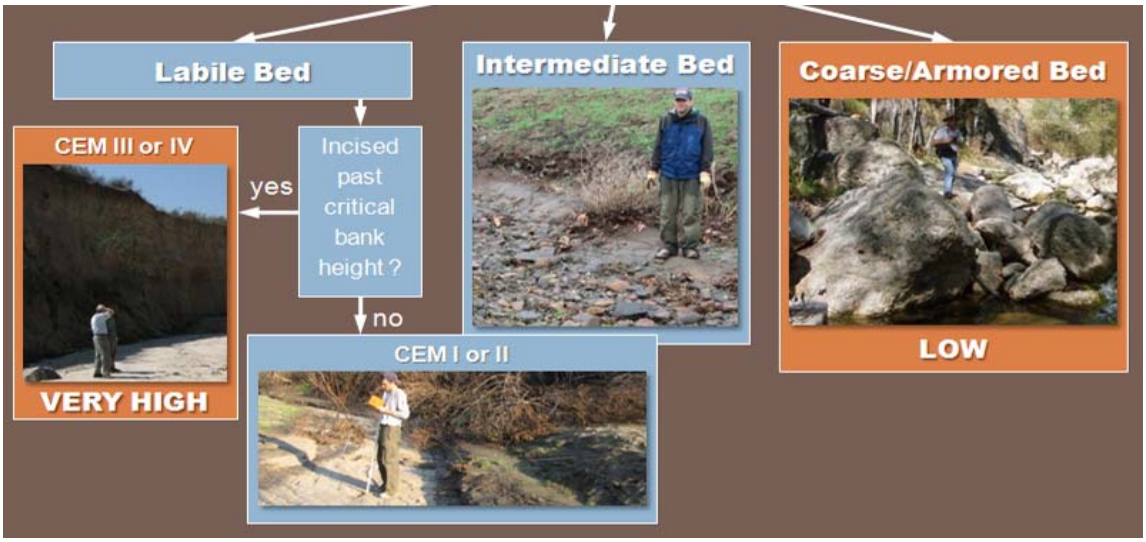
Form 2 Figure 1. Examples of % coverage by volume and substrate sizing adapted from *NRCS Field Book for Describing and Sampling Soils* (Schoeneberger *et al.* 2002) and Julien (1998).

(Sheet 2 of 2)

FORM 3: VERTICAL SUSCEPTIBILITY FIELD SHEET

Circle appropriate nodes/pathway for proposed site.





Form 3 Figure 1. Vertical Susceptibility photographic supplement to be used in conjunction with Form 3 Bed Resistance above.

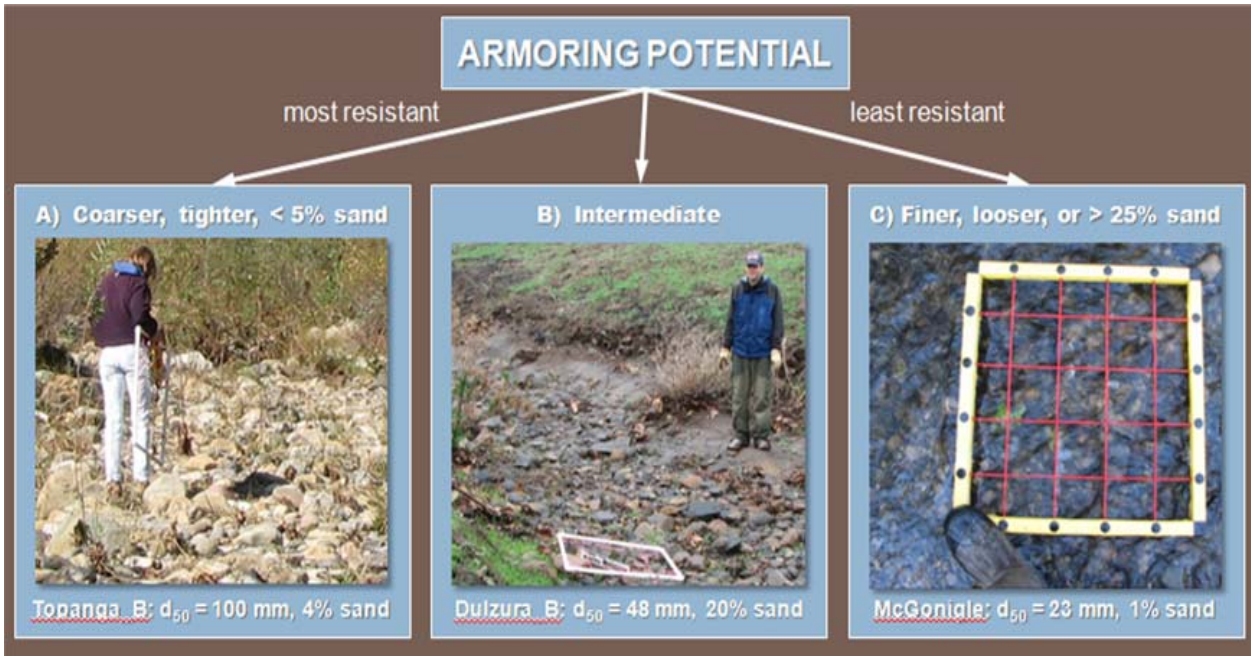
(Sheet 1 of 4)

Form 3 Support Materials

Form 3 Checklists 1 and 2, along with information recording in Form 3 Table 1, are intended to support the decisions pathways illustrated in Form 3 Overall Vertical Rating for Intermediate/Transitional Bed.

Form 3 Checklist 1: Armoring Potential

□	A	A mix of coarse gravels and cobbles that are tightly packed with <5% surface material of diameter <2 mm
□	B	Intermediate to A and C or hardpan of unknown resistance, spatial extent (longitudinal and depth), or unknown armoring potential due to surface veneer covering gravel or coarser layer encountered with probe
□	C	Gravels/cobbles that are loosely packed or >25% surface material of diameter <2 mm



Form 3 Figure 2. Armoring potential photographic supplement for assessing intermediate beds (16 < d_{50} < 128 mm) to be used i**n conjunction with Form 3 Checklist 1.**

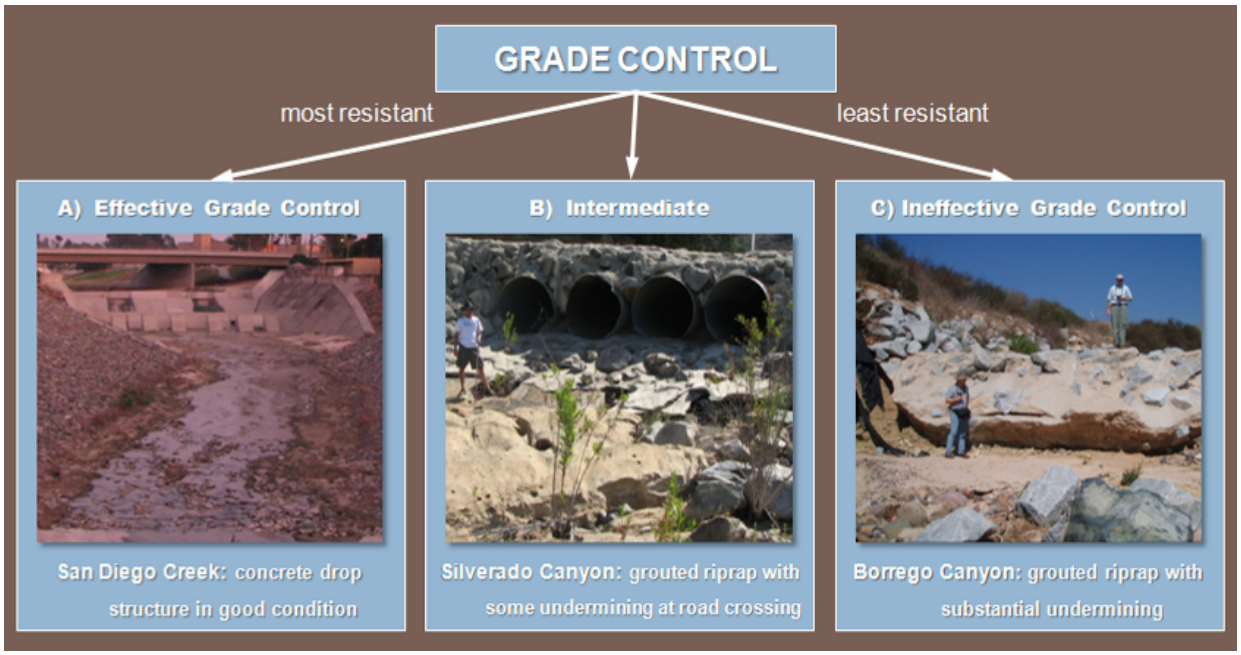
Form 3 Checklist 2: Grade Control

□ A Grade control is present with spacing <50 m or $2/S_v$ m

- No evidence of failure/ineffectiveness, e.g., no headcutting (>30 cm), no active mass wasting (analyst cannot say grade control sufficient if mass-wasting checklist indicates presence of bank failure), no exposed bridge pilings, no culverts/structures undermined
- Hard points in serviceable condition at decadal time scale, e.g., no apparent undermining, flanking, failing grout
- If geologic grade control, rock should be resistant igneous and/or metamorphic; For sedimentary/hardpan to be classified as 'grade control', it should be of demonstrable strength as indicated by field testing such as hammer test/borings and/or inspected by appropriate stakeholder

□ B Intermediate to A and C – artificial or geologic grade control present but spaced 2/Sv m to 4/Sv m or potential evidence of failure or hardpan of uncertain resistance

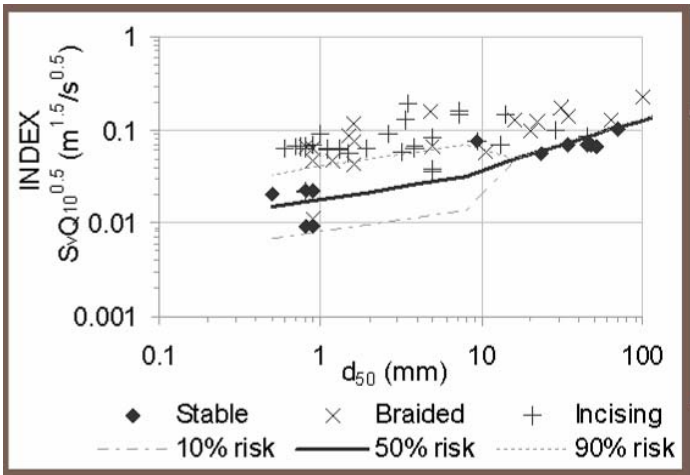
□ C Grade control absent, spaced >100 m or $>4/S_v$ m, or clear evidence of ineffectiveness



Form 3 Figure 3. Grade-control (condition) photographic supplement for assessing intermediate beds ($16 < d_{50} < 128$ mm) to be used in conjunction with Form 3 Checklist 2.

Regionally-Calibrated Screening Index Threshold for Incising/Braiding

For transitional bed channels (d_{50} between 16 and 128 mm) or labile beds (channel not incised past critical bank height), use Form 3 Figure 3 to determine Screening Index Score and complete Form 3 Table 1.



Model Type	d_{50} (mm)	50% Risk $S_vQ_{10}^{0.5}$ ($m^{1.5}/s^{0.5}$)
Logistic Regression $d_{50} \geq 16$ mm	128	0.145
	96	0.125
	80	0.114
	64	0.101
	48	0.087
	32	0.070
	16	0.049
Logistic Reg. $d_{50} < 16$ mm	8	0.031
	4	0.026
	2	0.022
	1	0.018
	0.5	0.015

Form 3 Figure 4. Probability of incising/braiding based on logistic regression of Screening Index and d_{50} to be used in conjunction with Form 3 Table 1.

Form 3 Table 1. Values for Screening Index Threshold (probability of incising/braiding) to be used in conjunction with Form 3 Figure 4 (above) to complete Form 3 Overall Vertical Rating for Intermediate/Transitional Bed (below).. Screening Index Score: A = <50% probability of incision for current Q_{10}, valley slope, and d_{50}; B = Hardpan/d_{50} indeterminate; and C = ≥50% probability of incising/braiding for current Q_{10}, valley slope, and d_{50}.

d_{50} (mm) *From Form 2*	**$S_v*Q_{10}^{0.5}$ ($m^{1.5}/s^{0.5}$)** *From Form 1*	**$S_v*Q_{10}^{0.5}$ ($m^{1.5}/s^{0.5}$)** *50% risk of incising/braiding from table in Form 3 Figure 3 above*	**Screening Index Score (A, B, C)**

Overall Vertical Rating for Intermediate/Transitional Bed

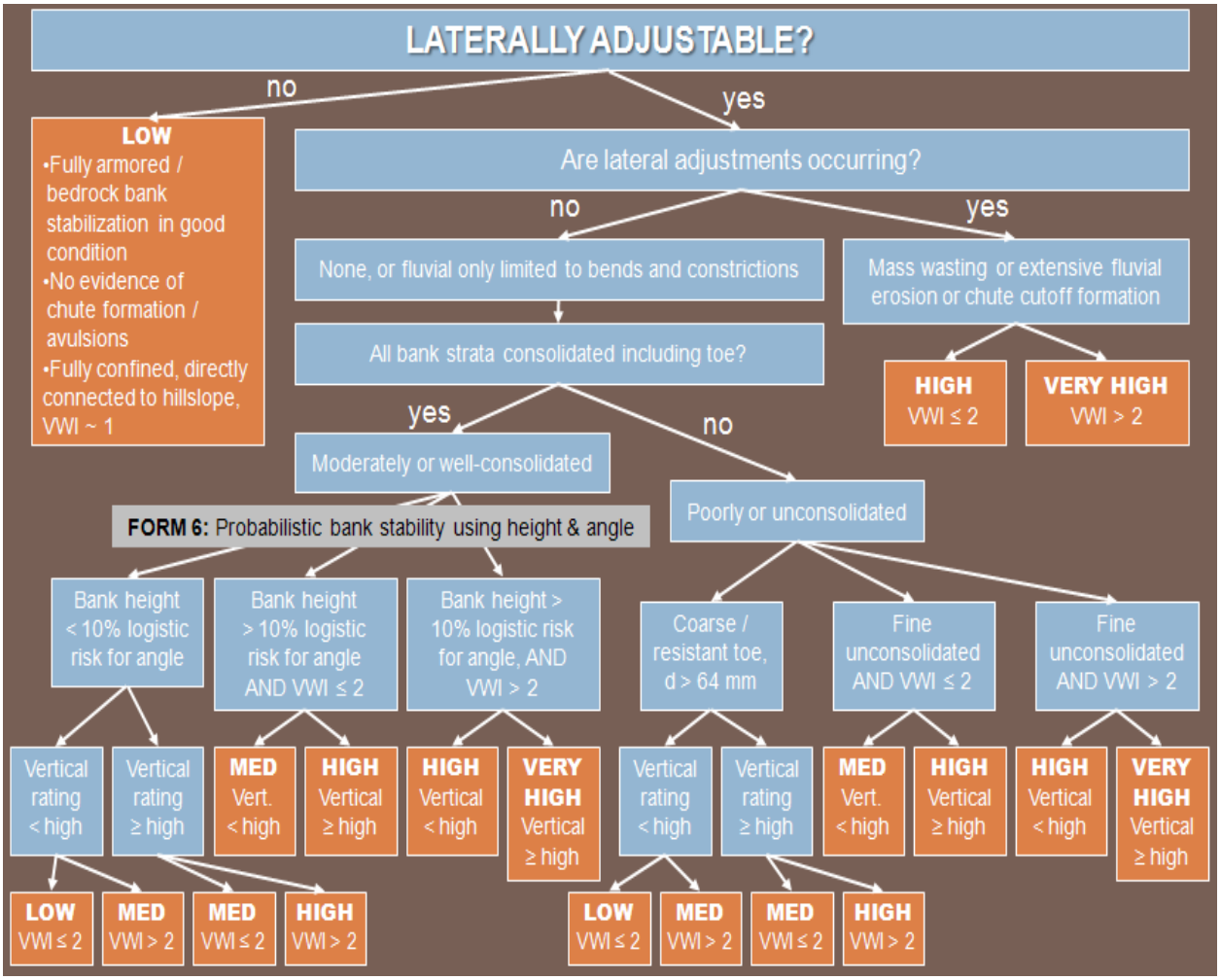
Calculate the overall Vertical Rating for Transitional Bed channels using the formula below. Numeric values for responses to Form 3 Checklists and Table 1 as follows: A = 3, B = 6, C = 9.

$$Vertical\ Rating = \sqrt{\{(\sqrt{armoring} * grade\ control) * screening\ index\ score\}}$$

Vertical Susceptibility based on Vertical Rating: <4.5 = LOW; 4.5 to 7 = MEDIUM; and >7 = HIGH.

FORM 4: LATERAL SUSCEPTIBILTY FIELD SHEET

Circle appropriate nodes/pathway for proposed site
OR use sequence of questions provided in Form 5.



(Sheet 1 of 1)

FORM 5: SEQUENCE OF LATERAL SUSCEPTIBILITY QUESTIONS OPTION

Enter Lateral Susceptibility (Very High, High, Medium, Low) in shaded column.
Mass wasting and bank instability from Form 6, VWI from Form 4, and Vertical Rating from Form 3.

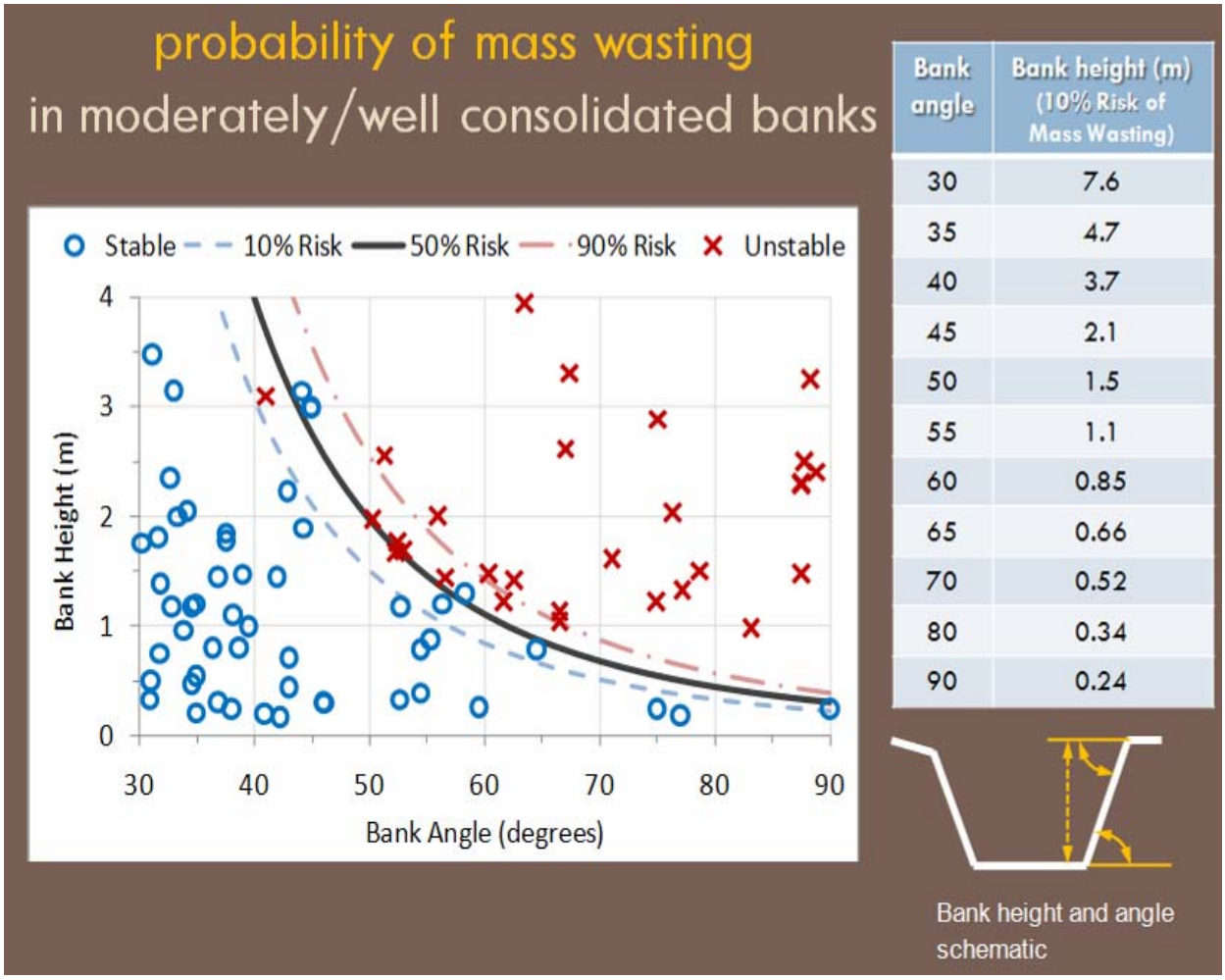
			Lateral Susceptibility
Channel fully confined with VWI ~1 – connected hillslopes OR fully-armored/engineered bed and banks in good condition?	If YES, then LOW		
If NO, Is there active **mass wasting** or extensive fluvial erosion (> 50% of bank length)?	If YES, VWI ≤ 2 = HIGH, VWI > 2 = VERY HIGH		
If NO, Are both banks consolidated?	If YES, How many risk factors present? **Risk Factors:** o Bank instability p > 10% o VWI > 2 o Vertical rating ≥ High	• All three = VERY HIGH • Two of three = HIGH • One of three = MEDIUM • None = LOW	
If NO, Are banks either consolidated or unconsolidated with coarse toe of d > 64 mm?	If YES, How many risk factors present? **Risk Factors:** o VWI > 2 o Vertical rating ≥ High	• Two = HIGH • One = MEDIUM • None = LOW	
If NO, At least one bank is unconsolidated with toe of d < 64 mm	How many risk factors present? **Risk Factors:** o VWI > 2 o Vertical rating ≥ High	• Two = VERY HIGH • One = HIGH • None = MEDIUM	

(Sheet 1 of 1)

FORM 6: PROBABILITY OF MASS WASTING BANK FAILURE

If mass wasting is not currently extensive and the banks are moderately- to well-consolidated, measure bank height and angle at several locations (i.e., at least three locations that capture the range of conditions present in the study reach) to estimate representative values for the reach. Use Form 6 Figure 1 below to determine if risk of bank failure is >10% and complete Form 6 Table 1. Support your results with photographs that include a protractor/rod/tape/person for scale.

	Bank Angle (degrees) *(from Field)*	**Bank Height (m)** *(from Field)*	**Corresponding Bank Height for 10% Risk of Mass Wasting (m)** *(from Form 6 Figure 1 below)*	**Bank Failure Risk** *(<10% Risk)* *(>10% Risk)*
Left Bank				
Right Bank				



Form 6 Figure 1. Probability Mass Wasting diagram, Bank Angle:Height/% Risk table, and Band Height:Angle schematic.

(Sheet 1 of 1)

APPENDIX C

Response to Coastkeeper Comments

Use of contents on this sheet is subject to the limitations specified at the end of this document.
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Tel: 858-514-8822
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TECHNICAL MEMO

Project No: 133904

San Diego Hydromodification Management Plan

Subject: Responses to Comments Provided by San Diego Coastkeeper

Date: February 16, 2010

To: Sara Agahi, P.E. – County of San Diego

From: Eric Mosolgo, P.E. – Brown and Caldwell

This draft technical memorandum has been prepared per the request of the County of San Diego to summarize responses to comments made in reference to the San Diego Hydromodification Management Plan (HMP) by San Diego Coastkeeper. These comments were submitted to the County of San Diego in letters dated April 14th, September 29th, and November 30th, 2009.

As mandated by Regional Water Quality Control Board (RWQCB) Order R9-2007-0001 Provision D.1.g, the purpose of hydromodification criteria is to prevent development-related changes in storm water runoff from causing, or further accelerating, stream channel erosion or other adverse impacts to beneficial stream uses.

The responses detailed in this memo have been incorporated into the Final HMP submitted to the San Diego Regional Water Quality Control Board (RWQCB) on December 29, 2009.

Responses to Coastkeeper Comments Dated November 30, 2009

Coastkeeper Comment – The inadequacies in applying LID are the HMP's most serious faults. They start with regarding LID as almost entirely a matter of infiltrating runoff, diminishing or ignoring the mechanisms of evapotranspiration and water harvesting and the practices associated with those mechanisms. Furthermore, the plan recommends basing infiltration assessments on coarse U.S. Department of Agriculture concepts and data instead of site-specific analysis and almost totally ignores the great potential of organic soil amendments to improve infiltration and evapotranspiration and reduce surface runoff quantities. The HMP reveals a poor appreciation of the status, performance, and practice of LID techniques today.

Limitations:

This document was prepared solely for the County of San Diego in accordance with professional standards at the time the services were performed and in accordance with the contract between the County of San Diego and Brown and Caldwell. This document is governed by the specific scope of work authorized by the County of San Diego; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work.

Response

- LID options modeled in determination of sizing factors account for both infiltration and evapotranspiration. Continuous simulation models are currently in development to determine the sizing factors for a wide range of development types, rainfall gauges, soil types, and BMP mitigation options. The evapotranspiration (ET) data is a key component of the continuous simulation models, along with the infiltration capacity of the soil, and is more certainly not an ignored mechanism. That said, BMPs studied in this analysis have to meet the County of San Diego's vector control guidelines along with the 85th percentile water quality and hydromodification standards. Thus, storage of runoff in excess of 72 hours will not be allowed.

- While water harvesting and reuse have obvious benefits, these criteria are not addressed or mandated in the Permit. From a hydromodification standpoint, water reuse facilities have some benefit for isolated rainfall events. When back-to-back storms occur, however, the hydromodification benefit is often not sufficient since the storage facilities are filled and provide no attenuation for the multiple concurrent storms. The use of rain water storage as a hydromodification control measure has not been ruled out. Rather, Copermittees can consider developer proposed storage facilities on a case by case basis. Such design strategies must prove compliance with hydromodification design criteria considering the long-term historical rainfall record.

- The Decision Matrix, located in Chapter 6 of the Final HMP, specifically states that site-specific geotechnical investigations be conducted to determine site-specific infiltration rates. Copermittees already require major development projects and many smaller projects to submit geotechnical soils reports which typically include identification of soil types. The referenced USDA information is part of the required Literature Review, which is located in Chapter 4 of the Final HMP. Infiltration parameters for the San Diego Region will be reviewed in details as part of the Sizing Calculator development process and further refined as part of the HMP implementation process.

- The use of amended soils has always been part of the HMP mitigation approach and the text of the Final HMP explicitly encourages the use of amended soils in the design of bioretention facilities. This concept is chronicled in both the HMP and the Model SUSMP. Similar to the approach used in Contra Costa County, several of the proposed BMP facilities will use an amended soil layer with an approximate infiltration rate of 5 inches per hour. Criteria provided in the Model SUSMP and HMP will work in concert. It should be noted that the use of amended soils will not promote deep infiltration for Types C and D soils, which are the dominant soil types in San Diego County. Thus, the use of underdrains may be required in urban environments.

- The Copermittees and the consultant team have developed detailed standards for LID implementation. These standards are provided in the Model SUSMP and are referenced in the Final HMP. The Final HMP recommends the use of LID facilities to satisfy HMP and 85th percentile water quality criteria.

- The intent of the HMP, as well as the Model SUSMP, is to encourage the use of LID facilities to meet hydromodification criteria. The text of Chapters 6 and 7 of the Final HMP were reviewed in detail and revised accordingly to encourage implementation of LID facilities.

- Defining the infiltration potential of a site is recommended to provide for sound engineering design. Even if infiltration is shown to be infeasible, LID facilities can be designed as filtration-type or evaporation-type facilities instead of infiltration-based facilities.
- Chapter 7 of the Final HMP has been revised to allow for evaporation-type facilities. It should be noted that such facilities may require implementation in series with more traditional LID approaches, such as biofiltration basins, in order to satisfy vector control and hydromodification criteria.

Coastkeeper Comment- Concerning the critical flow rate, the HMP presents an alternative to using a single value, a practice adopted elsewhere. The concept of multiple values is theoretically sound, but the plan falls short in specifying how the method it develops should be applied to assure proper use. Unless and until that gap can be filled, the appropriate single value, 10 percent of the 2-year flow event, should be used for the critical flow rate.

Response

- The San Diego HMP's varying lower flow threshold is a major advancement in the field of hydromodification management. This concept has been endorsed by the State Water Resources Control Board and other experts in the field. It is intuitive that erosion-prone streams should be held to a more stringent lower flow threshold as compared to erosion-resistant streams.
- Decision Matrices located in Chapter 6 clearly specify the method for determining the appropriate lower flow threshold. The method uses data from both the Southern California Coastal Water Research Project's (SCCWRP) channel screening tools (discussed in Chapter 5.2 and Appendix B) and the consultant team's critical flow calculator (discussed in Chapter 5.1) to determine the appropriate lower flow threshold.

Coastkeeper Comment – Exemptions put forward by the HMP fall into two categories: those that have been poorly thought through and, as presented in the plan, will continue to allow substantial hydromodification; and those that will forever consign degraded streams to that status. Both must be seriously reconsidered.

Response

- Exemptions proposed in the San Diego HMP have been thoroughly reviewed, discussed and analyzed.
- The exemption regarding projects that decrease both the pre-project impervious area and outlet discharge rates is logical. If the unmitigated post-project condition results in no increase to either impervious surface or resultant outflows as compared to pre-project conditions, then the project has no negative impact on downstream erosion .
- Exemptions regarding direct discharges to existing concrete channels have been thoroughly discussed with both the TAC and the Copermittee Work Group. This potential exemption was referenced in the Permit. A direct discharge to a concrete channel which connects to a

downstream exempt system poses an insignificant hydromodification related issue provided that the concrete channel has capacity to convey the ultimate condition 10-year flow. Note that if the downstream conveyance system passes through a stream segment susceptible to erosion, if the concrete channel does not have capacity to convey the ultimate condition 10-year flow, or if the project does not discharge directly to the existing concrete channel, then the existing concrete channel exemption may not be granted.

- Exemptions regarding direct discharges to large river systems have been analyzed using continuous simulation modeling and review of the resultant flow duration curves. This item has also been discussed in detail with the Copermittee Work Group, the TAC, and the Regional Board. This potential exemption applies only to river reaches with 100-year flows in excess of 20,000 cfs and drainage areas in excess of 100 square miles. The upstream limits of the specific potential exempt reaches, which are detailed in Table 6-1, were set based upon reach-specific review of the floodplain width, degree of upstream reservoir attenuation, etc. A detailed flow duration analysis was conducted to test the variability in flow duration curves based upon hypothetical additions of master development areas. Historical flow duration curves were based upon streamflow data in the San Diego River, as provided by USGS.

- Exemptions regarding urban infill projects in highly urbanized watersheds have been analyzed using continuous simulation modeling and review of the resultant flow duration curves. This item has also been discussed in detail with the Copermittee Work Group, the TAC, and the Regional Board. This potential exemption applies only to projects that discharge runoff directly to a stabilized conveyance system that extends beyond the Domain of Analysis. The exemption is only valid for watersheds with an existing impervious area of 40 percent or greater and with the potential for no more than a 3 percent impervious area increase in ultimate developed conditions (as compared to existing impervious area for the watershed). A detailed flow duration analysis was conducted to test the variability in flow duration curves based upon hypothetical additions of watershed impervious areas. It should be noted that the Permit allows for an exemption when the project discharges to a watershed with an existing impervious area percentage greater than 70 percent. Thus, this particular exemption is focused on highly urbanized watersheds containing an existing impervious area percentage between 40 and 70 percent.

Coastkeeper Comment – The subject of monitoring is only partially developed. At this stage it appears to be missing an in-stream component to determine if indeed the program is meeting its charge to manage channel erosion and impacts to beneficial uses and stream habitat.

Response

- As detailed in Chapter 8 of the Final HMP, in-stream monitoring is required at locations downstream of the monitored project site. Baseline cross section monitoring would be required prior to construction of the project. Subsequent cross section monitoring would then be required at defined intervals following construction of the site to assess effects of hydromodification mitigation controls.
- Chapter 8 of the Final HMP includes requirements for flow-based sediment monitoring. Results of such sediment monitoring can be used to determine the low flows which initiate sediment movement. This data can be used to further refine the low flow thresholds.
- Chapter 8 of the Final HMP also includes requirements for the monitoring of BMP inflows and outflows to assess BMP effectiveness. These protocols are similar to the monitoring requirements for the Contra Costa HMP.

Responses to Coastkeeper Comments Dated September 29, 2009

Coastkeeper Comment – The HMP is disconnected from the purpose and requirements of the MS4 permit. Following the first few meetings, we submitted an email that asked the TAC to take the opportunity to think more holistically and to stem the growing disconnect between the direction of the development of the HMP and the intent of the NPDES permit. We received assurances that the TAC and the consulting team were looking to take this opportunity to create "the most holistic HMP carried out to date in California." Unfortunately, this promise has not been kept. We understand the HMP must address erosion, but it must also address water quality issues. The Copermittee Working Group and TAC's silo approach may have devastating consequences down the line. When one regulatory effort moves forward without consideration of other ongoing efforts, implementation becomes impossible. This is especially true in light of significant movements by various Regional Boards (including San Diego Regional Board) to move toward a more holistic approach to MS4 Permit implementation.

Response

- Throughout the HMP development process, the Copermittees and the consultant team have held regular meetings with the Regional Board to discuss the approach. Through this process, the HMP direction has focused on the purpose and requirements of the MS4 permit.
- The San Diego HMP, Model SUSMP and subsequent implementation sizing tools explicitly recommend integrated facilities that provide for both water quality treatment and hydromodification flow control. The recommended implementation of Integrated Management Practices, such as LID bioretention basins, will provide for both 85th percentile water quality treatment and hydromodification flow control. Water quality issues have been addressed extensively in the Model SUSMP.

Coastkeeper Comment - The HMP inappropriately includes policy and compliance provisions. It appears the Copermittees misunderstand the role of the TAC itself. Throughout the HMP development process,

decisions have been made based not on science, but on "policy" grounds. For example, at the June HMP TAC meeting, a discussion centered on minimum orifice size for BMPs to meet HMP and flow rate requirements. The TAC recognized the conflict between the model and minimum orifice requirements predicted for fine-grained systems. In the end, the decision was labeled a "policy" choice to be made by the Copermittees. However, such decisions must be based on sound science to meet the goals of the Permit. The HMP contains other policy choices made by the TAC and Copermittee working group that are inappropriate for the technical document, and circumvent the Permit. For example, with regard to implementation of the HMP, restoration activities are listed as an alternative to compliance with flow control criteria. The Permit allows for implementation of such activities without adverse impacts to channel beneficial uses. However, the HMP proposes a cost-benefit analysis for implementation of the HMP design requirement. The Permit does not contain such "in-lieu of" language, nor can it be inferred from the Permit. Moreover, injecting such cost-benefit analysis into the Permit creates a loophole in implementation of the HMP. Such subjective analysis should not be part of the HMP in light of the mandate to "manage increases in runoff discharge rates and durations." Additionally, implementation of buffers, revegetation, etc. does not meet the twin roles of the HMP: addressing the "changes in a watershed's runoff characteristics resulting from development, together with associated morphological changes to channels receiving runoff." The in-lieu of planning measures does not address the change in watershed runoff characteristics. The HMP exemption for the lower third of the watershed is also an unsubstantiated policy decision. Impacts to all areas of a watershed need to be addressed. No support has been given for such an exemption, nor is it considered in the Permit. Runoff from impervious surfaces not only causes erosion, but also carries pollutants to receiving waters. As the Permit requires HMP implementation to prevent "significant adverse impacts to beneficial uses, attributable to changes in the discharge rates and durations," wholesale exemptions for portions of a watershed are inappropriate.

Response

- As was the case in both the Santa Clara and Contra Costa HMPs, the San Diego HMP included some policy decisions. These policy decisions, which were ultimately made by the Copermittee Workgroup considering advice provided by the TAC, were based upon scientific investigations and analysis as well as practical considerations. The Hydromodification/SUSMP Workgroup was convened periodically over the course of the project at times corresponding with key decision points in developing the HMP and the update to the Model SUSMP. This workgroup was tasked with providing regional standards and consistency in the development, implementation, assessment, and reporting of urban runoff activities and programs related to hydromodification management. As required by Permit Section D.1.g, the Workgroup assisted in the development of the regional HMP. A key element of the San Diego HMP was the creation and involvement of a Technical Advisory Committee (TAC). The TAC members consist of respected individuals from academia, technical resource agencies, the development community, consulting engineers, and environmental organizations. The TAC, which has been convened on ten occasions that correlated with key decision-making points in the development of the HMP, was tasked with providing technical input to the HMP's scientific approach and interpretation of results integral to the establishment of numerical flow control standards as well as to the Copermittees for their policy determinations.

- Regarding the minimum orifice size issue, detailed analyses were prepared using continuous simulation hydrology to assess the effects of the minimum orifice size criteria. As a result, the minimum orifice size criteria may only be used in very limited scenarios to avoid problems

resulting from clogged orifices and uncontrolled overflows. These scenarios are detailed in Chapter 6.2 of the Final HMP. The policy decisions regarding the minimum orifice size criteria were based on a detailed continuous simulation hydrologic analysis. This detailed analysis was combined with practical considerations regarding facility maintenance (specifically, the clogging of small orifices which would cause riser overflows and the potential for increased erosion downstream) to maximize HMP facility effectiveness.

- Regarding the stream restoration / rehabilitation options, this issue was fully discussed with the Regional Board, the TAC, and the Copermittee Work Group. As worded in the Final HMP, such channel rehabilitation options may be constructed in limited situations. Specifically, such options may only be constructed if the existing channel susceptibility is determined to be "High" (as determined by SCCWRP assessment), if the stream rehabilitation project extends downstream to an HMP exempt system, and if the stream rehabilitation project is constructed assuming ultimate development conditions upstream of the project. Details of the stream rehabilitation protocols are detailed in Chapter 6.3 of the Final HMP. Additionally, permits from resource agencies are necessary in most cases, and improvement to habitat and the environment are expected.
- The Final HMP contains no mention of a cost-benefit analysis regarding stream rehabilitation measures. However, developers will ultimately use cost-benefit analyses when selecting alternative methods for meeting Permit requirements.
- The final HMP contains no mention of the "lower third of the watershed" exemption.

Coastkeeper Comment – TAC consensus has been misrepresented to the Regional Board. Recently, we have become aware of the Copermittees misrepresentation of TAC consensus regarding decisions made in developing the HMP. Our continuing disagreements with the current conclusions of the draft HMP are evident from: our emailed comments submitted by Karen Franz on February 2, 2008; our comment letter from our expert Dr. Horner; submitted on April 14, 2009; and our requests for underlying technical data to support the HMP. Following the receipt of the responses to comments from Dr. Horner, we requested the supporting references and technical papers that were the basis for the development of the design storm formulation for the Santa Clara and Contra Costa HMPs. The request was made at the June 17th meeting, and no communication of the references or technical papers followed the request. Further, the draft HMP was not give to TAC members until after it was first presented to the Regional Board. A TAC meeting was held in October 2008, and another meeting was not held until February 2009. In the interim, the consultants met with the Copermittee working group, obtained approval of the draft HMP, and submitted it to the Regional Board. It was not until February 4, 2009 that TAC members were sent an electronic copy of the HMP. We obtained a physical copy of the draft HMP at the Copermittee meeting in January shortly after it was submitted to the Regional Board and before it was sent to the TAC. TAC consensus and approval are also misrepresented on key issues, such as HMP compliance through "no increase to pre-project impervious area and no increase to pre-project flow." Contrary to the document assertion, this has not been "discussed and approved by the TAC." Coastkeeper has and will continue to insist upon natural, pre-project flows and reduction in overall impervious area.

Response

- In the Final HMP, the phrase "majority TAC approval" was used to indicate the majority opinion of the cumulative TAC members.
- Technical memos detailing the preparation of the Santa Clara and Contra Costa HMPs are public information and located at the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPP) web site and the Contra Costa Clean Water Program (CCCWP) web site.
- The majority of the members of the TAC agreed that HMP requirements should not be imposed on developments that decrease the pre-project impervious cover and decrease the design flows to each outlet location.

Coastkeeper Comment – Coastkeeper's effectiveness has been stymied by a lack of transparency and unavailability of key documents. Coastkeeper concurs in the Regional Board's comments made on June 29, 2009. The lack of detail and transparency highlighted in the letter has been a particular concern for Coastkeeper as well. For instance, the BMP sizing tools and their reporting should be a transparent process. Although the tools go beyond the scope of the HMP development, they are a necessary piece of the process, and as such, the HMP should provide more oversight on their use. Additionally, Coastkeeper's specific comments from our technical expert Dr. Horner remain largely ignored or dismissed out of hand. Even to get an electronic copy of the draft HMP for our expert to review proved challenging. Several attempts were made to request the document by email, without success. We were ultimately forced to scan a paper copy we obtained from a Stormwater Copermittee meeting where the draft HMP was distributed. At a TAC meeting following submission of the comment letter, several TAC meeting attendees and members opined about the radical nature of our comments and marginalized Coastkeeper. This type of discussion is indicative of the limited role Coastkeeper was able to play in participating on the TAC. This process of excluding the TAC from critical decision-making, and information exchange has also hindered the usefulness of the TAC.

Response

- All documents prepared in association with the Final HMP are available for public review. These documents were presented on multiple occasions for review by the TAC, Copermittee Workgroup and the Regional Board. These documents are posted on the Project Clean Water web site.
- The BMP sizing tool development is a transparent and ongoing process. These are implementation tools and were not required as part of the HMP document. Key technical memos and data reviews will be circulated to the TAC, Copermittee Working Group and Regional Board throughout the Sizing Calculator development process.
- Dr. Horner's comments have been addressed in previous comments response document and in this comment response document.

Coastkeeper Comment – A lack of data inhibits progress. In addition to the lack of transparency in information exchange by consultants and Copermittees to TAC members, the delay in production of key

aspects of the HMP prohibits meaningful input from the TAC. For example, the San Diego region has three distinct geomorphic and hence geologic regions. The geologic conditions of a watershed/catchment area are the factors affecting the low flow threshold values. Other critical components that may never be reviewed by the TAC include development of maintenance and long-term monitoring protocols and the required approval process for Priority Development Projects. The incorporation of these tools into the decision matrix and preparation of consultant technical memos are critical steps in the HMP which have yet to be conducted, and may largely take place outside of the TAC.

Response

- The HMP was submitted on time to the Regional Board on December 29, 2009.
- Prior to the final submittal, multiple iterations of the HMP document and supporting memos were distributed to the TAC, Copermittee Work Group and the Regional Board.

Coastkeeper Comment – Exemptions remain ill-conceived and overused. The Draft HMP makes exemptions for hardened channels as arguably allowed by the current Permit, but these exemptions are neither required nor prudent. First, the Permit language gives some discretion to the Copermittees, not requiring exemptions and qualifying such decisions with the requirement not to impact beneficial uses. Moreover, the proposed South Orange County stormwater permit specifically requires hydromodification considerations for restoration of such hardened channels. Also, the Copermittees attempt to create an exemption for projects with "no net increase" in impervious area is also not in line with the Regional Board's interpretation of "pre-project" as highlighted in the proposed South Orange County Permit. Therefore, pre-project conditions in the current Permit should not make exceptions for "no net increase" unless such projects mimic naturally occurring conditions. Further, the "adoption and implementation of this NPDES permit relieves the Copermittee from developing a non-point source plan, for the urban category, under CZARA." CZARA requires implementation of management measures to prevent non-point source pollution from impacting or threatening coastal water quality. Therefore, exemptions for the lower portions of watersheds or large receiving waters are not allowed.

Response

- The exemption regarding projects that decrease both the pre-project impervious area and outlet discharge rates is logical. If there no increase to either impervious surface or resultant outflows as compared to pre-project conditions, then the project has no negative impact on downstream erosion.
- Exemptions regarding direct discharges to existing concrete channels have been thoroughly discussed with both the TAC and the Copermittee Work Group. This potential exemption was referenced in the Permit. A direct discharge to a concrete channel which connects to a downstream exempt system poses an insignificant hydromodification related issue provided that the concrete channel has capacity to convey the ultimate condition 10-year flow. Note that if the downstream conveyance system passes through a stream segment susceptible to erosion, if the concrete channel does not have capacity to convey the ultimate condition 10-year flow, or if the project does not discharge directly to the existing concrete channel, then the existing concrete channel exemption may not be granted.

- Exemptions regarding direct discharges to large river systems have been analyzed using continuous simulation modeling and review of the resultant flow duration curves. This item has also been discussed in detail with the Copermittee Work Group, the TAC, and the Regional Board. This potential exemption applies only to river reaches with 100-year flows in excess of 20,000 cfs and drainage areas in excess of 100 square miles. The upstream limits of the specific potential exempt reaches, which are detailed in Table 6-1, were set based upon reach-specific review of the floodplain width, degree of upstream reservoir attenuation, etc. A detailed flow duration analysis was conducted to test the variability in flow duration curves based upon hypothetical additions of master development areas. Historical flow duration curves were based upon streamflow data in the San Diego River, as provided by USGS.

- Exemptions regarding urban infill projects in highly urbanized watersheds have been analyzed using continuous simulation modeling and review of the resultant flow duration curves. This item has also been discussed in detail with the Copermittee Work Group, the TAC, and the Regional Board. This potential exemption applies only to projects that discharge runoff directly to a stabilized conveyance system that extends beyond the Domain of Analysis. The exemption is only valid for watersheds with an existing impervious area of 40 percent or greater and with the potential for no more than a 3 percent impervious area increase in ultimate developed conditions (as compared to existing impervious area for the watershed). A detailed flow duration analysis was conducted to test the variability in flow duration curves based upon hypothetical additions of watershed impervious areas. It should be noted that the Permit allows for an exemption when the project discharges to a watershed with an existing impervious area percentage greater than 70 percent. Thus, this particular exemption is focused on highly urbanized watersheds containing an existing impervious area percentage between 40 and 70 percent.

- The San Diego HMP complied with permit provision for the San Diego region, not the South Orange County permit.

Coastkeeper Comment – Selection and implementation of BMPs are vague or missing. The Draft HMP does not provide a list possible preferred BMPs, and the explanation of BMPs thus far at TAC meetings have been equally vague. At the outset we find that the BMP specific design criteria will be much more useful and transparent. It is unclear why the TAC has not chosen this route. Additionally, although the age of a BMP system has a great influence on the efficacy of that BMP, no provisions or requirements exist to address this issue. We have also asked to include infiltration and rainwater harvesting in the list of BMPs, but apparently only dry wells have been added so far. San Diego's reliance on imported water and its precipitation patterns create a tremendous regional opportunity for the development of rainwater harvesting systems to not only capture and reuse this resource, but also to reduce flow (and sediment) from Priority Development Projects. The Ventura County permit requires all features constructed to render impervious surfaces "ineffective:" to "infiltrate, store for reuse, or evapotranspire, without any runoff at least the volume of water that results from" the 85th percentile, 24-hour runoff event, annual runoff based on unit basin storage to achieve 80 percent or more volume treatment, or a 0.75 inch storm event. The San Diego HMP should contain greater emphasis on infiltration, reuse and evapotranspiration as well.

Response

- Chapter 7 of the Final HMP and the Model SUSMP include a suite of BMPs that can be used for water quality treatment and hydromodification flow control. The suite of BMPs listed, including bioretention basins, biorentention in series with cisterns, bioretention in series with vaults, extended detention basins, and flow-through planter boxes, corresponds to the BMP selection list that will be provided in the Sizing Calculator.
- While water harvesting and reuse have obvious benefits, these criteria are not addressed or mandated in the Permit. From a hydromodification standpoint, water reuse facilities have some benefit for isolated rainfall events. When back-to-back storms occur, however, the hydromodification benefit is often not sufficient since the storage facilities are filled and provide no attenuation for the multiple storms. The San Diego permit does not require rainwater harvesting for hydromodification mitigation. The use of rain water storage as a hydromodification control measure has not been ruled out. Rather, Copermittees can consider developer proposed storage facilities on a case by case basis. Such design strategies must prove compliance with hydromodification design criteria considering the long-term historical rainfall record.
- The 5 percent EIA requirement from the Ventura permit is not included in the San Diego MS4 permit.

Coastkeeper Comment – The HMP does not consider climate and land use change. Effects of climate and land use changes on low flows and other hydrologic responses have been well documented as to the hydrological effects that will result in our region. When employed singly and in combination, climate and land use changes have significant and varying effects on flow conditions. The draft HMP contemplates only one rate of land-use change. The HMP needs to consider the potential impacts of climate change and the effects that it will have on regional hydrologic conditions through its modeling. Hydrologic data is being generated by the Hydrologic Research Center, a San Diego-based international research center.

Response

- While climate change effects were not considered in this version of the HMP, it is possible that the rainfall data sets prepared in association with the HMP could be updated once predictive rainfall models have been developed. These data sets could be used to refine recommendations of future HMP updates.

Coastkeeper Comment – Implementation of a standard of 3 percent maximum allowable Effective Impervious Area (EIA) in all regulated projects, with a narrowly crafted alternative compliance provision for developments where severe site constraints, such as non-infiltrative soils, render compliance with the 3 percent EIA limitation impossible.

Response

- The Effective Impervious Area (EIA) requirement was not part of the San Diego MS4 permit.

Coastkeeper Comment – As a hydromodification standard, post-development peak flow rates and volumes shall not exceed the modeled peak flow rates and volumes of pre-European-settlement native land cover for all storms from the channel-forming event to the 100-year frequency stream flow. This requirement shall be satisfied to the maximum possible extent by retention of runoff on the development site through infiltration, evapotranspiration, and/or rainwater harvesting. If the requirement cannot be fully met by onsite retention, there shall be a demonstration and convincing justification, according to specific criteria, of why it is not achievable at that site. If such a convincing demonstration and justification can be made, the differential between the required retention and the amount that can be provided onsite shall be offset by performing or contributing to an offsite project, within the same watershed, to retain an equal or greater volume of runoff from such other site.

Response

- The hydromodification standard, as interpreted from the San Diego MS4 permit, requires the control of peak flows and durations within the geomorphically significant flow range to pre-project conditions. No mention of pre-European settlement is included in the San Diego MS4 permit.

Coastkeeper Comment – Monitoring of HMP compliance must be conducted at more than 5 sites in the entire County. At least one site per watershed must be monitored. Additionally, monitoring should begin before development, not after completion. Monitoring site selection should also be made with Regional Board staff input, not solely by Copermittees.

Response

- No HMP monitoring plan in the State of California proposes more than 5 countywide monitoring sites. The recommendations detailed in Chapter 8 exceed the requirements for Contra Costa County as approved by the San Francisco Regional Board.
- As detailed in Chapter 8 of the Final HMP, monitoring will begin before development and extend into the future following development.

Coastkeeper Comment – Individual Priority Development Projects must be required to monitor effectiveness and maintain HMP BMPs and compliance measures. A real, tangible monitoring mechanism and compliance determination must be implemented into the HMP. Without such requirements in the HMP, no assurance of long-term effectiveness will be provided. Such tools would also help Copermittees monitor specific BMP effectiveness in different watersheds.

Response

Monitoring of the 5 sites will be a regional Copermittee effort. Individual Priority Development Projects are required to inspect and maintain their treatment control and HMP facilities through maintenance agreements. Additionally, Copermittees conduct annual inspections of treatment BMPs and HMP facilities as required by the Municipal Permit.

Coastkeeper Comment – Urge the Regional staff to ensure strict compliance with the current Permit and look toward future consistency with other MS4 Permits in southern California, as setting the MEP standard.

Response

- We will defer to the Regional Board for a response to this comment.

Coastkeeper Comment – Future development, implementation, and monitoring of the HMP should be more transparent, including more availability for public input.

Response

- We will continue to provide technical memos and materials available for public review through the TAC, Copermittee Work Group and the Regional Board. These documents can be accessed at the Project Clean Water web site.

Coastkeeper Comment – High, Medium and Low susceptibility ratings should be removed. All watersheds should be treated as susceptible to erosion. Moreover, the classification of streams does not correlate to an appropriate HMP objective. For instance, for already unstable channels the standard is to "avoid acceleration of the existing erosion problems." This is unacceptable, and does not meet the spirit of intent of the Permit.

Response

- Stream classification, as provided for in this HMP by the SCCWRP channel susceptibility analysis, is a requirement of the MS4 permit (Permit Section D.1.g.(1)(a) and (m)). Therefore, this information will not be removed from the HMP. It is a critical component of the HMP for San Diego County and all counties in southern California.

Responses to Coastkeeper Comments Dated April 14, 2009

Coastkeeper Comment - Comparing the stated San Diego County criteria to hydromodification standards elsewhere, the County's criteria are relatively highly protective of runoff receiving waters in the cases of flows of 5- and 10-year frequencies. On the other hand, these criteria do not extend to the larger storms of less frequency. Some hydromodification criteria cover a range of storms up to the 50- and even 100-

year events. In the central city area of San Diego, rainfalls of 24-hour duration for different frequencies are approximately (http://ponce.sdsu.edu/noaa_24hr_sd_2x.html): 5-year—2.4, 10-year—2.8, 50-year—3.5, and 100-year—4.1 inches. Thus, it may be seen that extending the assessment from the 10- to the 100-year frequency enlarges the time period over which resource protection is evaluated by an order of magnitude (1000 percent) with an increase of just 46 percent in the rainfall quantity. The criteria should be extended to these larger storms, or the County should show why doing so is not necessary to protect and recover stream ecosystems.

Response

- Similar to the two previously approved hydromodification management plans in the State of California (Santa Clara County and Contra Costa County), the San Diego Final HMP recommends flow and duration control for a range of flows between a fraction of the 2-year flow event to the 10-year flow event. Neither the approved Santa Clara HMP nor the approved Contra Costa HMP required controls for flow recurrence events in excess of the 10-year design flow.
- The referenced 24-hour rainfall totals in the comment above refer to a single-event design storm approach, which is not applicable with the continuous simulation hydrologic modeling approach mandated in Permit R9-2007-0001. The Permit goes on to say that determination of peak flow frequency values shall be developed from analysis of the full rainfall record. In other words, hourly data from the entire rainfall record (35 to 50+ years) is used in the analysis as opposed to use of a singular rainfall depth as noted in the comment above.
- Finally, it should be noted that various geomorphologists across California and the nation have concurred that controls above the 10-year flow event have a minimal impact on cumulative sediment movement across the historical record. Sediment transport studies based on a continuous flow record, such as the long-term analysis prepared in association with the Santa Clara Hydromodification Management Plan, have shown that roughly 90 percent of the cumulative work exerted on a channel occurs within the relative flow ranges detailed in the Santa Clara, Contra Costa, and San Diego HMPs. Thus, it can be demonstrated that the significant cost associated with controls above the 10-year event would not result in significant additional protection to the stream processes from a hydromodification standpoint.

Coastkeeper Comment - Criteria setting is, "... based on the understanding that the 5-year design flow is considered the dominant channel-forming discharge for Southern California streams." If the basis is merely an "understanding", it is not strong enough. The basis must be rooted in detailed analyses. Such analyses elsewhere in the nation have identified flows having frequencies around 1.5 to 2-year to be the channel-forming discharges.

Response

- Per the Final HMP, lower flow threshold criteria were based upon a fraction of the 2-year design flow. This determination was made using a synthetic modeling approach which used the continuous rainfall record to determine hydrologic response. Sediment transport models were then simulated for the entire historical record for a wide variety of channel conditions.

- The commentary regarding the 5-year design flow in the comment above was provided in reference to determination of interim flow control standards. As a reasonable first step for the setting of the interim standards, initial determinations were made based upon previous research conducted by the Southern California Coastal Water Research Project (SCCWRP) and others. The final flow control standards are based upon detailed hydrologic and sediment transport analyses.

Coastkeeper Comment - The plan contains exemptions from requirements that will foreclose future stream restoration options, or at least substantially increase their difficulty. One such instance is allowance of planning measures as alternatives in lieu of stormwater flow controls. Another is the allowance of a demonstration that projected increases in runoff peaks and/or durations will not accelerate stream channel erosion. The plan further provides a dispensation for controls if a project applicant conducts a sediment transport analysis and shows no adverse impact. Such demonstrations could be convincingly made when a channel is hardened or already cut to bedrock, but each permitted increment of flow further reduces the opportunity to recover a natural stream, and its ecological values. The plan goes on to state specifically that hydromodification management flow controls will not be required for discharges into hardened channels or the downstream sub-watershed imperviousness is at least 70 percent and the potential for cumulative impacts is "minimal". This policy essentially consigns these channels perpetually to their artificial, highly degraded status with almost no ecological function. These exemptions should be removed, at least until a broad assessment of restoration potential can be completed and the most opportune cases prioritized for implementation.

Response

- The exemptions listed in the HMP closely follow recommendations provided in Permit R9-2007-0001, especially with regard to discharges to existing hardened channels, storm drain systems, and into existing highly urbanized watersheds (with a percent imperviousness > 70%).
- Planning measures such as implementation of Low-Impact Development (LID) facilities would still be required to demonstrate that the mitigated condition would meet mandated flow and duration control criteria.
- Planning measures such as the implementation of riparian buffers or non-hardened stream restoration/rehabilitation projects would require mitigation proof in the form of an accompanying hydraulic and/or sediment transport analysis of sufficient technical rigor. The HMP does not allow for the implementation of concrete channel solutions as a method for stream restoration/rehabilitation.

Coastkeeper Comment - The plan is silent on how the potential for cumulative impacts can or should be assessed and what "minimal" is. It should be explicit on these subjects.

Response

- Chapter 5.3 provides a discussion of cumulative watershed impacts.

- Definition of cumulative watershed impacts was quantified in the detailed continuous simulation models prepared in association with the river system exemption, highly urbanized watershed scenario, and minimum orifice size. This discussion is detailed in Appendix F.

Questions related to this comment response document should be directed to Sara Agahi at (858) 694-2665.

APPENDIX D

Flow Threshold Analysis Third Party Review

Use of contents on this sheet is subject to the limitations specified at the end of this document.
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December 19, 2008

Mrs. Sara Agahi, P.E.
County of San Diego.
5201 Ruffin Road, Suite D
San Diego, CA 92123

Subject: Review of Hydromodification Work by Phillip Williams and Associates (PWA)

Dear Mrs. Agahi:

This letter summarizes our findings from review of the subject PWA work as subconsultant to Rick Engineering Company and as authorized under County of San Diego Agreement Number 525773, Task Order Number 5.

According to the County of San Diego (the County) Municipal Separate Storm Sewer System (MS4) permit, the Hydromodification Program (HMP) must use standards to manage increases in runoff discharge rates and durations where these are likely to cause increased erosion of channel bed and banks, sediment pollutant generation, or other impacts to beneficial uses and stream habitat due to increased erosive force. Under the permit's definition of "flow duration" it is noted that flow duration within the range of geomorphically significant flows is important for managing erosion. The permit also requires that the HMP be based on continuous rainfall-runoff modeling. The purpose of the work by PWA is to help establish the flow thresholds for use with the County HMP.

The review consisted of examining the underlying assumptions of the analyses, the methodology followed in the analyses themselves (including the modeling techniques employed), development of results from the analyses, and conclusions reached based on those results. The data, analyses and models submitted for review were contained on a portable hard drive provided by Brown & Caldwell on 11/20/08. A memorandum from PWA to the County of San Diego dated 11/12/08 describing the watershed and channel modeling was also provided by Brown & Caldwell via e-mail on 11/25/08. Other background data was gathered from the periodic reports submitted by Brown & Caldwell and/or PWA to the Technical Advisory Group.

Method

The general methodology employed by PWA was to conduct a large simulation-based sensitivity analysis to cover the range of potential channel and watershed conditions found in western San Diego County. Three sample watersheds within the size to be regulated by the HMP were chosen in areas where development is expected to occur. Specifics of the analyses are commented upon below.

Hydrology

The hydrology for each site was developed using the San Diego Hydrology Model (SDHM) for pre-development, post-development, and post-development with flow mitigation (one, one, and six simulations, respectively). WEST verified the input data contained in the SDHM models for the Otay (Rolling Hills) and Peñasquitos basins. Tables 1 and 2 present a summary of pond sizes, outlet dimensions, and LID parameters (infiltration rate and reduction factors) for each of the scenarios for the two watersheds.

In the Otay input files, the same outlet dimensions (notch width, height, and orifice diameter) were maintained for each flow duration criteria simulation (10% Q_2, 10% Q_5, and 20% Q_5) for both the "non-LID" and "with-LID" cases (see Table 1). The pond size changes slightly, decreasing in the "with-LID" case because flow is lost through infiltration and the pond size can decrease while still meeting the duration criteria. However, WEST found that in the 10% Q_2 scenario, the riser diameter is set to 400 inches, while it is fixed at 48 inches for all other scenarios. The corresponding pond size changes from a square 750 feet on each side for the 10% Q_2 scenario to one 318 feet on each side for the 10% Q_2 with LID scenario. WEST suggests changing the diameter to 48 inches and re-running the simulation.

For the Peñasquitos watershed analyses we observed that while the riser dimensions were the same for all simulations, no consistent choice of notch height, width, and orifice diameter was maintained.

In addition, the SDHM uses only rainfall data from the Lindbergh Field gage in the simulations. Potential pitfalls with this assumption have already been pointed out by Brown & Caldwell elsewhere. All simulations used a 40-year period of record from this gage as input and runoff hydrographs were generated for the eight cases discussed above for each of the sample basins. Eight cases multiplied by three basins resulted in a total of 24 hydrologic simulations.

PWA assumptions for land use (land cover, vegetation, percent impervious) for the test watersheds were not confirmed by measurement in a geographic information system (GIS), but seemed reasonable by inspection.

The assumption that all runoff would be routed into a single runoff control facility is probably not realistic (especially given the resulting single basin sizes compared to the overall watershed area), but is justified for this type of comparative analysis.

Table 1. Otay SDHM Parameters

OTAY	Pond Length (ft)	Pond Width (ft)	Depth (ft)	Riser Height (ft)	Riser Diameter (in)	Notch Height (ft)	Notch Width (ft)	Orifice diameter (in)	Pond Volume at Riser Head (ac-ft)	Infiltration Rate (in/hr)	Reduction Factor	Percent Infiltrated
10% Q_2	750	750	5	4	400	0.0954	4	0.86	54.09	n/a	n/a	n/a
10% Q_5	232	232	5	4	48	0.0878	3.9584	5.543	5.55	n/a	n/a	n/a
20% Q_5	211	211	5	4	48	0.0954	3.94	7.9314	4.624	n/a	n/a	n/a
10% Q_2 with LID	318	318	5	4	48	0.0954	4	0.86	10.154	0.7	0.25	88.74
10% Q_5 with LID	225	225	5	4	48	0.0878	3.9584	5.543	5.241	0.7	0.25	41.65
20% Q_5 with LID	210	210	5	4	48	0.0954	3.94	7.9314	3.5	0.7	0.25	34.47

Table 2. Peñasquitos SDHM Parameters

PEÑASQUITOS	Pond Length (ft)	Pond Width (ft)	Depth (ft)	Riser Height (ft)	Riser Diameter (in)	Notch Height (ft)	Notch Width (ft)	Orifice diameter (in)	Pond Volume at Riser Head (ac-ft)	Infiltration Rate (in/hr)	Reduction Factor	Percent Infiltrated
10% Q_2	307	307	7	6	72	0.14	6.00	2.82	14.73	n/a	n/a	n/a
10% Q_5	172	172	7	6	72	0.2835	5.94	7.7877	5.041	n/a	n/a	n/a
20% Q_5	162	162	7	6	72	0.178	5.94	10.673	4.54	n/a	n/a	n/a
10% Q_2 with LID	251	251	7	6	72	0.178	5.94	2.9834	10.121	0.7	0.25	53.82
10% Q_5 with LID	179	179	7	6	72	0.3185	5.94	8.2677	5.445	0.7	0.25	24.13
20% Q_5 with LID	183	183	7	6	72	0.2626	6	7.5051	5.632	0.7	0.25	25.2

Hydraulics and Sediment Transport

As opposed to the site-specific characteristics employed in the hydrologic analysis, the hydraulic and sediment transport analyses appear to be completely hypothetical in nature. The eight hydrographs produced from the SDHM simulations previously discussed were used as input to the HEC-RAS hydraulic and sediment transport model. Other key input parameters such as cross section geometry, channel slope, roughness, and sediment characteristics were selected to cover a "representative" range corresponding to potential field conditions. Forty-two combinations of basin, grain size, slope and width-to-depth ratio were simulated in HEC-RAS for each of the eight hydrologic scenarios resulting in at least 336 models created and executed (additional models were created for sensitivity analyses). The volume of sediment leaving a "project reach" over the 40-year simulation for each of the post-development analyses were compared with pre-development yield and the results interpreted to select the minimum flow rated that should be regulated in the HMP.

Significant time and effort was obviously spent in preparing, executing and debugging the numerous models. Model instabilities led to using a sediment rating curve approach for computing sediment yield. There are significant issues regarding the modeling and computations which throw the validity of the results and the conclusions drawn from them into question. Specific comments are provided in the following sections.

Cross Section Geometry

The synthetic cross section geometry (width and depth) used for the analyses was generated using empirical relationships developed from various sources. These include equations for gravel-bed rivers in the UK and US, relations for sand-bed streams, and regression equations developed from measurements of Southern California streams (references in PWA memorandum of 11/12/08). Application of some of these equations to San Diego Country streams is problematic, while other similar equations developed from US data (e.g., Lee and Julien[1]) were not employed. In any case, cross sections were developed by imposing a small "bankfull" channel at the bottom of a v-shaped section with 10% side slopes (10 horizontal feet for each 1 vertical foot). Width to depth (W:D) values were computed using the various methods, and a set of width to depth values were chosen, apparently only loosely linked to the specific method results. A trapezoidal channel containing three bottom points was created at the bottom of each cross section. Based on spreadsheets and models provided W:D ratios of 3, 6, and 10 were run for both the Peñasquitos and Otay sites. A W:D ratio of 20 was also used for the Otay site for certain combinations of grain size and slope. Channel depths in HEC-RAS, based on the equation results, were set between 0.25 to 0.5 feet for Peñasquitos and 0.7 feet or less for Otay. Therefore, even though numerous combinations of W:D ratio were used, the absolute dimensions were still very small (for a depth of 0.5 feet the top width would vary from 1.5 feet to 5 feet for W:D ratios of 3 and 10, respectively).

Several of these cross section geometry relationships rely on bankfull or channel-forming discharge as an input parameter. This discharge was estimated by PWA using USGS regression

[1] "Downstream Hydraulic Geometry of Alluvial Channels," Lee and Julien, *Journal of Hydraulic Engineering* Vol. 132, No. 12, December 2006.

equations[2]. Although it is recognized that few methods exist outside of site-specific investigations to estimate this discharge, the USGS equations are known to be very approximate. The equations are based on gauging stations from Santa Barbara to San Diego, from the coast to elevations above 5,000 feet and using data available in 1975. The mean annual precipitation (MAP), also an input to the regression equation, was assumed to be 15 inches for this exercise although it does vary from about 9 inches at the coast to over 25 inches at higher elevations. The MAP at both the Peñasquitos and Otay sites is close to 12 inches. It could be argued that a 5-year return interval would be a more appropriate indicator of bank-full discharge than a 2-year flow, but this is a topic that is still being researched and is far from resolved for semi-arid regions such as San Diego.

Roughness was held constant apparently for all simulations with Manning's coefficients of 0.03 for the channel and 0.05 for the overbanks. This could have an impact on the overall results and conclusions as roughness will usually increase with both increasing grain size and increasing slope (two of the variables in the PWA analysis).

Boundary Conditions

The combination of a short (500 foot) channel length and uncertain boundary conditions casts doubt on the results. Modelers recognize that results near boundaries often reflect inaccuracies in assumptions at those boundaries and will therefore extend their models beyond the immediate area of concern to minimize these boundary effects. The current models incorporate boundary effects at both the upstream and downstream ends. An "equilibrium" inflowing sediment load was developed with the HEC-RAS model such that the upstream most cross section would neither aggrade nor degrade with time. This load was based on uniform sediment size, slope, cross section shape, etc. and is a necessary but fictitious assumption to perform the simulations. At the downstream end, the assumption of normal depth at a fixed energy slope can have similar results. In addition, using a depth rather than an elevation at the downstream end with a movable bed model can prevent the model from ever reaching an equilibrium state. For example, at an aggrading downstream boundary, instead of increased velocity (increased sediment transport potential at a shallower flow depth) the water surface elevation will simply increase to match the bed increase in order to maintain the computed normal depth.

Sediment Grain Sizes

The uniform grain sizes used in the simulations are not representative of field conditions and the model results cannot reflect preferential transport of various size classes nor armoring of the bed ("hiding" of smaller size particles by larger ones on the surface).

Hydrologic Record

Model run times and output were larger than necessary because **all** flows were simulated, even zero flows. Typically in arid regions modeling, zero flows and very low flows estimated not to be able to move particles are excluded from simulations. In the arid Southwest, it is not unusual to have a 50 year period of record with only 10-20 years of actual flow data modeled.

[2] "Magnitude and Frequency of Floods in California," Waananen and Crippen, USGS *Water Resources Investigations 77-21*, 1977.

Maximum Erosion Depth

The maximum depth of erosion (or "hard bottom") was set to 5 feet for all models. By itself, this is a reasonable value given the very small channel dimensions. However, the fact that the cross sections hit this hard bottom many times, prompting the switch to the analytical (rating curve) approach, *even for existing conditions* (no increased flows) should have been an indicator that other modeling problems were present. An example is given in Figure 1.

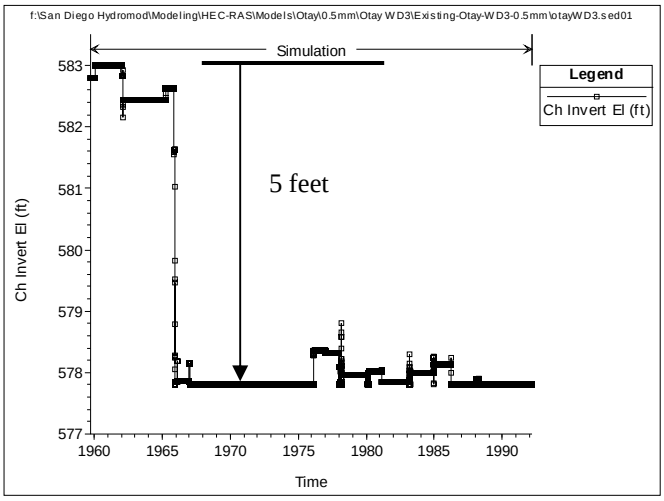

Figure 1. Otay site, existing conditions, bed hits hard bottom December, 1965

Overall, it appears that given all of the assumptions, uncertainty with inputs, and modeling problems, that a stable slope type analysis would have given similar results with much less effort involved.

Conclusions

Based on examination of the materials provided, this reviewer has serious concerns about the results obtained and their application to flow thresholds for hydromodification requirements. All results are related to baseline conditions – good practice in sedimentation modeling – but it is not clear that the baseline results are reasonable. Additionally, as noted by PWA in their memorandum, implementation of a threshold of 0.1Q2 will be a challenge in practical terms as this will encompass a very large range of flows. However, is 0.1Q2 a reasonable threshold based solely on sediment movement? Based on the EPA Nationwide Urban Runoff Program (NURP) results and continuous simulation modeling, Bledsoe and Watson[3] argue that standard hydrologic design practices are inadequate for characterizing the cumulative effects of urbanization on flow events that are *more frequent than Q2* (emphasis added) in terms of sediment transport and channel disturbance potential. That is to say, additional work leading from questions about the methodology and/or results of the PWA study may not result in an increase in a lower flow threshold for the HMP. Because of site-specific values of grain size, slope, roughness, and

[3] "Effects of Urbanization on Channel Instability," Bledsoe and Watson, *Journal of the American Water Resources Association*, Volume 37, No. 2, April 2001.

channel shape, it is not clear that using any specific frequency discharge as an indicator of shear stress that will move particles is a tenable approach.

Recommendations

Clearly the goal of the County must be to meet intent of MS4 permit with a reasonable effort to quantify flow thresholds. PWA's hydraulic and sediment transport results should be supplemented with real data from sites in order to set thresholds (flows, shear stresses, or velocities). With the help of the technical advisory group and others, existing information could be gathered to provide additional base data. Slope, sediment properties, roughness, and channel shape data from other studies could be used to compute shear stresses that would move significant amounts of sediment. If frequency discharges are available for a site, the critical shear could be related to a return period. If enough sites are available, the data could be analyzed to see if there is a consistent value of return period. If such a value is found, this could used for a regulatory threshold. If not, a site specific analysis may be required for each project.

Thank you for the opportunity to perform this review and contribute to stormwater management practice in San Diego County. Please call me at (858) 487-9378 if you have any questions.

Sincerely,

Martin J. Teal, P.E., P.H., D.WRE
Vice President

APPENDIX E

SDHMP Continuous Simulation Modeling Primer

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BROWN AND CALDWELL

Memorandum

9665 Chesapeake Drive, Suite 201
San Diego, CA 92123
Tel: 858-514-8822
Fax: 858-514-8833

Project Title: San Diego County Hydrograph Modification Plan

Project No: 133904

San Diego County Hydrograph Modification Plan

Subject: Using Continuous Simulation to Size Storm water Control Facilities

Date: April 30, 2008

To: Sara Agahi, San Diego County

From: Tony Dubin, Brown and Caldwell
Nancy Gardner, Brown and Caldwell

Brown and Caldwell prepared this memo to help civil engineers through the process of sizing storm water control facilities to meet San Diego County's Interim Hydromodification Criteria (IHC). Since the publication of the IHC this past January, the County has been engaged in outreach activities to explain the new storm water modeling methods required by the IHC and storm water facilities that could meet the IHC performance standard. In response to the outreach efforts, the County has received several questions and comments along a common theme:

1. How do we perform continuous hydrologic modeling analyses to size storm water control facilities?
2. What is the precise meaning of the peak flow and flow duration curve matching standard described in the IHC memo?

This document is not a complete "how-to manual" for conducting continuous hydrologic modeling to meet the County's IHC, but we hope it addresses the major technical concerns of the local engineering community.

Using Continuous Simulation Models to Size Storm Water Facilities

The IHC requires continuous simulation hydrologic modeling to adequately size storm water control facilities. This is a significant break with the common local practice of using event-based modeling to determine whether a storm water pond, swale or other device was properly sized. Event-based modeling computes storm water runoff rates and volumes generated by a synthetic rainfall event with a total depth that matches local records (e.g., rainfall depths shown in County isopluvial maps). By contrast, continuous modeling uses a long time series of actual recorded precipitation data as input a hydrologic model. The model in turn simulates hydrologic fluxes (e.g., surface runoff, groundwater recharge, evapotranspiration) for each model time step.

Continuous hydrologic models are usually run using one-hour or 15-minute time steps, depending on the type of precipitation data available and computational complexity of the model. Continuous models generate outputs for each model time step and most software packages allow the user to output a variety of different hydrologic flux terms. For example, a continuous simulation model setup with 25 years of hourly precipitation data will generate 25 years of hourly runoff estimates, which corresponds to runoff estimates for

each of the 219,000 time steps (each date and hour) of the 25 year simulation period. While creating and running continuous simulation models involves more effort than running event-based models, the clear benefit of the continuous approach is that these models allow an engineer to estimate how often and for how long flows will exceed a particular threshold. Limiting how often and for how long geomorphically significant flows occur is at the heart of San Diego County's approach to hydrograph modification management.

Two common models were presented at a recent APWA workshop on HMP issues: HSPF and HEC-HMS. HSPF refers to the Hydrologic Simulation Program-FORTRAN and is distributed by the USEPA. HEC-HMS refers to the Hydrologic Modeling System (HMS) produced by the US Army Corps of Engineers Hydraulic Engineering Center (HEC). Engineers unfamiliar with these software packages should seek out training opportunities and online guidance. The USEPA conducts training workshops around the US to help teach engineers how to use HSPF. HEC-HMS training is provided through ASCE and third-party vendors.

The following list describes the major elements of developing a hydrologic model and using that model to size storm water facilities that meet the IHC.

1. Select an appropriate historical precipitation dataset for the analysis.
   a. The precipitation station should be located near the project site or at least receive similar rainfall intensities and volumes as the project site.
   b. The station should also have a minimum of 25-years of data recorded at hourly intervals or more frequently.
2. Develop a model to represent the pre-project conditions, including
   a. Land cover types
   b. Soil characteristics
   c. General drainage direction
3. Develop a model to represent the post-project conditions, including
   a. New land cover types – more impervious surfaces
   b. Soil characteristics
   c. Any modifications to the drainage layout
4. Examine the model results to determine how the proposed development affects storm water flows
   a. Compute peak flow recurrence statistics (described below)
   b. Compute flow duration series statistics (described below)
5. Iteratively size storm water control facilities until the post-project peak flows and durations meet the performance standard described below.

Understanding the Peak Flow and Flow Duration Performance Criteria

The IHC is based on a peak flow and flow duration performance standard. To compute the peak flow and flow duration statistics described in the standard, model users must have a method for evaluating long time series outputs (usually longer than the 65,000 rows available in MS Excel 2003 and earlier versions) and computing both peak flow frequency statistics and flow duration statistics.

We recommend computing **peak flow frequency statistics** by constructing a partial-duration series (rather than an "annual maximum" series). This involves examining the entire runoff time series generated by the model, dividing the runoff time series into a set of discrete unrelated events, determining the peak flow for each event, ranking the peak flows for all events and then computing the recurrence interval or plotting position for each storm event. To limit the number of discrete events to a manageable number, we usually only select events that are larger than a 3-month recurrence when generating the partial duration series. We consider flow events to be "separate" when flow rates drop below a threshold value for a period of at least 24 hours.

The exercise described above will generate a table of peak flows and corresponding recurrence intervals (i.e., frequency of occurrence for a particular flow). For continuous modeling and peak flow frequency statistics, it is important to remember that events refer to *flow events* and not precipitation events. Peak flow frequency statistics estimate how often flow rates will exceed a given threshold. For example, the 5-year flow event represents the flow rate that is equaled or exceeded an average of once per 5 years (and the storm generating this flow does not necessarily correspond to the 5-year precipitation event). Ranking the storm events generated by a continuous simulation and computing the recurrence interval of each storm will generate a table similar to Table 1 below.

Readers who are unfamiliar with how to compute the partial-duration series should consult reference books or online resources for additional information. For example, *Hydrology for Engineers*, by Linsley et all, 1982, discusses partial-duration series on pages 373-374 and computing recurrence intervals or plotting positions on page 359. *Handbook of Applied Hydrology*, by Chow, 1964, contains a detailed discussion of flow frequency analysis, including Annual Exceedance, Partial-Duration and Extreme Value series methods, in Chapter 8. The US Geological Survey (USGS) has several hydrologic study reports available online that use partial-duration series statistics (see http://water.usgs.gov/ and http://water.usgs.gov/osw/bulletin17b/AGU_Langbein_1949.pdf).

Table 1. Example Peak Flow Frequency Statistics

Recurrence Interval (years)	Peak Flow (cfs per acre)
58.5	0.73
21.9	0.69
13.5	0.53
9.8	0.53
7.6	0.51
6.3	0.51
5.3	0.50
4.6	0.50
4.1	0.49
3.7	0.48
3.3	0.48
3.0	0.46
2.8	0.45
2.6	0.45
2.4	0.45
2.3	0.45
2.1	0.44
2.0	0.42

Flow duration statistics are more straightforward to compute than peak flow frequency statistics. Flow duration statistics provide a simply summary of how often a particular flow rate is exceeded. To compute the flow duration series, rank the entire runoff time series output and divide the results into discrete bins. Then, compute how often the flow threshold dividing each bin is exceeded. For example, let's assume the results of a 35-year continuous simulation hydrologic model with hourly time steps show that flows leaving a project site exceeded 5 cfs an average of about once per year for 30 hours at a time. This corresponds to a total of

1050 hours of flows exceeding 5 cfs over 35 years. Another way to express this information is to say a flow rate of 5 cfs is exceeded 0.34 percent of the time. Computing the "exceedance percentage" for other flow rates will fill out the flow duration series. Table 2 lists an example flow duration series.

Table 2. Example Flow Duration Statistics

Flow (cfs per acre)	Percent of Time Flow Rate is Exceeded
0.02	0.67%
0.03	0.43%
0.04	0.34%
0.06	0.27%
0.07	0.21%
0.09	0.17%
0.10	0.15%
0.12	0.12%
0.13	0.11%
0.15	0.09%
0.16	0.08%
0.17	0.07%
0.19	0.06%
0.20	0.05%
0.22	0.05%
0.23	0.04%
0.25	0.04%
0.26	0.03%

The intention of the IHC performance standard is to limit the potential for new development to generate accelerated erosion of stream banks and stream bed material in the local watershed by matching the post-project hydrograph to the pre-project hydrograph for the range of flows that are likely to generate significant amounts of erosion within the creek. The IHC memo identified the geomorphically significant flow range as extending from two-tenths of the 5-year flow to the 10-year flow (0.2Q5 to Q10). The performance standard requires the following:

A. For flow rates from 20% of the pre-project 5-year runoff event (0.2Q5) to the pre-project 10-year runoff event (Q10), the post-project discharge rates and durations shall not deviate above the pre-project rates and durations by more than 10% over more than 10% of the length of the flow duration curve.

B. For flow rates from 0.2Q5 to Q5, the post-project peak flows shall not exceed pre-project peak flows. For flow rates from Q5 to Q10, post-project peak flows may exceed pre-project flows by up to 10% for a 1-year frequency interval. For example, post-project flows could exceed pre-project flows by up to 10% for the interval from Q9 to Q10 or from Q5.5 to Q6.5, but not from Q8 to Q10.

Determining When a Storm Water Control Facility Meets the IHC Performance Standard

The previous section discussed how to calculate peak flow frequency and flow duration statistics. By comparing the peak flow frequency and flow duration series for pre-project and post-project conditions, an engineer can determine whether a stormwater control facility would perform adequately or if its size should be increased or decreased. The easiest way to determine if a particular storm water facility meets the IHC performance standard is to plot peak flow frequency curves and flow duration curves for the pre-project and post-project conditions.

Figure 1 shows a **flow duration curve** for a hypothetical development. The three curves show what percentage of the time a range of flow rates are exceeded for three different conditions: pre-project, post-project and post-project with storm water mitigation. Under pre-project conditions the minimum geomorphically significant flow rate (assumed to be 0.2Q5) is 0.10 cfs and flows would equal or exceed this value about 0.14% of the time (about 12 hours per year). For post-project conditions, this flow rate would occur more often – about 0.38% of the time (about 33 hours per year). This increase in the duration of the geomorphically significant flow after development illustrates why duration control is closely linked to protecting creeks from accelerated erosion. Higher flows that last for longer durations provide the energy necessary to increase the amount of erosion in local creeks. The post-project mitigated condition would include stormwater controls designed to limit the duration of geomorphically significant flows. Figure 1 shows that flows exceed 0.10 cfs only 0.08% of the time, which is less than pre-project conditions. This means the stormwater control mitigations would counteract the effects of the increased pavement associated with development projects.

An engineer can easily interpret the flow duration plots to determine whether a stormwater control facility would meet the IHC. Looking at the flow range between 0.2Q5 and Q10, the post-project mitigated curve should plot on or to the left of the pre-project curve. If the post-project curve plots to the left of the pre-project curve, this means a particular flow would occur for shorter durations due to storm water controls. Minor deviations where the post-project durations exceed the pre-project durations are allowed over a short portion of the flow range as described in IHC item A above.

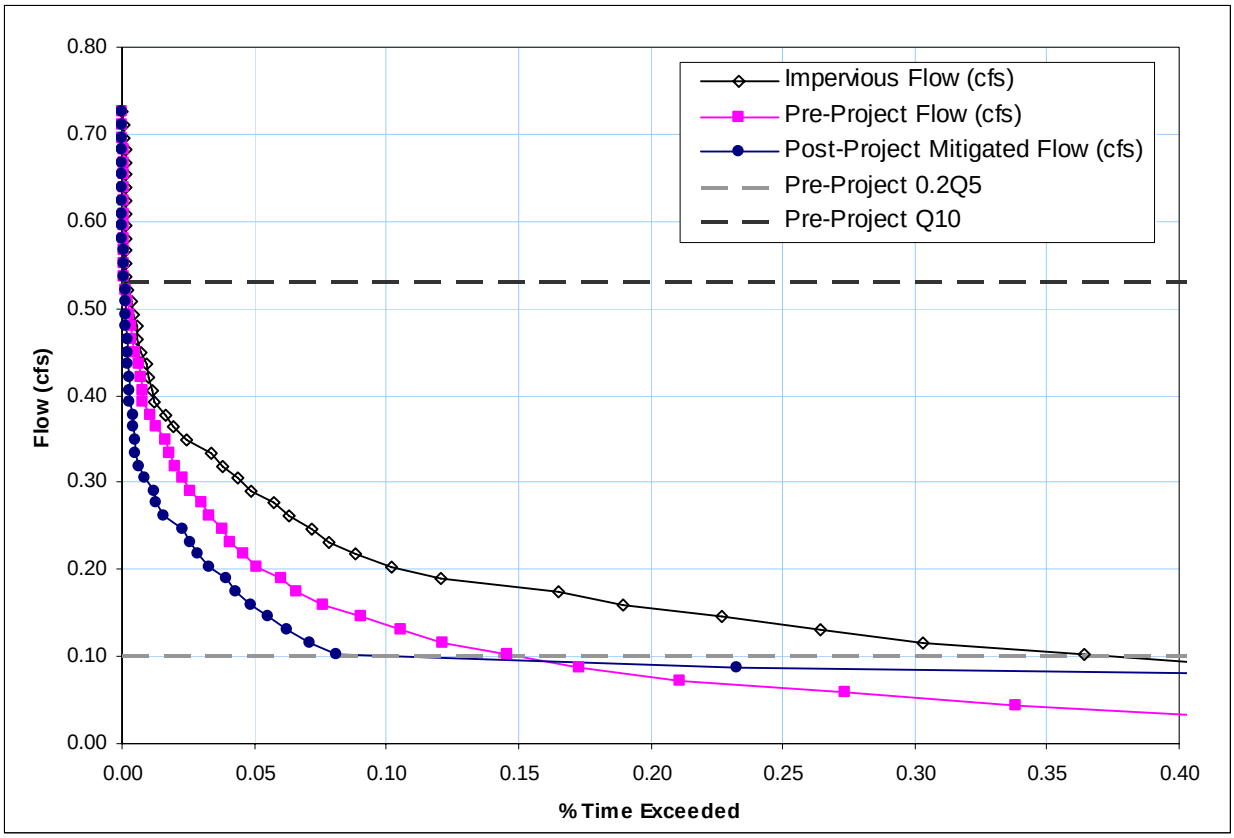

Figure 1. Flow Duration Series Statistics for a Hypothetical Development Scenario

Figure 2 shows a **peak flow frequency curve** for pre-project, post-project and post-project with storm water mitigation scenarios. The curves indicate how often a particular flow rate would be equaled or exceeded. For example, the pre-project 5 year flow rate would be 0.5 cfs per acre. This means under pre-project conditions, a flow rate of 0.5 cfs per acre would be equaled or exceeded an average of once per 5 years. For developed conditions, this 0.5 cfs per acre peak flow rate occur more often – about once per 1.5 years or, expressed another way, more than 3 times as often. The developed 5 year flow rate would increase by 30 percent over the pre-project condition, from 0.5 cfs per acre to about 0.65 cfs per acre.

Storm water control facilities should reduce peak flows from the site to levels less than or equivalent to the pre-project conditions. To determine whether a storm water facility provides sufficient protection, examine the peak flow frequency curves to see if the post-project mitigated peak flows are lower than pre-project peak flows of the same recurrence interval. The post-project mitigated scenario curve should plot below the pre-project curve for recurrence intervals between 0.2Q5 and Q10 to meet the IHC performance standard, with the possible exception of the small, allowable deviations described above in IHC item B.

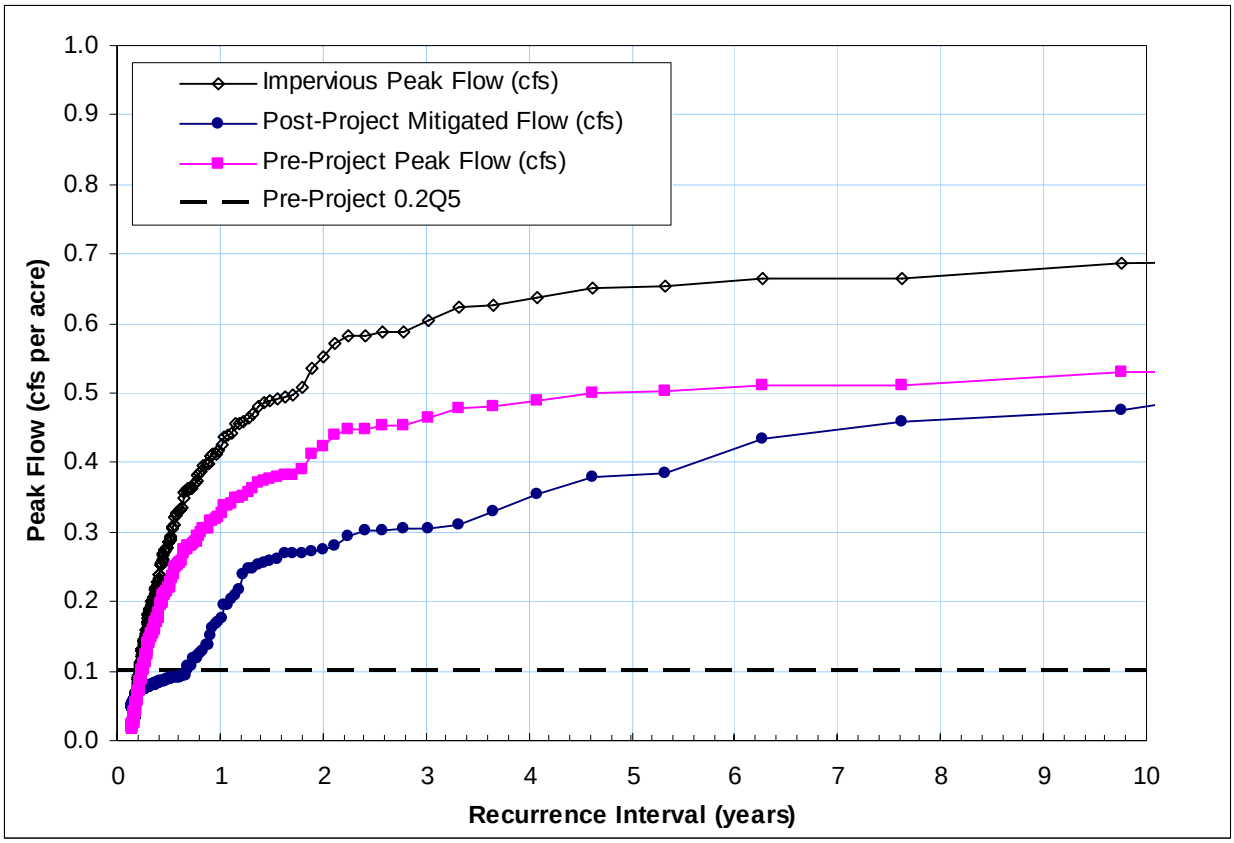

Figure 2. Peak Flow Frequency Statistics for a Hypothetical Development Scenario

References

Linsley, RK Jr.; Koher, MA; Paulhas, JLH; *Hydrology for Engineers,* 1982; McGraw-Hill Inc.

Chow, VT; *Handbook of Applied Hydrology,* 1964; McGraw-Hill Inc.

APPENDIX F

HSPF Modeling Analysis - Technical Memos

Use of contents on this sheet is subject to the limitations specified at the end of this document.
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BROWN AND CALDWELL

Memorandum

9665 Chesapeake Drive, Suite 201
San Diego, CA 92123
Tel: 858-514-8822
Fax: 858-514-8833

Project Title: San Diego County Hydrograph Modification Plan

Project No: 133904

San Diego County Hydrograph Modification Plan

Subject: HMP Sensitivity Analysis

Date: December 16, 2009

To: Sara Agahi, San Diego County

From: Tony Dubin, Brown and Caldwell
Eric Mosolgo, Brown and Caldwell

This memorandum evaluates three conditions where the HMP requirements could be modified without appreciable impacts on the receiving water body:

1. Development that is directly tributary to a large river
2. Development in highly urbanized watershed
3. Limited small developments within a watershed

The following sections describe the technical analysis that was performed to test the sensitivity of river flow durations to specific modifications in the HMP requirements. The results of the technical analysis can be used to justify and/or discard any planned special conditions that allow the HMP requirements to be modified.

Issue #1: Could Developments Near Large Rivers Be Exempted from Flow Duration Requirements?

To test whether development that is directly tributary to large rivers could potentially be exempted from flow duration control requirements, we examined the historical flow record for the San Diego River and evaluated how much additional development could occur without an appreciable change in the range of flows within the San Diego River channel.

We acquired the historical, hourly stream flow records for the San Diego River at Fashion Valley (USGS 11023000) and San Diego River at Mast Road (USGS 11022480) directly from the US Geological Survey. The data was available from October 1988 through November 2009. Next, we computed flow duration statistics for the river and computed relevant statistics, such as the peak 2-year flow rate.

After summarizing the river flows, we built HSPF models to simulate the conversion of undeveloped land to suburban development, assuming a 10-acre hypothetical development. We then ran the HSPF models and computed flow duration curves for the pre- and post-development conditions. We ran one scenario that used the Fashion Valley rain gauge and another scenario that used the Santee rain gauge. Table 1 lists the NRCS soil groups, land uses, and rain gauges that were used to simulate the different development scenarios.

Table 1. HSPF Model Assumptions for Large River Exemption Simulations							
No.	Scenario Description	Rain Gauge	Basin Acres	Soil and Land Use Combinations (area in acres)			
				Impervious	C/D, Dirt	C/D, Grass	C/D, Shrub
1	Undeveloped conditions in lower watershed	Fashion Valley	10	0	5	0	5
2	Developed (unmitigated) conditions in lower watershed	Fashion Valley	10	4	0	4	2
3	Undeveloped conditions in lower watershed	Santee	10	0	5	0	5
4	Developed (unmitigated) conditions in lower watershed	Santee	10	4	0	4	2

To simulate the incremental effects of development on flow durations, the pre-development flow duration curve was subtracted from the post-development flow duration curve. To represent multiple developments, the flow portion of this *difference flow duration curve* was scaled linearly with area to represent 100, 500, 1000, and 2000-acres of additional development within the San Diego River watershed. The simple scaling of the flow duration curves ignores the curve smoothing that could result from the staggered timing of flows reaching the San Diego River, and as such, this simple scaling of the flow duration curves should provide a conservative approximation of the impacts of multiple developments.

Finally, to gauge the impact of multiple developments on the range of San Diego River flows, the *difference flow duration curves* for 10, 100, 500, 1000, and 2000-acres of additional development were superimposed on the observed San Diego River flow duration curve. Figure 1 and Figure 2 (on the following pages) show the combined effect of multiple developments in the vicinity of the Fashion Valley stream flow gauge. Figure 2 shows the same information, but with the scale that focuses in on the part of the curve where the differences are most noticeable. Figure 3 and Figure 4 show the same results for the Mast Road (near Santee) stream flow gauge.

Recommendations

The post-development flow duration curves show very little difference from existing condition flow duration curves until about 2,000 acres or more of additional development occurs. Even when there are differences in the flow duration curves, the flow rates are sufficiently high that the incremental difference would not appreciably increase the level of sediment movement and river bank erosion. As such, we recommend exemptions for these reaches of the San Diego River and other similar rivers from flow duration control requirements.

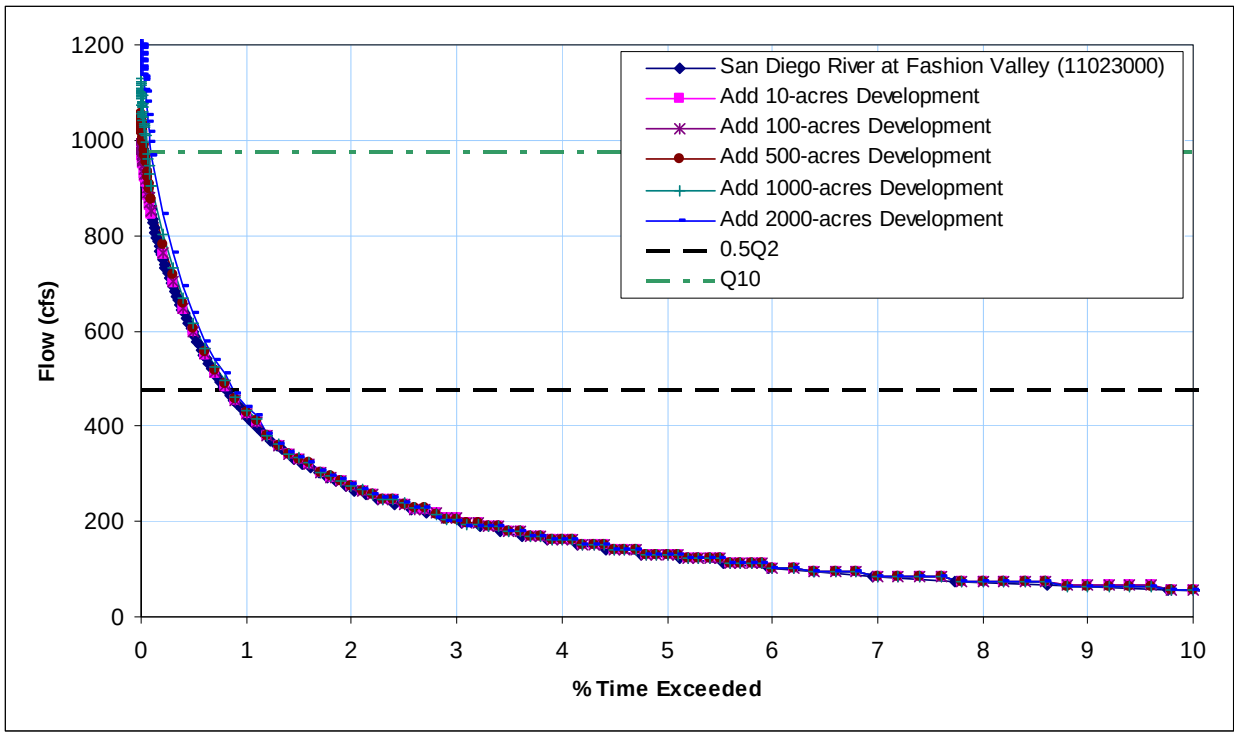

Figure 1. Effects of Additional Development near the San Diego River at Fashion Valley

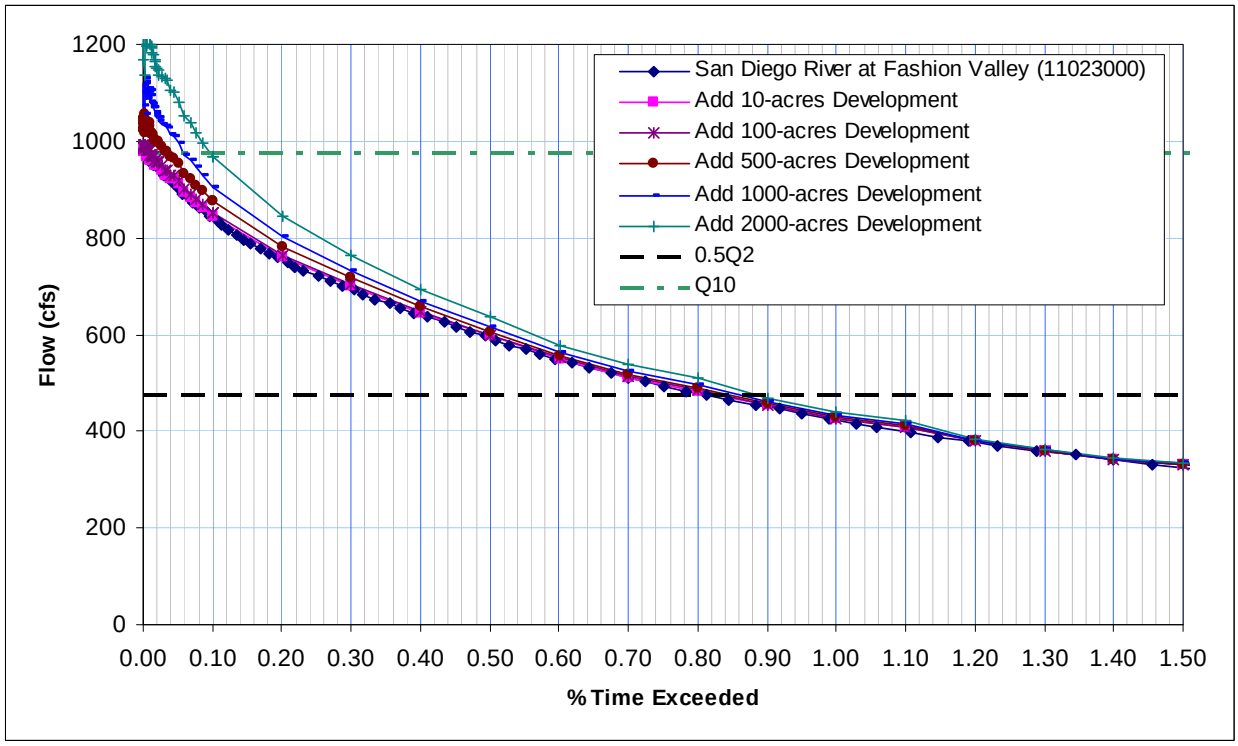

Figure 2. Effects of Additional Development near the San Diego River at Fashion Valley, Zoomed View

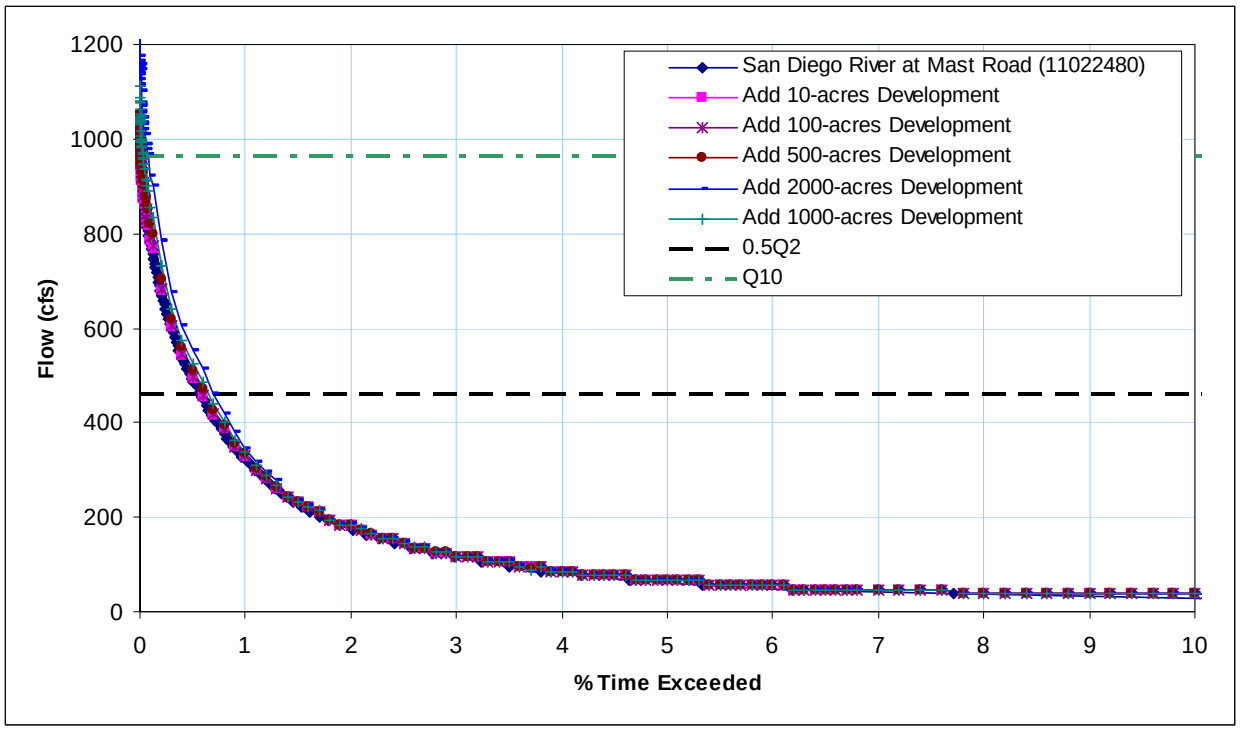

Figure 3. Effects of Additional Development near the San Diego River at Mast Road (near Santee)

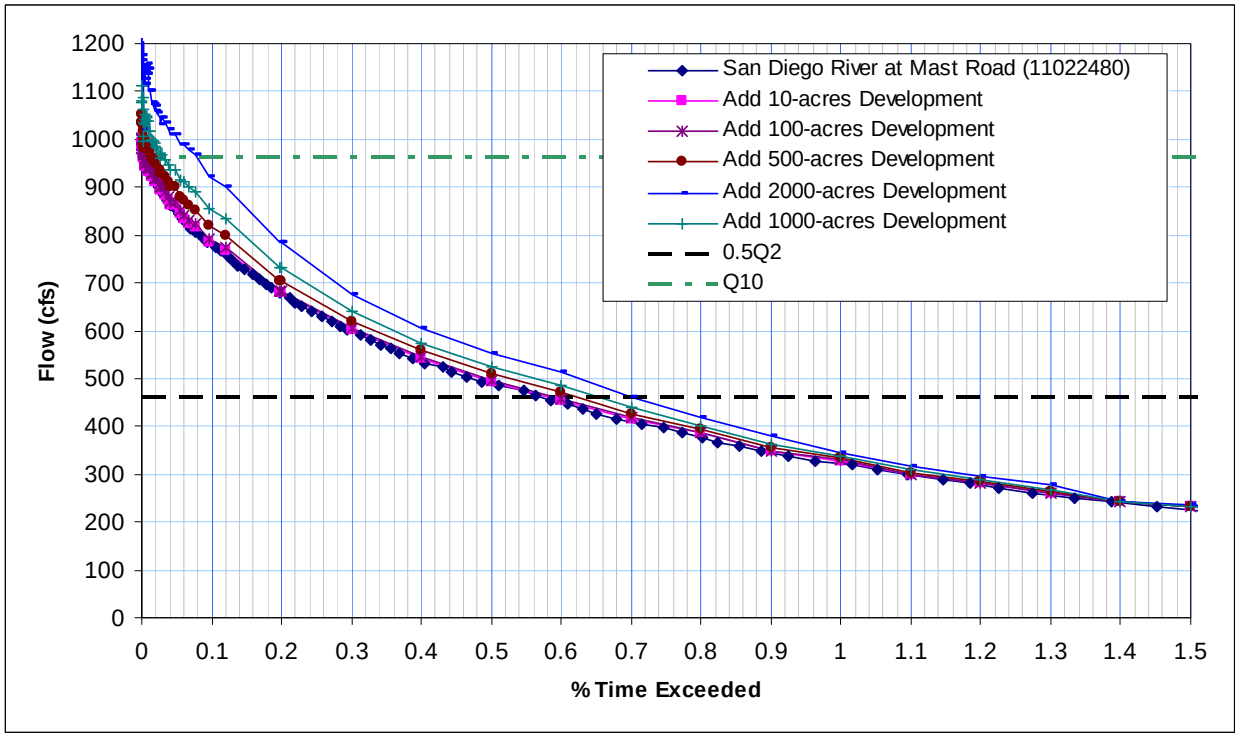

Figure 4. Effects of Additional Development near the San Diego River at Mast Road (near Santee), Zoomed View

Issue #2: Could Limited Infill Development within Highly Urban Watersheds Be Exempted from Flow Duration Control Requirements?

To test whether limited infill development within urbanized watersheds would appreciably impact flow durations in receiving water bodies, we built HSPF models to simulate the stormwater runoff that would occur in 10-acre, 100-acre, and 500-acre urbanized watersheds with 40, 50, and 60-percent total impervious areas. Table 2 lists the soil, land use, and rain gauges that were used to develop the models.

Table 2. HSPF Model Assumptions for Urban Infill Exemption Simulations

No.	Scenario Description	Rain Gauge	Basin Acres	Soil and Land Use Combinations (area in acres)			
				Impervious	C/D, Dirt	C/D, Grass	C/D, Shrub
1	10-acre urban watershed (40% impervious)	Fashion Valley	10	4	0	4	2
2	100-acre urban watershed (40% impervious)	Fashion Valley	100	40	0	40	20
3	500-acre urban watershed (40% impervious)	Fashion Valley	500	200	0	200	100
4	10-acre urban watershed (50% impervious)	Fashion Valley	10	5	0	4	1
5	100-acre urban watershed (50% impervious)	Fashion Valley	100	50	0	40	10
6	500-acre urban watershed (50% impervious)	Fashion Valley	500	250	0	200	50
7	10-acre urban watershed (60% impervious)	Fashion Valley	10	6	0	3	1
8	100-acre urban watershed (60% impervious)	Fashion Valley	100	60	0	30	10
9	500-acre urban watershed (60% impervious)	Fashion Valley	500	300	0	150	50

Figure 5 (on the following page) shows a peak flow frequency curve for the 100-acre, 40, 50, and 60-percent impervious scenarios. Figure 6 shows the flow duration curves for these 100-acre watershed scenarios. Figure 7 focuses on the portion of the flow duration curves where the differences in the simulations are most noticeable. The 10-acre and 500-acre scenarios produced similar results (on a unit area basis).

Recommendations

The extent of the spread among the 40, 50, and 60-percent model scenarios demonstrates that unchecked development within urbanized watershed would have a noticeable effect on the peak flows and flow durations observed within the receiving waters. However, some modest level of urbanized development would produce minor or negligible effects on the peak flows and flow durations. Based on our examination of the peak flow frequency and flow duration curves, we recommend the following allowances in highly urbanized watersheds:

> For subwatershed areas containing between 40 percent and 70 percent existing imperviousness (as measured from the project site downstream to a natural creek confluence), projects may be exempt from HMP criteria if:

1. The potential cumulative impacts within the subwatershed would not increase the composite impervious area percentage by more than 3 percent, and;

2. The project discharges runoff to an existing hardened system (storm drain or concrete channel) that extends beyond the Domain of Analysis determined for the project site.

For subwatershed areas containing existing impervious percentages greater than 70 percent (as measured downstream to the Pacific Ocean, San Diego Bay, a tidally influenced lagoon, or an exempt river system), projects are exempt from HMP criteria. Additionally, for subwatershed areas containing less than 40 percent existing imperviousness, projects are subject to HMP criteria unless they qualify for another exemption (per HMP Decision Matrix).

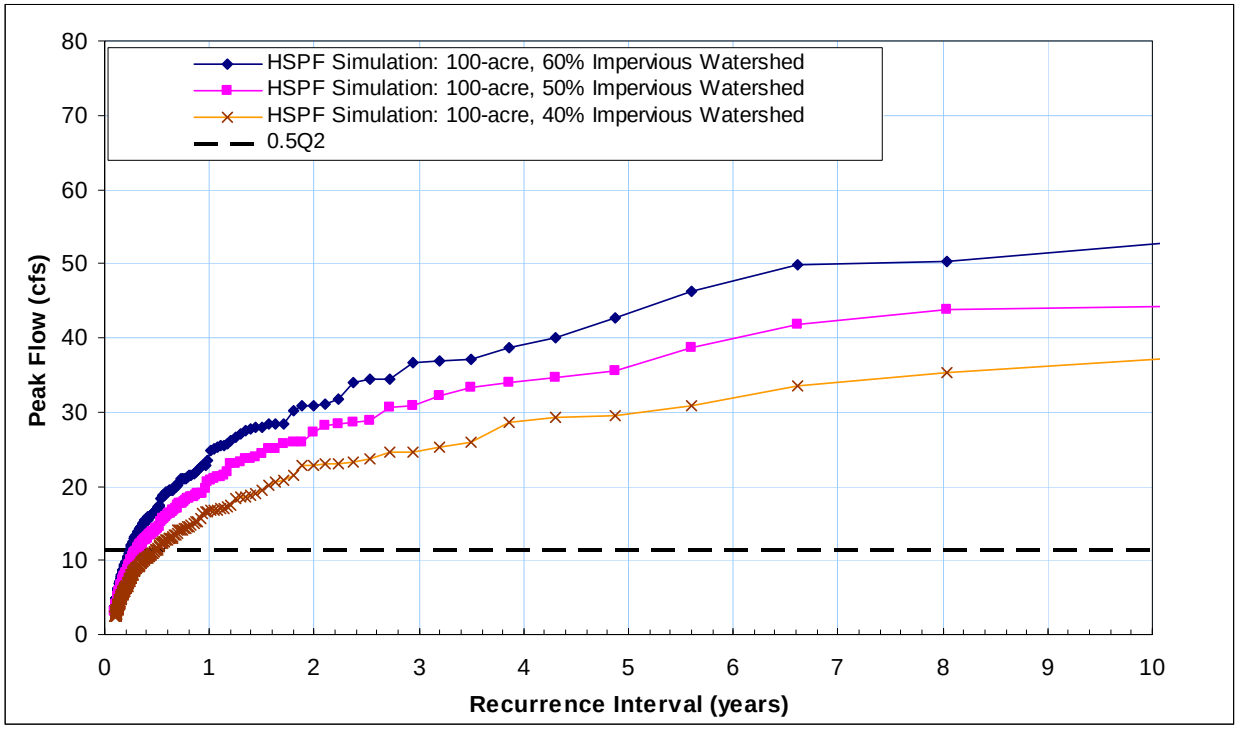

Figure 5. Simulated Peak Flow Frequencies for 100-acre Urbanized Watershed (Fashion Valley rainfall)

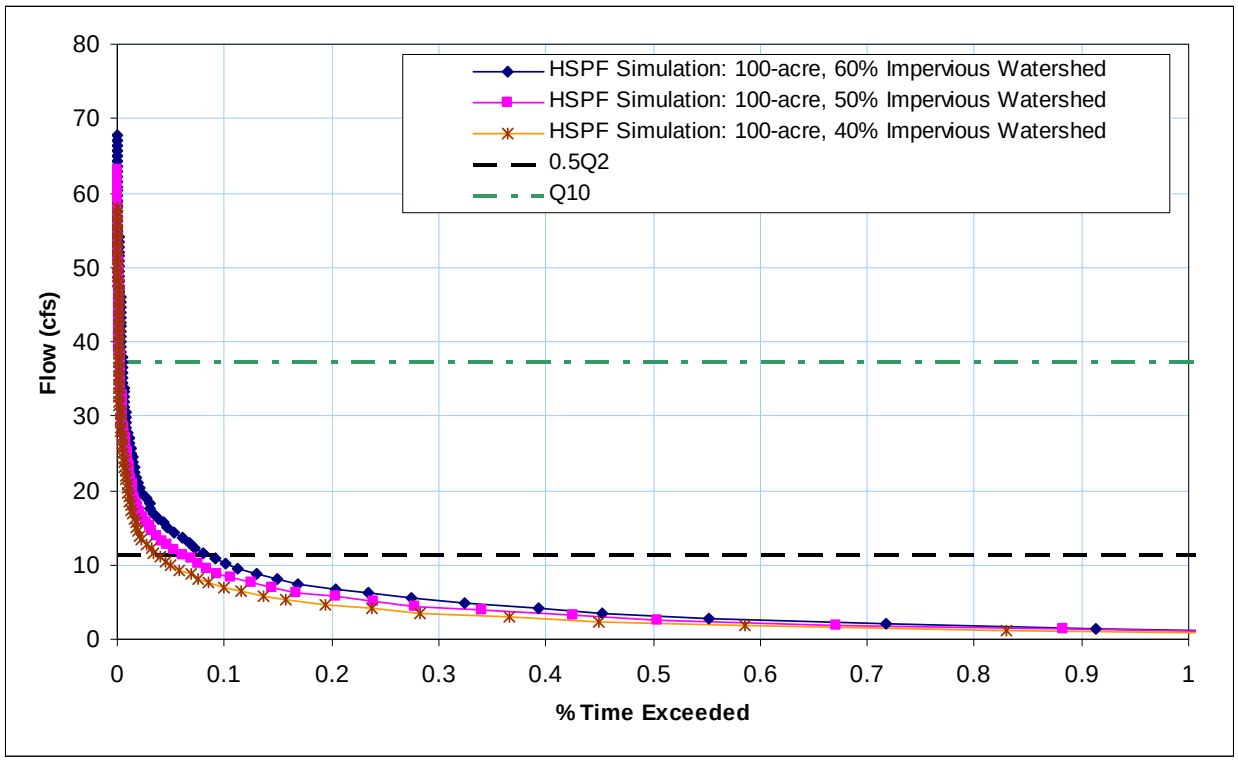

Figure 6. Simulated Flow Durations for 100-acre Urbanized Watershed (Fashion Valley rainfall)

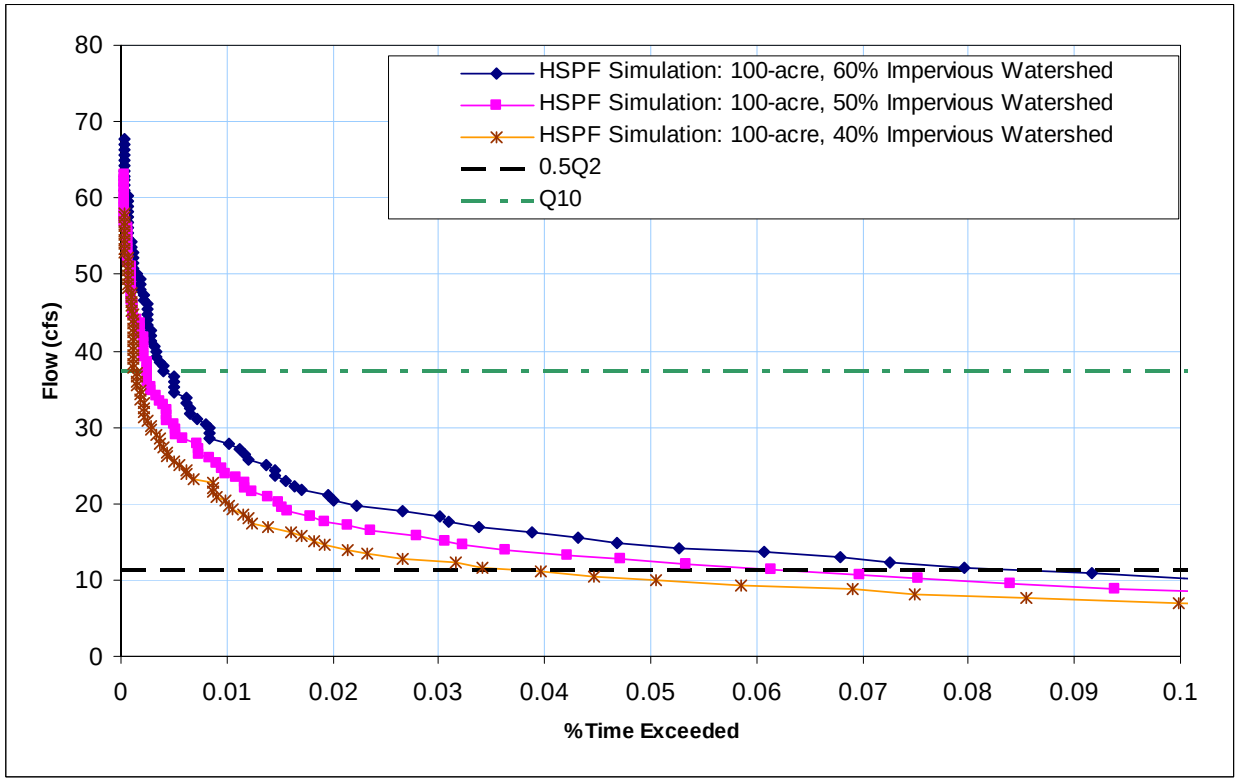

Figure 7. Simulated Flow Durations for 100-acre Urbanized Watershed (Fashion Valley rainfall), Zoomed View

Issue #3: Could Limited Small Developments Specify a Minimum 3-inch Diameter Orifice for Detention Pond Design without Affecting the Receiving Water's Flow Durations?

Due to concerns about clogging, a 3-inch diameter minimum diameter orifice has been proposed for stormwater detention pond design. This size orifice would not provide the required level of flow restriction for small developments, because the 3-inch diameter orifice capacity is greater than the lower flow control range (0.1Q2, 0.3Q2, 0.5Q2) in the Final HMP. As such, we tested whether a limited number of small developments could use a 3-inch minimum orifice diameter without generating appreciable cumulative effects on the receiving water's flow durations.

We built HSPF models to represent undeveloped 100-acre and 500-acre watersheds in the vicinity of the Lower Otay rain gauge. We then built HSPF models to represent undeveloped and developed-mitigated conditions for 5-acre and 10-acre development sites. The developed-mitigated scenarios included detention ponds with 3-inch diameter lower orifice and an upper high flow release.

Similar to the large watershed development scenarios evaluated for Issue #1 above, we computed flow duration curves for the undeveloped and developed-mitigated scenarios, and then subtracted the undeveloped flow duration curve from the developed-mitigated flow duration curve to estimate the difference in conditions. Then, we scaled the difference flow duration curve in increments of 5, 10, 25, and 50-acres and superimposed these curves on the 100-acre and 500-acre undeveloped scenarios to determine when the cumulative impacts would be noticeable. Table 3 lists the soil, land use, and rain gauges that were used for this analysis.

Table 3. HSPF Model Assumptions for 3-inch Minimum Orifice Diameter Simulations

No.	Scenario Description	Rain Gauge	Basin Acres	Soil and Land Use Combinations (area in acres)			
				Impervious	C/D, Dirt	C/D, Grass	C/D, Shrub
1	100 ac undeveloped conditions	Lower Otay	100	0	50	0	50
2	500 ac undeveloped conditions	Lower Otay	500	0	250	0	250
3	1 ac undeveloped conditions	Lower Otay	1	0	0.5	0	0.5
4	5 ac undeveloped conditions	Lower Otay	5	0	2.5	0	2.5
5	10 ac undeveloped conditions	Lower Otay	10	0	5	0	5
6	1 ac mitigated conditions with 3-in diameter outlet	Lower Otay	1	0.4	0	0.4	0.2
7	5 ac mitigated conditions with 3-in diameter outlet	Lower Otay	5	2	0	2	1
8	10 ac mitigated conditions with 3-in diameter outlet	Lower Otay	10	4	0	4	2

Figure 8 shows the flow durations curves for the 100-acre undeveloped scenario, plus developed-mitigated scenarios with increments of 5, 10, 25, and 50-acres of development. For the developments, we are assuming the ponds serve 10 acre increments of development (except for the 5-acre increment scenario) and include a 3-inch diameter lower control orifice.

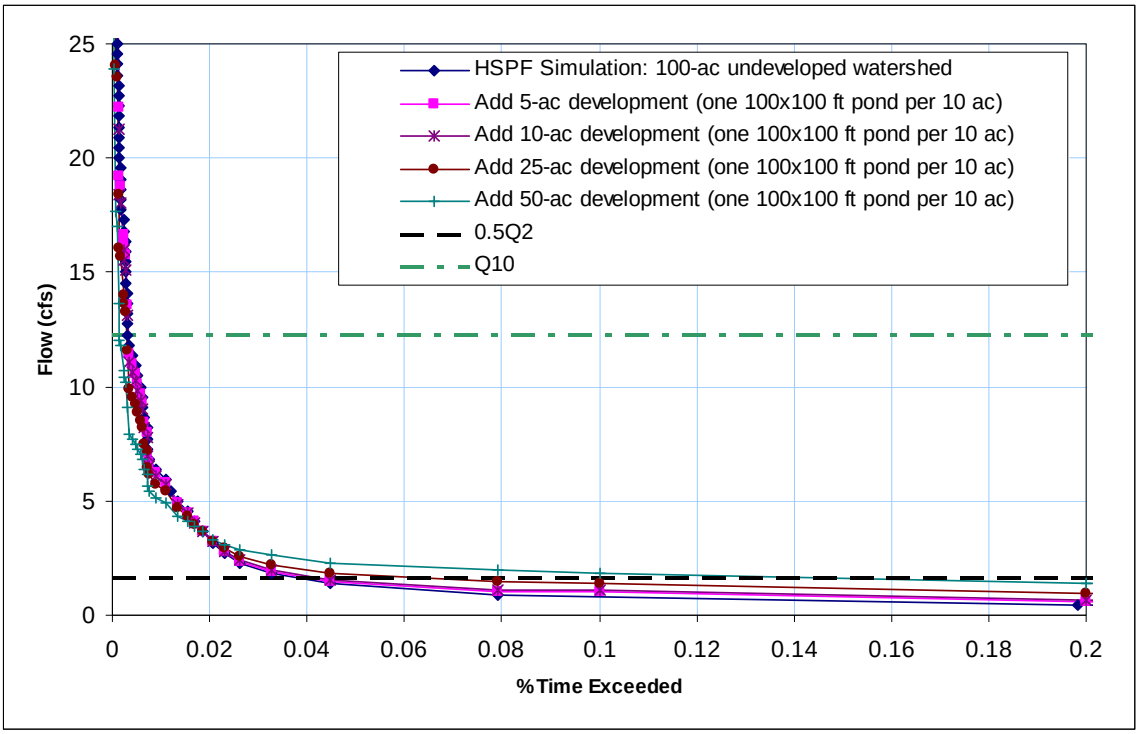

Figure 8. Simulated Flow Durations for Adding Development and Extended Duration Ponds with 3-inch Minimum Diameters to a 100-acre Undeveloped Watershed (Lower Otay rainfall)

The results show that the cumulative development flow duration curve approximately matches the undeveloped flow duration curves when development occurs in 10 percent or less of the watershed. For development levels in excess of 10 percent, the cumulative flow duration curve deviates noticeably from the undeveloped condition. The 500-acre undeveloped watershed simulations indicated a similar threshold sensitivity to development.

Recommendations

The HSPF analysis indicated limited situations where a 3-inch minimum orifice size standard could be applied. However, it should be noted that for small sites where orifices less than 3-inches would be required for HMP mitigation, we recommend an LID requirement in lieu of extended detention facilities.

For project sites 1 acre of less in size:

- HMP mitigation must be attained through the use of LID facilities (because a 3-inch outlet orifice would provide no tangible mitigation)

For project sites greater than 1 acre and less than 5 acres in size:

- HMP mitigation should be attained through the use of LID facilities

If LID implementation is not possible and extended detention basins are used:

- A 3-inch minimum outlet orifice size may be used provided that the potential cumulative impacts in the subwatershed area, as measured from the project site downstream to a natural creek confluence, would not increase the composite impervious area in the subwatershed to more than 10 percent.

If the potential cumulative impacts in the subwatershed areas would result in an impervious area percentage greater than 10 percent, then the 3-inch minimum orifice size waiver would not be granted.

Appendix A: Assumed Water Movement Hydraulics for Modeling BMPs

At minimum, each BMP consists of a reservoir for surface water storage, an overflow outlet and a soil medium. In general, runoff flows into the surface storage reservoir and either infiltrates into the soil or flows through the overflow outlet structure.

Water that does not overflow the surface-storage reservoir infiltrates into the top soil medium and is stored as soil water. Once in the soil, water percolates downward at a rate that is dependent on the soil moisture content, the hydraulic properties of the soil and the boundary conditions of the soil layer.

Many BMPs also include a gravel or aggregate layer below the upper soil layer. Similarly, the rate at which water percolates downward through the gravel/aggregate layer is dependent on the soil moisture content, the hydraulic properties of the soil and the boundary conditions. The lower boundary is often controlled using an underdrain with an orifice outlet.

The following sections describe the theoretical relationships used to develop the FTABLEs for HSPF modeling of the BMPs. The first four sections of this appendix describe the discharge equations used for each of three overflow outlet types and the underdrain orifice:

- Circular Overflow Outlet,
- Straight, Sharp-crested Weir,
- V-notch Weir,
- Underdrain Orifice.

The last three sections describe infiltration, soil water storage and soil water movement.

Circular Overflow Outlet

A circular overflow outlet is basically a vertical pipe with a horizontal opening set to a specific height. This type of outlet is used for bioretention and the flow-through planter BMPs. Hydraulically, this is sufficiently similar to the overflow gate and weir designs shown in the Countywide SUSMP.

Outflow control conditions vary as head over the pipe opening increases. As the water level begins to rise above the opening the pipe acts as a circular weir and flow is crest-controlled. As the head over the opening increases the flow condition transitions to become orifice-controlled and eventually pipe-controlled (the pipe flows full).

Under crest-controlled conditions outflow is calculated using a modified weir equation:

$$Q = C_d \left(\pi R\right) H^{3/2} \qquad \textbf{Equation 1}$$

Where Q = outflow in cfs, C_d = discharge coefficient, R = pipe radius in ft, and H = the head over the crest in ft.

The discharge coefficient for crest-controlled flow is highly variable depending on the head over the crest, the radius of the circular weir, and the ratio of the inlet height to radius. USBR (1987) published a series of curves that are used to determine the appropriate discharge coefficient for each water surface level.

Straight Sharp-crested Weir

A second type of overflow outlet is a straight sharp-crested weir. A sharp-crested weir is used to control overflow in a vegetated/grassy swale. The following weir equation is used to calculate overflow discharge:

$$Q = C_d L H^{3/2} \qquad \textbf{Equation 2}$$

Where Q = outflow in cfs, C_d = discharge coefficient, L = weir length in ft and H = head over the weir crest in ft. The weir coefficient is assumed to be 3.10 for straight sharp-crested weirs.

V-notch Weir

In some cases a v-notch is added to the overflow weir. A v-notch weir is incorporated into the overflow weir of the vegetated bioswale with check dams. The flow through the v-notch is calculated using the following equation.

$$Q = C_d \tan\left(\frac{\phi}{2}\right) H^{5/2} \qquad \textbf{Equation 3}$$

Where Q = outflow in cfs, C_d = discharge coefficient, ϕ = angle of the v-notch, and H = head over the weir crest in ft. The v-notch is assumed to be 90 degrees and the weir coefficient was assumed to be 2.55.

Underdrain Outlet

The perforated pipe of lateral underdrains is assumed to be sufficiently large as to not limit the flow into the drain. Drain outflow is limited by single orifice at the end of the drain pipe. Outflow through this orifice was calculated using the orifice equation:

$$Q = C_d A \sqrt{2gH} \qquad \textbf{Equation 4}$$

Where Q = outflow, C_d = discharge coefficient, A = area of the orifice, g = gravitational constant, H = head over the centerline of the orifice. The discharge coefficient is assumed to be 0.6 in all cases.

Infiltration

Infiltration is the process of water penetrating from the ground surface into the soil (Chow et al. 1988). Many factors influence the rate of infiltration including ground cover, soil hydraulic properties and soil moisture. As water infiltrates into the soil the

soil moisture and hydraulic gradient change. As a result the infiltration rate itself changes over time. This non-linear relation is given by Richard's equation, which is the governing equation for unsteady unsaturated flow in a porous medium. Eagleson (1970) presents Richard's equation in its one-dimensional form:

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial z}\left[D\frac{\partial \theta}{\partial z} + K \right]. \qquad \textbf{Equation 5}$$

Where D = diffusivity, K = hydraulic conductivity, q = soil moisture content, z = elevation and t = time.

Numerous equations have been developed as approximate solutions to Richard's equation. Eagleson (1970) shows that Horton's equation is derived from Richard's equation by assuming D and K are constants independent of soil moisture:

$$f(t) = f_c + (f_0 - f_c)e^{-kt}. \qquad \textbf{Equation 6}$$

Where, f_0 = initial infiltration rate, k = decay constant and f_c = final constant infiltration rate. Using Horton's approximate solution we can see how infiltration rate changes over time.

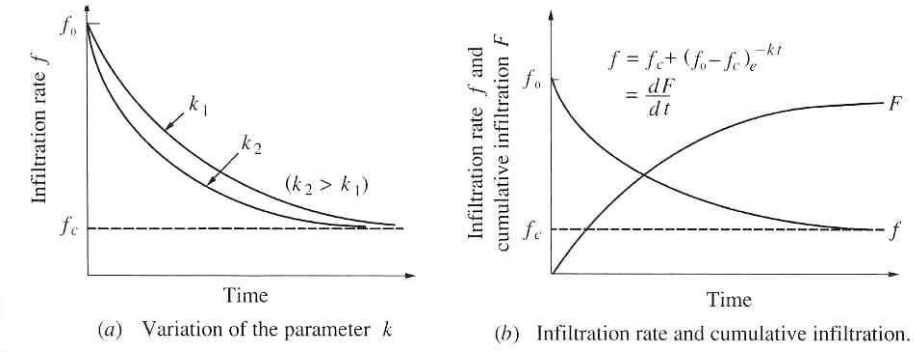

Figure B1– Horton's Equation for Infiltration (graphs from Chow et al. 1988)

We can see from Figure B1 that infiltration begins at a very high rate due to the high matric potential in a dry soil and decreases exponentially as the soil becomes saturated, matric potential becomes insignificant and gravity governs the hydraulic gradient. Thus the infiltration rate approaches a steady-state final rate that approximately corresponds to the saturated hydraulic conductivity of the soil.

After water has been infiltrated into the soil the movement of water through the soil is termed percolation. The rate of percolation can be calculated using Darcy's Law (see Soil Water Movement Section).

Horton's equation showed that the potential infiltration rate of water into the soil always exceeds the saturated hydraulic conductivity of the soil. Conversely, the percolation rate of soil water is limited by the saturated hydraulic conductivity of the soil. Therefore, it is reasonable to assume that the potential infiltration rate is always

greater than the percolation rate, and that the percolation rate will limit the flow rate through the soil layer.

Water Storage

The amount of water stored in soils (soil moisture) is expressed as a dimensionless ratio called the volumetric water content, θ. For any given water content the total volume of water stored in the soil, V_{water}, is equal to the volumetric water content (θ) times the total volume of soil, V_{total}.

$$\theta = \frac{V_{water}}{V_{total}} \qquad \textbf{Equation 7}$$

The total void space within a soil is the porosity, η. Soil is saturated when the volumetric water content is equal to the porosity.

Some voids do not actively store and convey water. The void space within the soil that is hydrodynamically effective is called the effective porosity, θ_e. The difference between the total porosity and the effective porosity is known as the residual water content, θ_r. Maidment (1993) provides typical porosity, effective porosity and residual water content values by soil texture (see Table B1).

Table B1– Soil Porosity, Effective Porosity and Residual Water Content by Soil Texture (Maidment, 1993)

Soil Type	Porosity η	Effective Porosity θ_e	Residual Water Content θ_r
GRAVEL[1]	0.420	0.415	0.005
SAND	0.437	0.417	0.020
LOAMY SAND	0.437	0.401	0.035
SANDY LOAM	0.453	0.412	0.041
LOAM	0.463	0.434	0.027
SILT LOAM	0.501	0.486	0.015
SANDY CLAY LOAM	0.398	0.330	0.068
CLAY LOAM	0.464	0.390	0.075
SILTY CLAY LOAM	0.471	0.432	0.040
SANDY CLAY	0.430	0.321	0.109
SILTY CLAY	0.479	0.423	0.056
CLAY	0.475	0.385	0.090

1 – Values for gravel were obtained from Fayer (1992) as presented in INEEL (2002).

Porosity, effective porosity and residual water content values by hydrologic soil group were obtained for this project by assuming each group corresponds with a specific soil texture.

- Group A → Sand
- Group B → Loam
- Group C → Sandy Clay Loam

- Group D → Clay

These assumptions were based on the hydrologic soil group descriptions provided by NRCS (2001). Table B2 provides the assumed porosity, effective porosity and residual water content values by hydrologic soil group.

Table B2 – Soil Porosity, Effective Porosity and Residual Water Content by Hydrologic Soil Group

Soil Type	Porosity η	Effective Porosity θ_e	Residual Water Content θ_r
HYDROLOGIC SOIL GROUP: A	0.437	0.417	0.020
HYDROLOGIC SOIL GROUP: B	0.463	0.434	0.027
HYDROLOGIC SOIL GROUP: C	0.398	0.330	0.068
HYDROLOGIC SOIL GROUP: D	0.475	0.385	0.090

Soil Water Movement

Darcy's Law is used to calculate the rate of water movement through a porous medium:

$$q = -K\frac{\partial h}{\partial z} \qquad \textbf{Equation 8}$$

Where q = Darcy flux, K = hydraulic conductivity of the porous medium, h = total hydraulic head, and z = elevation. The total head, h, is the sum of the matric head, ψ, and the gravity head, z (velocity head is negligible):

$$h = \psi + z \ . \qquad \textbf{Equation 9}$$

Assuming flow only in the vertical direction and substituting for h, Equation 1 becomes:

$$q = -K\frac{d(\psi + z)}{dz} \ . \qquad \textbf{Equation 10}$$

The matric potential within a soil varies greatly with soil moisture. The relation between matric potential and soil moisture for a specific soil is known as the water-retention characteristic of that soil. Figure B2 shows some examples of typical water-retention curves for soils of various textures.

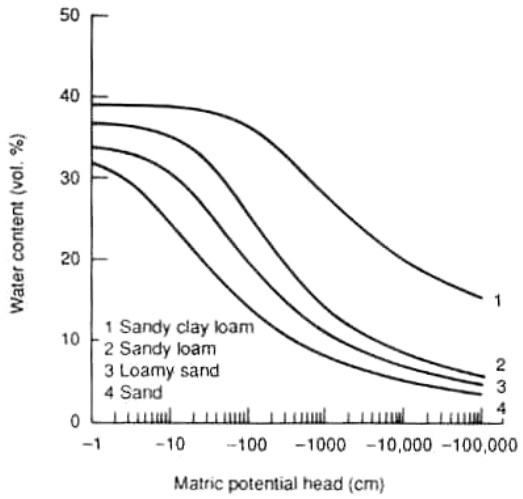

Figure B2 – Typical water retention curves (graph from Maidment, 1993)

Several equations have been developed to approximate water-retention relationships based on the physical characteristics of the soil. One such equation was developed by van Genuchten (1980):

$$\frac{\theta-\theta_r}{\eta-\theta_r}=\left[\frac{1}{1+(\alpha\psi)^n}\right]^m \qquad \textbf{Equation 11}$$

Where the constants α, n and m are given by:

$$\alpha=(h_b)^{-1} \qquad \textbf{Equation 12}$$

$$n=\lambda+1 \qquad \textbf{Equation 13}$$

$$m=\frac{\lambda}{\lambda+1}\ . \qquad \textbf{Equation 14}$$

The bubbling pressure head, h_b, and pore-size index, λ, are soil-specific parameters. Maidment (1993) provides typical bubbling pressures and pore-size index values by soil texture (see

Table B3).

Table B3 – Bubbling Pressure and Pore-size Index by Soil Texture (Maidment, 1993)

Soil Type	Bubbling Pressure (cm) h_b	Pore-size Distribution λ
GRAVEL[1]	0.20	1.190
SAND	7.26	0.694
LOAMY SAND	8.69	0.553
SANDY LOAM	14.66	0.378
LOAM	11.15	0.252
SILT LOAM	20.76	0.234
SANDY CLAY LOAM	28.08	0.319
CLAY LOAM	25.89	0.242
SILTY CLAY LOAM	32.56	0.177
SANDY CLAY	29.17	0.223
SILTY CLAY	34.19	0.150
CLAY	37.30	0.165

1 – Values for gravel were obtained from Fayer (1992) as presented in INEEL (2002).

As discussed previously, soil properties were assigned to hydrologic soil groups based on soil textures. Table B4 provides the bubbling pressure and pore-size index values by hydrologic soil group.

Table B4 – Bubbling Pressure and Pore-size Index by Hydrologic Soil Group

Soil Type	Bubbling Pressure (cm) h_b	Pore-size Distribution λ
HYDROLOGIC SOIL GROUP: A	7.26	0.694
HYDROLOGIC SOIL GROUP: B	11.15	0.252
HYDROLOGIC SOIL GROUP: C	25.89	0.242
HYDROLOGIC SOIL GROUP: D	37.30	0.165

Hydraulic Conductivity, *K*, is also dependent on soil moisture. Van Genuchten (1980) also developed a relationship to approximate the hydraulic conductivity of soils based on soil properties:

$$\frac{K(\theta)}{K_s} = \left(\frac{\theta-\theta_r}{\eta-\theta_r}\right)^{1/2}\left\{1-\left[1-\left(\frac{\theta-\theta_r}{\eta-\theta_r}\right)^{1/m}\right]^m\right\}^2 . \qquad \textbf{Equation 15}$$

Saturated hydraulic conductivity, K_s, is a measure of a saturated soil's ability to transmit water along a hydraulic gradient. This value is highly variable in field conditions; however, Maidment (1993) does provide estimates of saturated hydraulic conductivity by soil texture (see

Table B5).

Table B5 – Saturated Hydraulic Conductivity by Soil Texture (Maidment, 1993)

Soil Type	Saturated Hydraulic Conductivity (cm/hr) K_s
GRAVEL[1]	1260
SAND	23.56
LOAMY SAND	5.98
SANDY LOAM	2.18
LOAM	1.32
SILT LOAM	0.68
SANDY CLAY LOAM	0.3
CLAY LOAM	0.2
SILTY CLAY LOAM	0.2
SANDY CLAY	0.12
SILTY CLAY	0.1
CLAY	0.06

1 – Values for gravel were obtained from Fayer (1992) as presented in INEEL (2002).

As discussed previously, soil properties were assigned to hydrologic soil groups based on soil textures. Table B6 provides the saturated hydraulic conductivity by hydrologic soil group.

Table B6 – Saturated Hydraulic Conductivity by Hydrologic Soil Group

Soil Type	Saturated Hydraulic Conductivity (cm/hr) K_s
HYDROLOGIC SOIL GROUP: A	23.56
HYDROLOGIC SOIL GROUP: B	1.32
HYDROLOGIC SOIL GROUP: C	0.20
HYDROLOGIC SOIL GROUP: D	0.06

Figure B3(a) shows a plot of the van Genuchten relationships using the soil properties assumed for a loamy sand soil. Figure B3(b) is a graph from Chow et al. (1988) that shows the typical variation of matric head and hydraulic conductivity based on experimental data for an example soil.

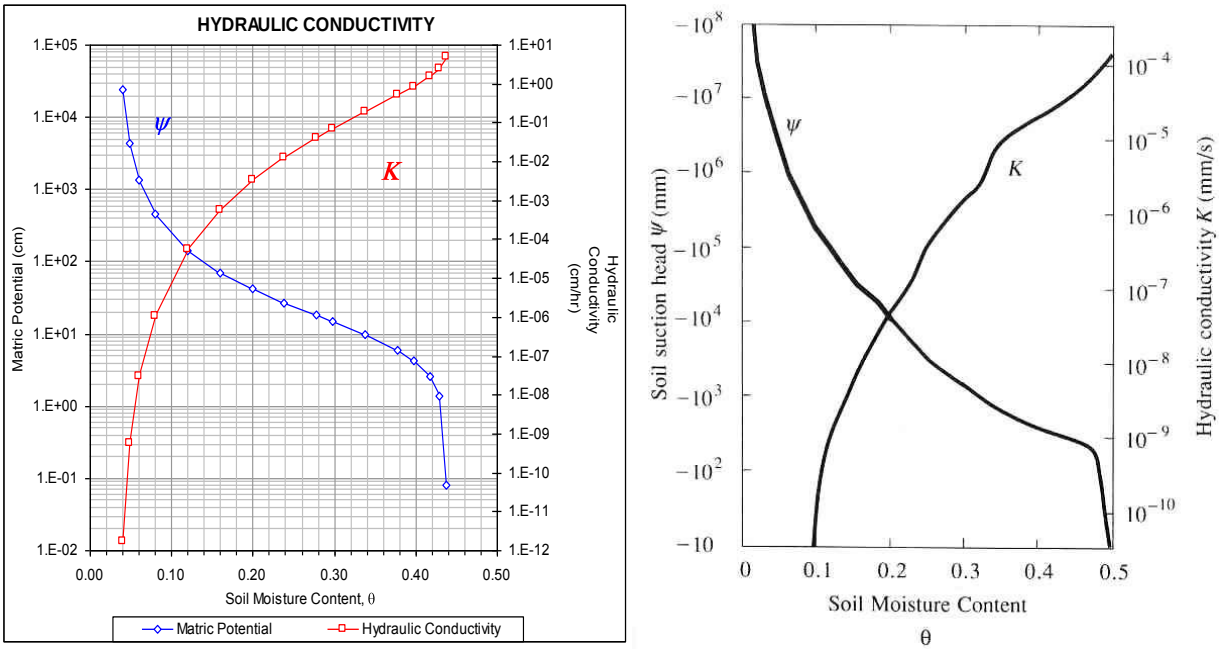

Figure B3 - (a) variation of matric head and hydraulic conductivity for a loamy sand using van Genuchten relations, (b) example provided in Chow et al. (1988)

The van Genuchten relations were used to calculate the matric head and hydraulic conductivity for a given soil moisture content. These results were then used in the Darcy equation to compute the flow through the soil. Calculated over a range of soil moisture contents, a table can be created relating soil water storage and flow through the soil layer.

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Draft Technical Memorandum

Project Title: San Diego County Hydromodification Management Plan

Project No: 133904

San Diego County Hydromodification Management Plan

Subject: HMP Modeling Approach and BMP Configurations

Date: March 2, 2010

To: Sara Agahi, San Diego County

From: Tony Dubin, Brown and Caldwell
Eric Mosolgo, Brown and Caldwell

This memorandum describes the modeling approach that is being used to size low-impact development dbest management practices (LID BMPs) for the San Diego Hydromodification Management Plan (HMP), including the range of scenarios performed and key assumptions for describing pre-project and post-project conditions, and BMP hydraulics. The memo also describes the type, configurations and dimensions of the LID BMPs that will be modeled in support of the BMP Sizing Tool software. The memo is organized into the following sections:

- **Section 1** provides a brief overview of the HSPF model setup and BMP sizing process.
- **Section 2** describes in greater detail how the HSPF models are setup for the San Diego HMP, including key input data.
- **Section 3** summarizes the general process for computing LID BMP sizing factors.
- **Section 4** describes the physical configurations of the BMPs.

1. Overview of HSPF Modeling and BMP Sizing Approach

The purpose of the runoff simulation for existing and post-development site conditions is to evaluate the effectiveness of BMPs which mitigate the increase in stormwater runoff resulting from the conversion of pervious land surfaces to impervious surfaces. The pre-project runoff regime must be characterized for a variety of baseline soil groups, land cover, slope and rainfall scenarios. Increases in runoff peaks and durations from each of these baseline scenarios establish the impacts to be fully mitigated by a BMP in a particular site development project. This section summarizes the overall steps used in this study to size BMPs.

1.1 Develop Pre-Project and Post-Project Runoff Time Series

San Diego County and its Copermittees' approach to compliance with the stormwater runoff control provision of its NDPES permit is to ensure that post-project runoff at any given development does not exceed pre-project runoff peaks or durations for the range of flows that could potentially have significant

impacts on receiving streams. This approach aims to address the potential impacts of an individual development and the cumulative effects of many developments in the same watershed.

Brown and Caldwell has developed sets of HSPF model parameters to represent a range of pre-project site conditions that may be encountered in San Diego County. The parameter selection process and parameter values are described in a separate technical memorandum entitled, *San Diego HMP HSPF Model Parameter Selections*, dated March 2010. The various possible combinations of these parameters determined the number of "scenarios" that might be required to adequately characterize the pre-project condition for any given development project in the County. Runoff from each scenario was simulated using locally collected rainfall time series data.

Once a continuous runoff time series was generated for the rainfall period of record for each scenario, partial duration frequency and duration analyses were performed on each time series to identify recurrence frequencies and durations for different size runoff events. (This step is needed to characterize the peak flows for various recurrence intervals).

Consistent with the general design guidance in the *Countywide Model SUSMP*, designers are expected to minimize the amount of pervious surface that drains to BMPs. Post-project site runoff was therefore evaluated by simulating runoff from a unit area converted to 100% impervious surface. Comparing the pervious surface model output with the impervious surface model output shows the effects of development prior to adding a BMP.

1.2 Model the Hydraulic Response of BMPs

The project team has constructed representations of each BMP in HSPF. For example, a bioretention basin is represented with separate surface ponding, growing medium, storage layers, an overflow relief outlet, a restricted underdrain outlet (as appropriate), and transmissivity of underlying soils. The configuration of these BMP elements and associated hydraulic characteristics can be varied to determine the configuration that provides the best performance in the least amount of space. The HSPF method for representing storage facilities is called an F-TABLE, and is described further in Section 3.1.1.

1.3 Establish BMP Sizing Factors

To compute sizing factors for each BMP, the impervious runoff time series was routed through the BMP to develop a post-project "mitigated" runoff time series. Each BMP mitigates post-project runoff by providing infiltration and/or reduction of discharge rates to the drainage system. The post-project mitigated time series is then compared to the pre-project runoff time series to assess BMP performance. The BMP size (typically surface area) was varied over the course of multiple model iterations until a size was identified that adequately matched post-project to pre-project runoff. The runoff comparison was performed both for peak rates and durations. The following standard applied to assess BMP performance:

- Flow duration control - For flow rates ranging from 10%, 30% or 50% of the pre-project 2-year runoff event ($0.1Q_2$, $0.3Q_2$, or $0.5Q_2$) to the pre-project 10-year runoff event (Q_{10}), the post-project discharge rates and durations shall not deviate above the pre-project rates and durations by more than 10% over and more than 10% of the length of the flow duration curve. The specific lower flow threshold will depend on results from the SCCWRP channel screening study and the critical flow calculator.
- Peak flow control - For flow rates ranging from the lower flow threshold to Q_5, the post-project peak flows shall not exceed pre-project peak flows. For flow rates from Q_5 to Q_{10}, post-project peak flows may exceed pre-project flows by up to 10% for a 1-year frequency interval. For example, post-project flows could exceed pre-project flows by up to 10% for the interval from Q_9 to Q_{10} or from $Q_{5.5}$ to $Q_{6.5}$, but not from Q_8 to Q_{10}.

1.4 Incorporate Sizing Factors into BMP Sizing Calculator

The sizing factors computed using the above process will be incorporated into a BMP Sizing Calculator that development engineers and municipal plan review staff will use to describe site hydrology, compute pre- and post-project runoff rates, and size BMPs.

During the site design process, the project applicant's engineer will divide a project site into separate drainage management areas that will drain to individual BMPs. Based on the type of BMP selected, the amount of impervious and pervious tributary land, local soil type and site slope, the BMP Sizing Calculator will look up the appropriate value derived from the HSPF modeling analysis. An adjustment will be applied to the BMP sizing factor based on the location of the project in the County to account for the different rainfall characteristics.

The BMP Sizing Calculator will also provide prescriptive guidance on using self-retaining landscaping, soil amendments, and other techniques to limit site runoff, and contains a conservative approach to scale BMPs based on tributary pervious areas (i.e., in addition to the tributary impervious areas). The approaches to be used for scaling the sizing factors according to local rainfall variations will be described in a separate technical memorandum.

2. HSPF Model Development

This section describes in detail how HSPF models are developed to simulate pre-project and post-project runoff for San Diego County.

2.1 HSPF Modeling Overview

An HSPF modeling study of a single watershed typically begins with gathering hydrologic information about the area, such as precipitation data, soil groups, growing medium layer depths, vegetation types, vegetation canopy thickness, etc. This information is used to develop appropriate input parameters to the HSPF model. HSPF parameters fall into three general categories:

1. Prescriptive parameters that set flags and specify algorithms to use.
2. Measured or estimated parameters, such as basin area, that are set by GIS analysis or physical measurement.
3. Calibration parameters that may be estimated by measurement, but must be adjusted during the model calibration process. Examples of calibration parameters are infiltration rates, upper soil depth, and groundwater conductivity.

Together these parameters describe the vertical movement (e.g. interception, depression storage, infiltration, evapotranspiration) and lateral movement (e.g. surface runoff, interflow, groundwater flow) of water in HSPF. For studies of individual watersheds, the values of calibration parameters are adjusted, or tuned, until the model simulations reproduce an observed stream flow record.

The purpose of hydrologic modeling within the HMP is to produce a County-wide assessment tool for sizing BMPs. This requires several modifications to the approach used in evaluating a single watershed. Sets of regional, representative parameters were applied to a theoretical unit area, instead of developing and calibrating a specific watershed model. The representative model parameters were initially selected based on other HSPF studies in the area, such as the Santa Monica Bay HSPF watershed-scale model developed by staff at the Southern California Coastal Water Research Project (SCCWRP). In addition, the range of parameter variations across different soil types and slope values were estimated using other references, including EPA Technical Note 6 and various Brown and Caldwell studies. The HSPF model parameters that are used to characterize the hydrologic response of pervious land surfaces to rainfall area (e.g., PERLND parameters) are described in detail in a separate memo entitled, *San Diego HMP HSPF Model Parameter Selections*, dated March, 2010.

Adapting the compiled HSPF parameters for use in San Diego County required an assessment of the local characteristics that affect surface runoff, such as precipitation data, basic soil groups and vegetation cover. The following subsections briefly summarize the range and variability in rainfall volumes and soil types within the County.

2.1.1 Rainfall Data Evaluation

Evaluating the distribution of rainfall across the County helped determine (1) which precipitation gauges to use as input to HSPF for modeling simulations and (2) the extent of rainfall variation throughout the County. The San Diego Alert Network operates a series of precipitation stations across the County, and the National Oceanographic and Atmospheric Administration (NOAA) operates a station at Lindberg Field in San Diego. Eighteen stations with datasets containing at least 30 years of hourly data were evaluated in detail by Brown and Caldwell. Brown and Caldwell prepared and submitted summary technical memoranda that assessed the data records, identified data gaps, and provided recommendations for filling the data gaps.

Table 1 lists reference information about the gauges and Figure 1 shows the variation in mean annual rainfall depth. Mean annual precipitation values vary from 8.7 inches at Bonita to 30.4 inches at Lake Cuyamaca, with the majority of stations recording annual rainfall amounts between 10 and 15 inches.

Table 1. San Diego County Rain Gauge Station Reference Information									
Station Name	**Watershed**	**Start Date**	**End Date**	**Length of Record**	**Latitude**	**Longitude**	**Elevation (ft)**	**Max Hour Rain (in)**	**Mean Annual Rain (in)**
Bonita	Sweetwater River	11/25/1970	5/25/2008	37 years	32.3922	-117.0203	120	1.10	8.7
Encinitas	North County Coastal	9/4/1963	6/30/2008	45 years	33.0237	-117.1639	242	0.88	10.2
Escondido	Escondido Creek	9/24/1964	5/23/2008	44 years	33.0711	-117.0542	645	0.88	13.7
Fallbrook	San Luis Rey River	7/25/1951	6/30/2008	57 years	33.213	-117.1513	675	1.40	15.1
Fashion Valley	San Diego River	1/2/1968	6/30/2008	40 years	32.4555	-117.1033	20	0.96	10.3
Flinn Springs	San Diego River	8/8/1963	6/30/2008	45 years	325055	-1165129	880	1.05	13.1
Kearny Mesa	San Diego River	9/8/1964	6/30/2008	44 years	32.5003	-117.0744	425	1.40	11.0
Lake Cuyamaca	Upper San Diego River	9/1/1967	6/30/2008	41 years	32.5921	-116.3513	4590	2.30	30.4
Lake Henshaw	Upper San Luis Rey River	1/2/1950	6/30/2008	58 years	331419	-1164542	2990	1.79	22.3
Lake Wohlford	Upper Escondido Creek	10/8/1949	7/7/2008	59 years	33.0959	-117.0016	1490	1.60	16.8
Lindbergh Field	Coastal – San Diego Bay	10/17/1948	6/30/2008	60 years	32.7333	-117.1833	15	1.36	9.8
Lower Otay	Otay River	8/28/1951	6/30/2008	57 years	32.3632	-116.554	491	0.84	10.3
Oceanside	San Luis Rey River	7/1/1951	6/30/2008	57 years	33.1238	-117.2112	30	1.20	11.7
Poway	Los Penasquitos River	10/4/1962	6/30/2008	46 years	32.5658	-117.0346	440	0.80	12.0
Ramona	Upper San Dieguito River	8/8/1963	6/30/2008	45 years	33.0253	-116.5139	1450	1.16	14.2
San Onofre	North County Coastal	11/25/1970	6/30/2008	38 years	33.2105	-117.3155	162	1.60	11.3
San Vicente	San Diego River	1/1/1973	6/10/2008	35 years	32.55	-116.5558	663	1.00	12.7
Santee	San Diego River	1/1/1973	9/26/2008	36 years	32.502	-117.013	300	1.00	13.2

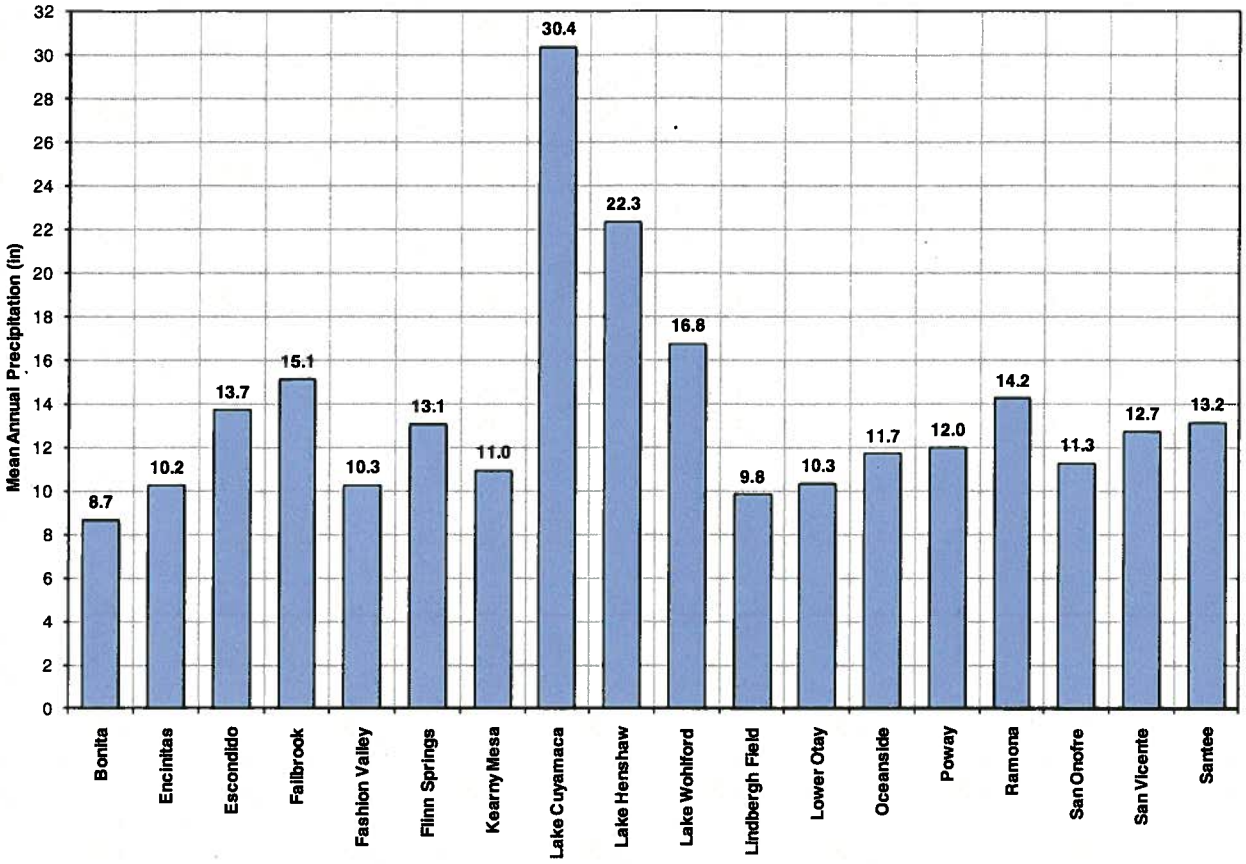

Figure 1. Rainfall Variation in San Diego County

2.1.2 San Diego Soils Map Evaluation

The HSPF model development was based on the commonly occurring and easy-to-identify soil hydrologic groupings used by the National Soils Conservation Service (NRCS). The NRCS uses four groupings called (in decreasing order of hydraulic conductivity) Group A, B, C and D. Group A soils are sandy and exceedingly well drained, while Group D soils are typically poorly drained clays. Group B and Group C soils exhibit hydraulic characteristics between those of Group A and Group D soils.

Figure 2 shows NRCS soil mapping for San Diego County. According NRCS data, about 43 percent of San Diego County is classified as NRCS Group D soils. Approximately one-quarter of the County consists of Group C soils and one-quarter Group B soils. The remaining 7 percent is classified as Group A soils. The well drained Group A and Group B soils occur more commonly in the eastern portions of the County that are not covered under this HMP. The central and western portions of the county consist mainly of the less hydraulically conductive Group C and Group D soils.

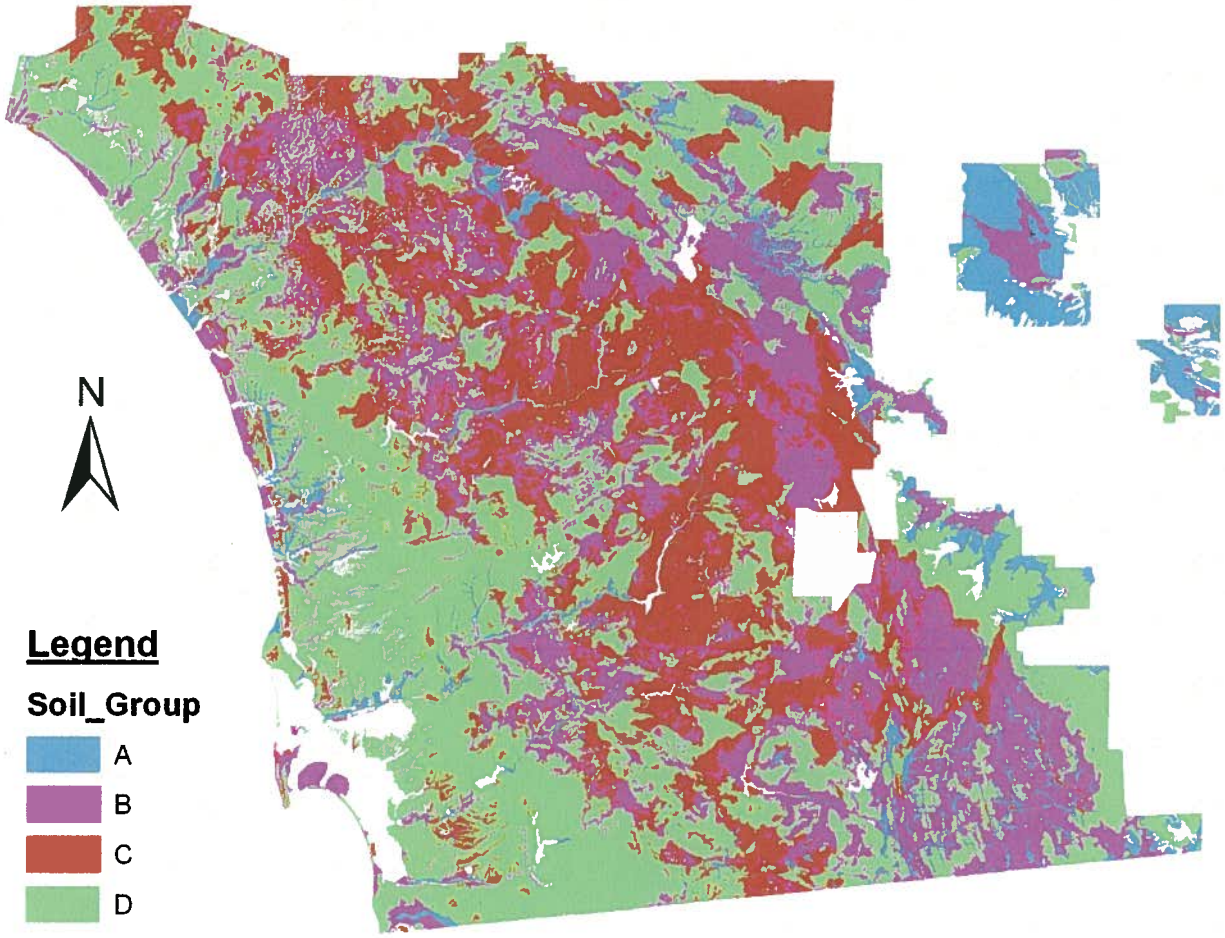

Figure 2. NRCS Soils Mapping of San Diego County

2.2 Scenarios Modeled

HSPF was used to characterize 12 different pre-project runoff scenarios corresponding to 4 soil types and 3 ranges of slopes. The range of land cover and vegetation types is not sufficiently variable among developable lands to require separate scenarios for different pre-project pervious land cover types. Table 2 below summarizes the scenario components. The specific HSPF pervious land surface parameters for these scenarios are described separately in the *San Diego HMP HSPF Model Parameter Selections* technical memo.

Table 2. HSPF Scenarios for Characterizing Pre-Project Conditions

Scenario No.	NRCS Soil Group	Land Cover	Slope
1	A	Scrub, Shrub	Low (<5%)
2	A	Scrub, Shrub	Moderate (10%)
3	A	Scrub, Shrub	Steep (>15%)
4	B	Scrub, Shrub	Low (<5%)
5	B	Scrub, Shrub	Moderate (10%)
6	B	Scrub, Shrub	Steep (>15%)

Table 2. HSPF Scenarios for Characterizing Pre-Project Conditions			
Scenario No.	**NRCS Soil Group**	**Land Cover**	**Slope**
7	C	Scrub, Shrub	Low (<5%)
8	C	Scrub, Shrub	Moderate (10%)
9	C	Scrub, Shrub	Steep (>15%)
10	D	Scrub, Shrub	Low (<5%)
11	D	Scrub, Shrub	Moderate (10%)
12	D	Scrub, Shrub	Steep (>15%)

3. Hydrologic Modeling Approach to Sizing BMPs

This section describes the technical approach used to represent BMPs in the HSPF model. The discussion focuses on the key physical aspects of BMP performance (i.e., how a BMP routes water through its different layers) and how these physical processes are represented in HSPF. This section also describes key hydraulic and modeling assumptions and how these assumptions impact both the modeling process and the accuracy of the results across the full range of flow conditions.

3.1 General BMP Characteristics

The flow control BMP designs selected by San Diego County and its Copermittees all include some combination of detention storage and water quality treatment media. For example, the bioretention BMP includes (in order of vertical routing) a surface ponding layer, a growing medium layer, and a storage layer. Each layer has its configuration, porosity, volume, and hydraulic conditions that influence the rate of flow to the next layer (see Figure 3).

HSPF uses stage-storage-discharge tables to represent the hydraulic behavior of devices that detain and discharge water (e.g., all of the LID BMPs included in the HMP). The *stage* represents depth of water in the facility, the *storage* represents the volume of water stored in the facility for that stage, and the *discharge* is the calculated outflow for that stage. Outflow may be via an orifice, infiltration, evaporation, or any other mechanism for which a relationship to stage or storage can be defined.

The following general hydraulic assumptions were applied to all of the BMPs modeled:

- Inflow is uniformly distributed over the area of the BMP (i.e. level-pool ponding).
- Infiltration and soil water movement is a 1-dimensional flux in the vertical direction (neglecting lateral flows is a conservative assumption).
- Soil moisture within a homogeneous growing medium layer is assumed to be evenly distributed throughout the growing medium layer both vertically and horizontally. This assumes an engineered BMP would be free of macropores.
- Percolation from the growing medium layer to the storage layer is computed based on unsaturated or saturated hydraulic equations, based on the amount of moisture contained in the growing medium during each model time step.
- Water flows out the bottom of the BMP into the surrounding soil at the rate of saturated hydraulic conductivity.
- The sandy loam soil used for the growing medium has an effective porosity of 0.412, based on Table 5.3.2 in the *Handbook of Hydrology* (Maidment, 1994). A sensitivity analyses conducted to determine the

effect of porosity on BMP performance determined that porosity has little influence on the required sizing factor.

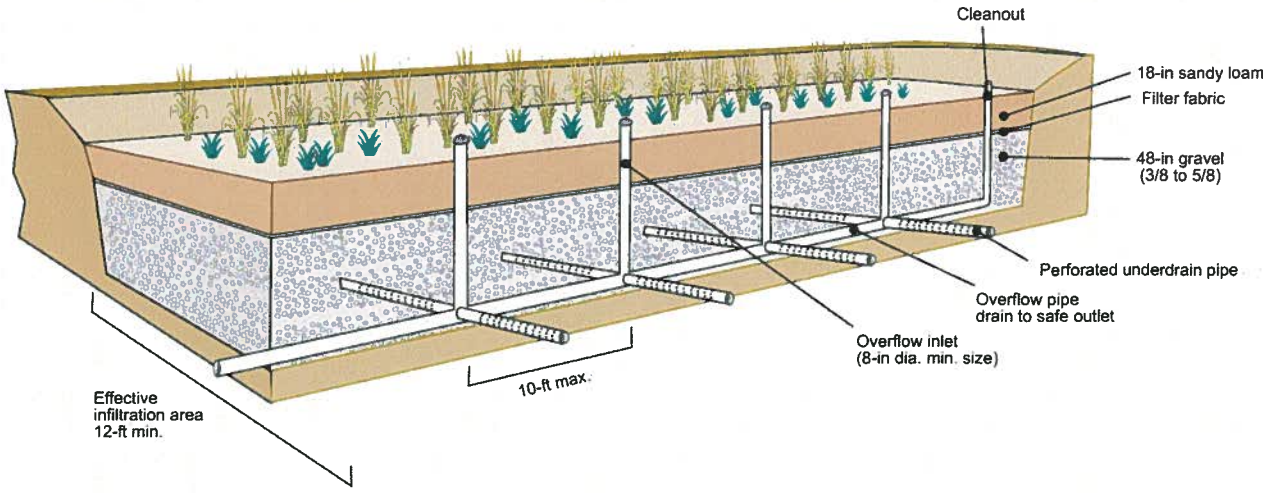

Figure 3. Cross-Section View of Bioretention BMP, Group C/D Soil Configuration

3.1.1 Bioretention BMP HSPF Representation

The bioretention BMP is modeled using two FTABLEs. The first FTABLE represents the surface ponding layer, growing medium layer, and overflow outlet. The second FTABLE represents the storage layer, exfiltration to surrounding soils, and underdrain outflow, if applicable. Percolation from the growing medium to the storage layer is modeled as an outflow from the first FTABLE and inflow to the second FTABLE.

FTABLE 1: Upper Growing medium layer, Ponding Storage and Overflow Outlet

Stormwater routed from impervious surfaces first enters the upper layer of an In-Ground Planter, represented by FTABLE 1 (Figure 4). The HSPF model assumes that all inflow will infiltrate if the layer is not saturated. This is a reasonable assumption based on the anticipated range of inflows (see Appendix A for a complete discussion of soils physics). The growing medium layer is represented by depths from 0 to 1.5 feet. The volume of storage at 1.5 ft is equal to the storage within the growing medium layer at saturation. Above this depth water is stored in the ponding reservoir.

Water contained in the upper growing medium layer is stored as soil moisture. Although there are depths indicated in the first column of the FTABLE, the soil water is considered to be evenly distributed throughout the growing medium layer (e.g. a soil depth of 0.5 feet in FTABLE 1 corresponds to one-third saturated, not water filling the bottom 0.5 feet of the upper growing medium layer). Above 1.5 ft, water ponds on the planter surface, and the FTABLE 1 depth column corresponds to the actual water surface.

The fourth column in FTABLE 1 lists the rate of soil water percolation out the bottom of the upper growing medium layer and into the lower gravel layer. This column is calculated using Darcy's Law and the van Genuchten relations (see Appendix A). Percolation does not occur unless the soil water content exceeds the holding capacity of the soil (i.e. the gravitational head is greater than the suction or *matric head* within the soil pores). The percolation rate calculations assume a free surface at the interface with the lower layer. However, the percolation rate is limited if the lower layer reaches capacity and becomes saturated. In this case the percolation rate through the upper layer is limited to the percolation rate though the lower layer,

which in itself is limited by the total outflow from the lower layer through the underdrain orifice and percolation to the surrounding soil. Thus, the percolation rate through the upper layer is limited to underdrain outflow rate plus a small amount of percolation to the surrounding soil when the planter reaches capacity.

The fifth column in the FTABLE is the outflow through the overflow pipe, which is calculated using a weir equation (see Appendix A). Outflow through the overflow pipe does not occur until the depth of storage in the ponding reservoir is above the pipe inlet.

```
 FTABLE      1
rows cols                                                  ***
  31    5
    Depth       Area     Volume     Q Perc     Q Over    ***
     (ft)     (acres)  (acre-ft)     (cfs)      (cfs)    ***
     0.00       0.03     0.0000     0.0000      0.000
     0.10       0.03     0.0012     0.0000      0.000
     0.20       0.03     0.0024     0.0000      0.000

     1.40       0.03     0.0168     0.0132      0.000
     1.50       0.03     0.0180     0.0707      0.000
     1.60       0.03     0.0210     0.0760      0.000

     2.40       0.03     0.0495     0.1957      0.100
     2.50       0.03     0.0525     0.1957      0.312
 END FTABLE1
```

Figure 4. Example FTABLE Describing Upper Layer of In-Ground Planter

FTABLE 2: Lower Gravel Layer, Percolation to Surrounding Soils, Underdrain Outlet

The second FTABLE represents the lower gravel layer and the underdrain. Percolation outflow from the first FTABLE is routed as inflow to the second FTABLE (Figure 5). This FTABLE represents the lower gravel layer, which has a depth of 1.5 ft. Water is stored as volumetric water content with a maximum storage limited to saturation of the gravel medium. The percolation rate out the bottom of the lower layer is limited by the hydraulic conductivity of the surrounding soil, which is a conservative assumption (percolation will actually be faster when native soils are unsaturated).

When an underdrain is included in the configuration, the 'Q Outlet' column is included in the FTABLE for the outflow rate. This rate is calculated using the orifice equation (see Appendix A) so that the underdrain flow will match lower flow control rate when the lower gravel layer is fully saturated.

```
 FTABLE      2
rows cols                                                        ***
  16    5
    Depth       Area     Volume     Q Perc   Q Outlet          ***
     (ft)     (acres)  (acre-ft)     (cfs)      (cfs)          ***
     0.00       0.03     0.0000     0.0000      0.000
     0.10       0.03     0.0012     0.0001      0.000
     0.20       0.03     0.0025     0.0007      0.001
     0.30       0.03     0.0037     0.0007      0.005
     0.40       0.03     0.0050     0.0007      0.018
     0.50       0.03     0.0062     0.0007      0.047
     0.60       0.03     0.0075     0.0007      0.104
     0.70       0.03     0.0087     0.0007      0.133
     0.80       0.03     0.0100     0.0007      0.142
     0.90       0.03     0.0112     0.0007      0.151
     1.00       0.03     0.0125     0.0007      0.159
     1.10       0.03     0.0137     0.0007      0.167
     1.20       0.03     0.0149     0.0007      0.174
     1.30       0.03     0.0162     0.0007      0.181
     1.40       0.03     0.0174     0.0007      0.190
     1.50       0.03     0.0187     0.0007      0.195
END FTABLE2
```

Figure 5. Example FTABLE Describing Lower Gravel Layer of In-Ground Planter

3.1.2 Iterative BMP Sizing Steps

Once the geometric characteristics of the BMP were represented in FTABLEs, as described above, the sizing factors were computed using an iterative process involving multiple HSPF simulations and statistical analyses. The process involved varying the surface area until peak flow and flow duration control were achieved.

The ability of the BMP to achieve peak flow and flow duration control was evaluated by generating and comparing partial duration series statistics and flow duration statistics for (a) the pre-project runoff from a pervious land surface and (b) the post-project outflow from the BMP serving an equivalent area that has been converted to an impervious surface. A 24-hour inter-event period (as defined by 24 hours with BMP outflow less than 0.05 cfs/ac) was used to separate storm events in the partial duration series. The footprint of the BMP was included in the calculations to preserve equivalence between the pre-project and post-project analysis (i.e. Pre-project Area = Impervious Area + BMP Area). The HSPF model allowed rainfall directly on the BMP.

BMP surface area was increased incrementally with each iteration until flow and duration control were achieved. Flow and duration control were considered to be achieved when the mitigated post-project peak flows and flow durations were less than or equal to the pre-project flows, as defined by the performance criteria in the Final HMP.

4. Low-Impact Development (LID) BMP Descriptions

This section describes the LID BMPs that are included in the Countywide Model SUSMP, focusing on the elements that are explicitly represented within HSPF. The following LID BMPs will be evaluated for flow control and/or water quality treatment:

1. Bioretention
2. Cistern with bioretention
3. Bioretention with flow control vault
4. Flow-through planter
5. Dry well
6. Vegetated bioswale (for water quality treatment only)

Non-structural strategies for stormwater management, such as pervious pavement, self-retaining areas, and self-treating areas will be described in separate memoranda.

4.1 Bioretention

The bioretention facility consists of a surface ponding layer, a growing medium layer, and a below ground storage layer (Figure 6). The bioretention BMP captures water in the ponding layer, filters it through a growing medium that consists of soil and plant roots, percolates water from the growing medium into a storage layer, and then slowly discharges treated stormwater via exfiltration to surrounding native soils and regulated discharge through an underdrain pipe to the local stormwater drainage system. For applications with well-draining native soils (e.g., NRCS hydrologic group A or B soils), an underdrain pipe would not be included.

For the HMP, we will simulate the bioretention BMP using separate a) ponding layer, b) growing medium, and c) storage layer components. We will assume the following depths for each layer:

- **Ponding layer:** 10-inches active storage, 2-inches of freeboard above overflow relief
- **Growing medium:** 18-inches of soil at 40 percent porosity
- **Storage layer:** 30-inches of gravel at 40 percent porosity

As described above in Section 3.1.2,the plan area of the BMP will be iteratively sized until the BMP controls limit outflows to levels that are less than or equal to pre-project conditions across flow rates ranging from the lower flow control limit ($0.1Q_2$, $0.3Q_2$ or $0.5Q_2$) to the upper flow control limit (Q_{10}). The sizes of the ponding layer and storage layer will be converted into volumes, so that the project designer can flexibly configure the ponding layer and storage layer to meet site constraints. For example, the design engineer could configure the ponding layer with half the depth but twice the plan area called for by the sizing factor if this fits the project site. Additionally, the designer could use commercially-available storage vessels to meet the volume requirements instead of using gravel.

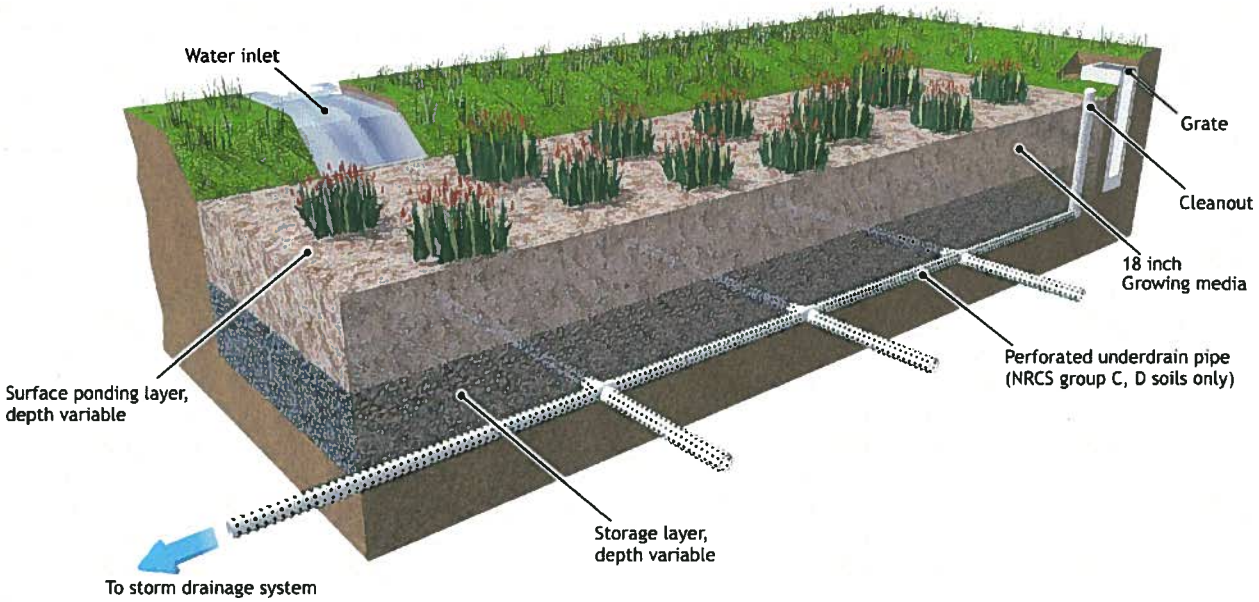

Figure 6. Bioretention BMP Example Illustration

4.2 Cistern with Bioretention

The cistern with bioretention BMP is a flow-control and treatment train BMP. There is no water quality treatment-only option. The cistern component captures and detains site runoff, and then slowly releases the water to a nearby bioretention device that provides water quality treatment by filtering the stormwater through its soil matrix.

The cistern will contain two outlets. A lower orifice will be located at the bottom of the cistern and will be designed to release water at the lower flow control limit ($0.1Q_2$, $0.3Q_2$ or $0.5Q_2$) where it will be routed through the bioretention device. Because the cistern accomplishes the flow control requirement, the bioretention only provides water quality treatment and an underdrain is permissible for all soil groups. However, due to the high infiltration capacity of NRCS hydrologic group A soils, the underdrain should only be used in Group B, C, and D soils. For Group A soils, the bioretention element is not necessary and cistern discharges should be routed into native soils for infiltration and treatment. A small depression should be included in the landscaping to provide sufficient time for infiltration to occur.

For the HMP, we will simulate the performance of the cistern with bioretention BMP using the following key assumptions:

- **Cistern configuration:** The cistern is modeled as a 4-foot tall vessel. However, designers could use other configurations, so long as the lower outlet orifice is sized to properly restrict outflows.
- **Cistern upper outlet:** The upper outlet from the cistern would consist of a weir or other flow control structure set at an elevation of 7/8th of the way to the top of the cistern (see Figure 7). The overflow weir would be sized to pass approximately 1 cfs per acre of tributary impervious area.
- **Bioretention configuration:** The bioretention needs only a small depression/ponding area to settle inflows prior to infiltration. For water quality treatment, the bioretention should be 1.5 feet deep and

contain the soil mixture specified in the *Countywide Model SUSMP* that allows a continuous infiltration rate of 5 inches per hour. The bioretention basin should be sized to pass the cistern outlet flows.

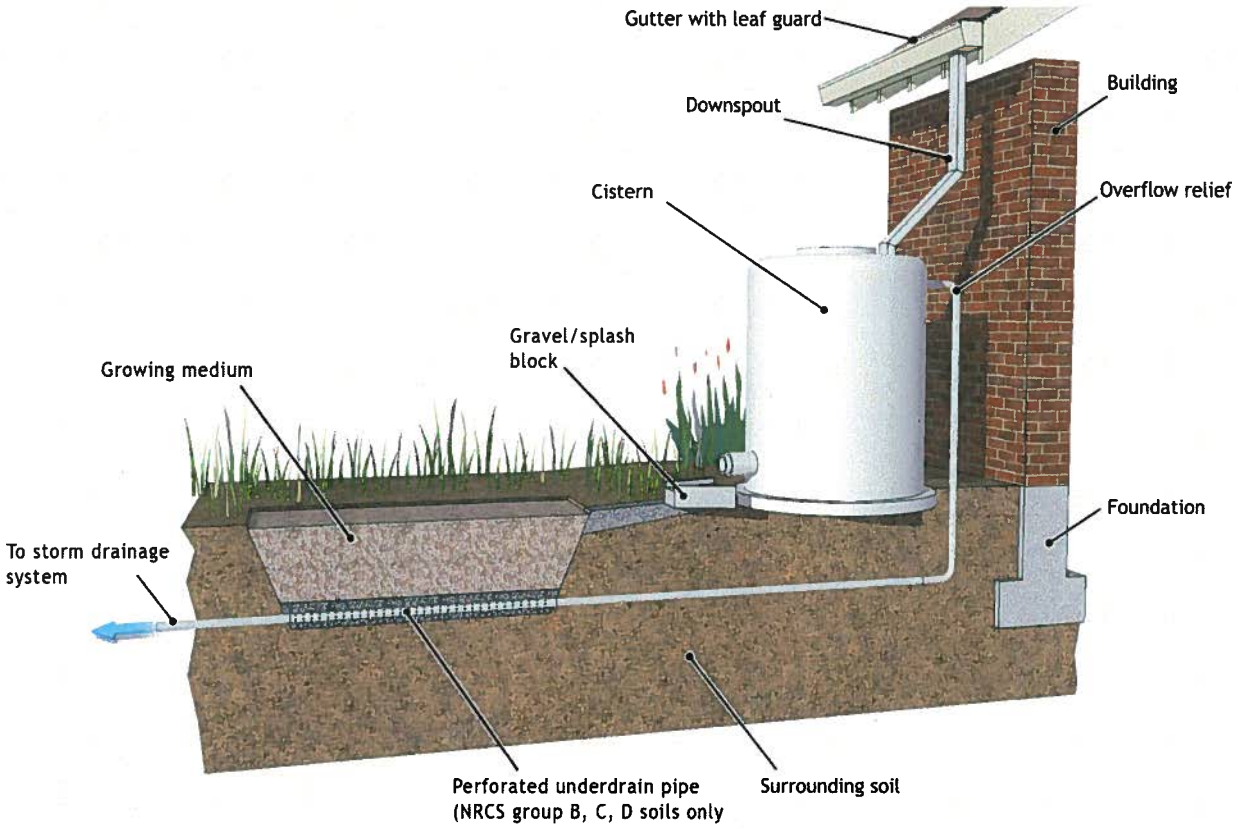

Figure 7. Cistern with Bioretention BMP Example Illustration

4.3 Bioretention with Vault

This BMP configuration would route stormwater through a bioretention basin for water quality treatment, and then discharge water to a nearby vault for detention and release (Figure 8). The vault would contain a lower orifice to restrict outflows to meet the HMP's flow control requirements. The vault portion of the BMP could be located below, adjacent or farther away from the bioretention portion of the BMP. This BMP is particularly effective in commercial applications where distributed water quality treatment outflows could be collected into a single vault for flow control underneath a parking lot. There is not water quality treatment-only option.

For the HMP, we will simulate the performance of the bioretention with vault BMP using the following key assumptions:

- **Bioretention configuration:** The bioretention portion of this BMP would be designed similarly to the bioretention BMP, except that the storage layer would be only deep enough to contain a perforated underdrain pipe that would convey treated runoff to the vault portion of the BMP.
- **Vault configuration:** The vault would contain concrete side wall and top, as well as an access hatch for inspection and maintenance. The bottom of the vault would be open to allow infiltration to the

surrounding soils. The vault was simulated as a 4-foot deep chamber, but the designer could select other configurations that were similar or lesser depths.

- **Vault outlets:** The vault would contain two outlets. The lower outlet would be a flow control orifice that would release water at a maximum rate equal to the lower flow control limit ($0.1Q_2$, $0.3Q_2$, $0.5Q_2$). The upper outlet from the vault would be located at 80 percent of the vault's height and would have a capacity of approximately 1 cfs per acre of tributary impervious area. The overflow relief should be located no lower than the elevation of the vault's inlet pipe.

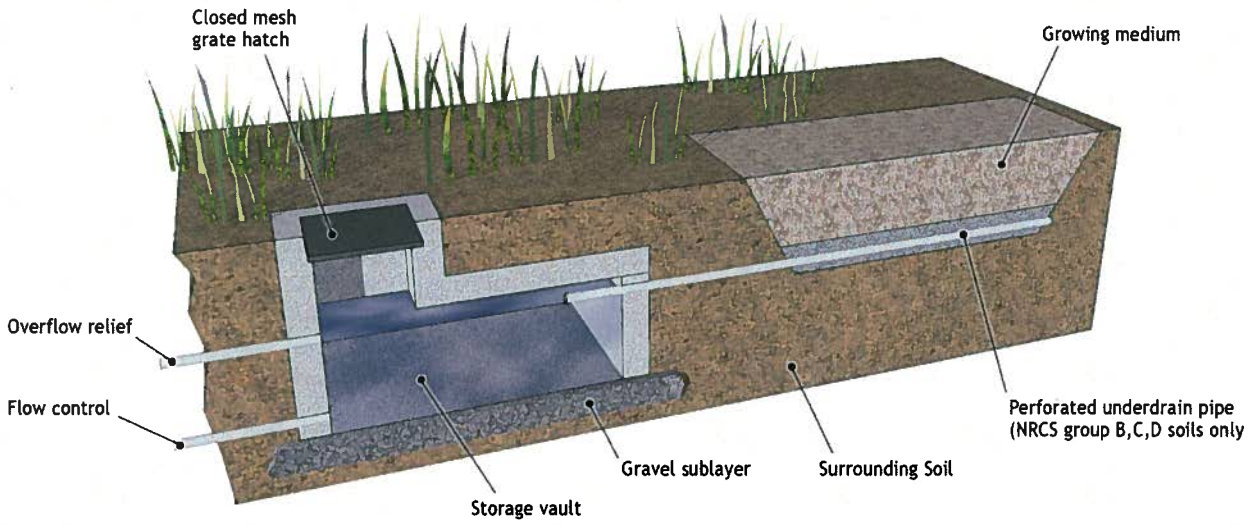

Figure 8. Bioretention with Vault BMP Example Illustration

4.4 Flow Through Planter

Flow-through planters treat and detain runoff without allowing seepage into the underlying soil. Typical applications would be next to buildings or on steep slopes, where the infiltration associated with bioretention facilities could cause problems. Flow-through planters typically receive runoff via downspouts leading from the roofs of adjacent buildings. However, they can also be set in-ground and receive sheet flow from adjacent paved areas.

Pollutants are removed as runoff passes through the growing medium layer and is collected in an underlying storage layer (Figure 9). A perforated-pipe underdrain is typically connected to a storm drain or other discharge point. An overflow inlet conveys flows which exceed the capacity of the planter. The flow through planter BMP should only be used in Group C or D soil applications.

For the HMP, we will simulate the flow through planter BMP using separate a) ponding layers, b) growing medium, and c) storage layer components. We will assume the following depths for each layer:

- **Ponding layer:** 10-inches active storage, 2-inches of freeboard above overflow relief
- **Growing medium:** 18-inches of soil at 40 percent porosity
- **Storage layer:** 30-inches of gravel at 40 percent porosity

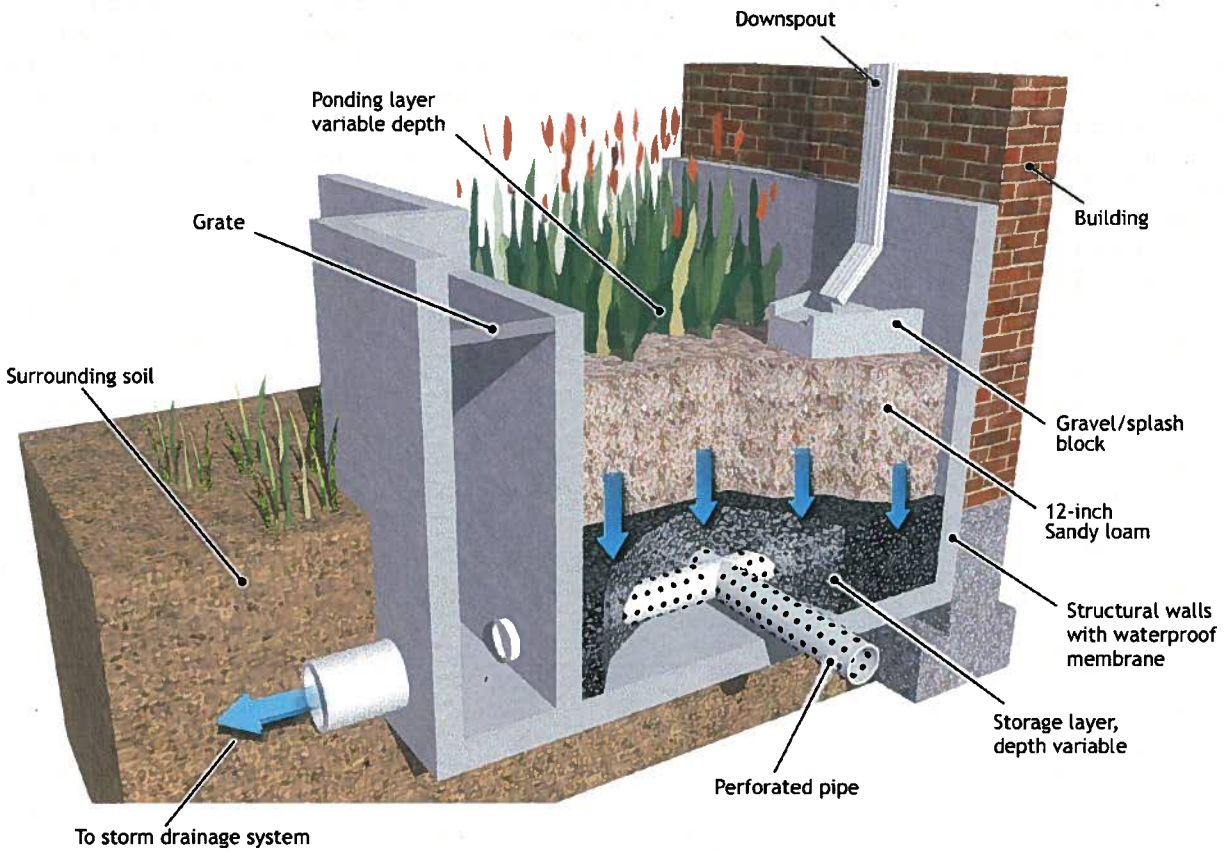

Figure 9. Flow Through BMP Example Illustration

4.5 Drywell

The drywell BMP is a below ground structure that can be used in areas with well-drained soils, such as NRCS Group A or B soils. The drywell consists of an initial soil layer to trap pollutants underlain with gravel, drain rock or some other free draining material (Figure 10). The dry well should have an access hatch to limit access.

For the HMP, we will simulate the drywell BMP using the following key assumptions:

- **Ponding layer:** a nominal 6-inch ponding layer should be included below the access hatch to allow for water spreading and infiltration during intense storms.
- **Soil layer:** 12 inches of soil should be included to remove pollutants
- **Free draining layer:** The drywell is sized assuming a 6-foot deep free draining layer. However, designers could use shallower drywells.

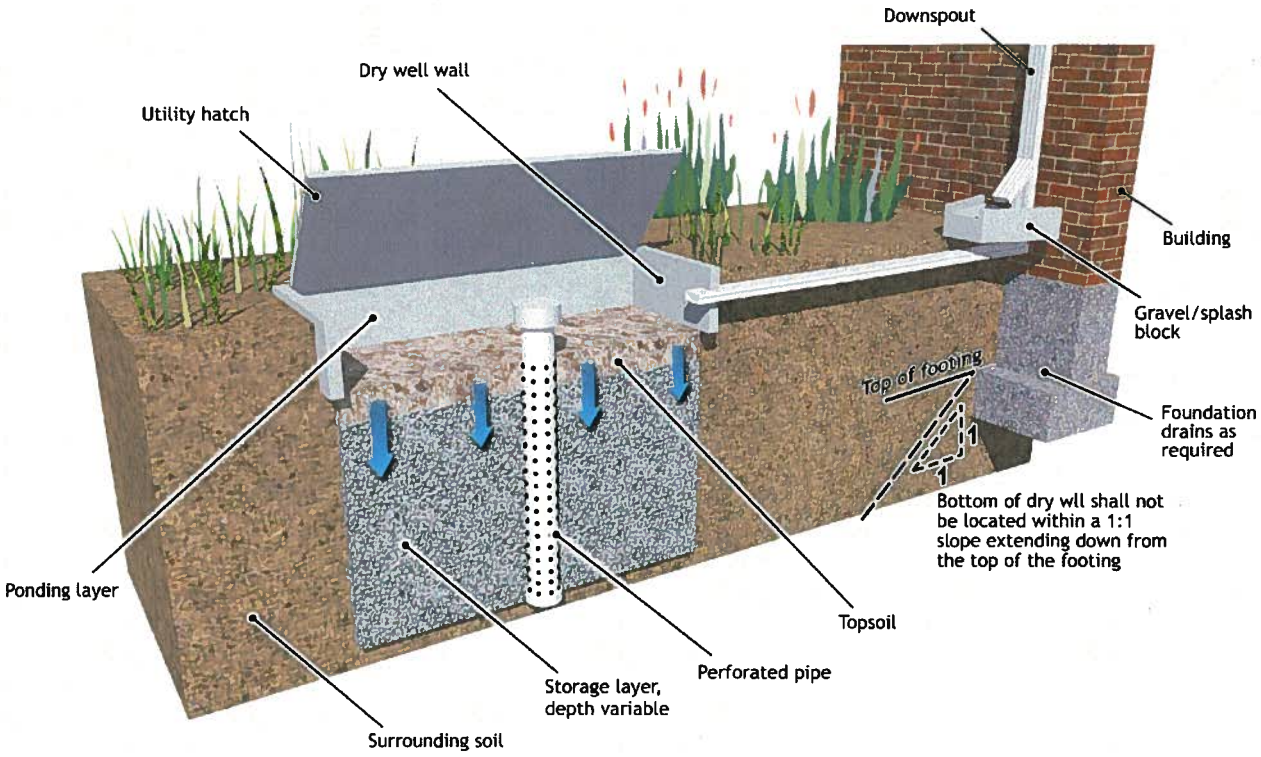

Figure 10. Dry Well BMP Example Illustration

4.6 Vegetated Bioswale

The vegetated bioswale BMP could be used to provide water quality treatment but not to provide stormwater flow control (Figure 11). The conventional swale design uses available on-site soils and does not include an underdrain system. Where soils are clayey, there is little infiltration. Treatment occurs as runoff flows through grass or other vegetation before exiting at the downstream end.

For the simulations, the vegetated bioswale will be sized to meet the minimum detention time specified in the Model SUSMP. If the bioswale is designed to pass stormwater through at a steady rate, its length will be computed based on flow velocities (i.e., slope and dimensions). If the vegetated bioswale is designed with a check dam structure to hold water, its size will be computed based on the volume provided by the swale.

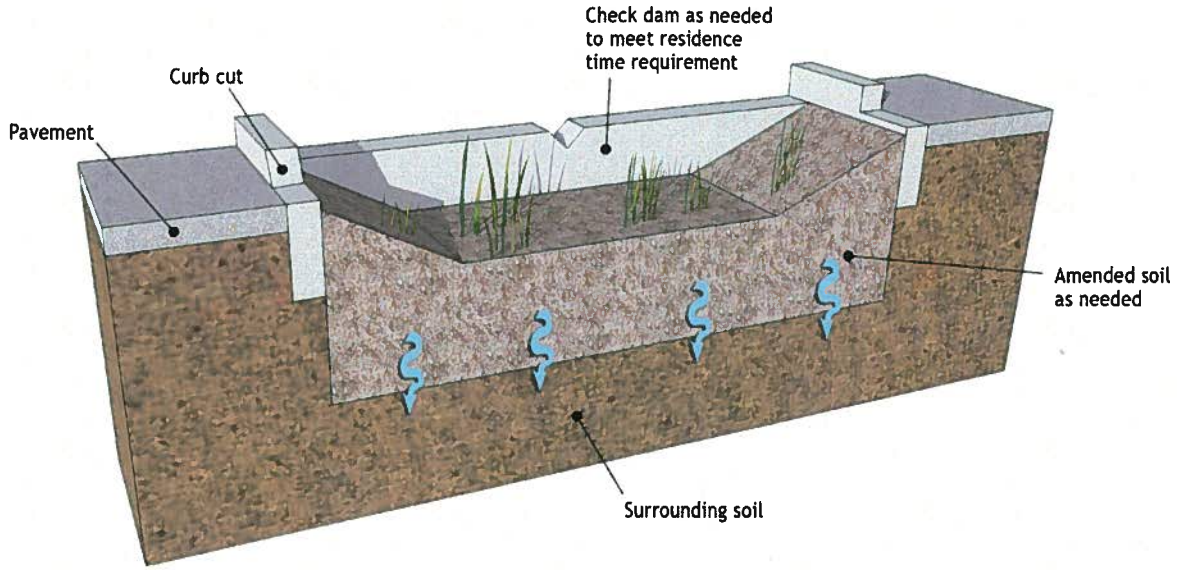

Figure 11. Vegetated Bioswale BMP Example Illustration

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Draft Technical Memorandum

Project Title: San Diego County Hydromodification Management Plan

Project No: 133904

San Diego County Hydromodification Management Plan (HMP)

Subject: Selection of PERLND Parameters for HSPF Modeling

Date: April 23, 2010

To: Sara Agahi, San Diego County

From: Tony Dubin, Brown and Caldwell
Eric Mosolgo, Brown and Caldwell

This memorandum presents the HSPF PERLND parameters recommended for the San Diego HMP's Best Management Practice (BMP) sizing analysis. These parameter values will be used in HSPF to simulate runoff rates and other hydrologic processes across a range of pervious surface conditions. The resulting long-term runoff time series (and key statistical series computed from these time series) will form the pre-project condition baseline that new and redevelopment projects must match by mitigating site runoff rates and durations through the use of BMPs.

This memo is organized as follows:

Section 1 defines a PERLND and describes how HSPF simulates water movement on and through pervious surfaces.

Section 2 describes the published studies using HSPF that were reviewed for this project.

Section 3 summarizes the available PERLND parameter sets that were reviewed.

Section 4 describes how Brown and Caldwell (BC) tested various parameter values to identify sensitive parameters and examined how the selection of specific parameter values would affect the runoff time series.

Section 5 presents conclusions and recommendations.

1. PERLND Description and Schematic

The PERLND block within the HSPF input file contains parameters that affect the vertical and lateral movement of water moisture through a pervious land segment. Figure 1 is a schematic view of the PERLND water budget terms and key HSPF parameters. The schematic illustrates the movement of water among interception storage, upper zone storage, lower zone storage, groundwater storage, and deep/inactive groundwater storage. The schematic also illustrates flux terms, such as overland flow and interflow.

The algorithms that control the movement among these storage layers are described thoroughly in the HSPF User's Manual, which is available from the US EPA as part of the BASINS documentation (http://www.epa.gov/waterscience/basins/bsnsdocs.html). The parameters listed in Figure 1 are described in greater detail in Section 1.1.

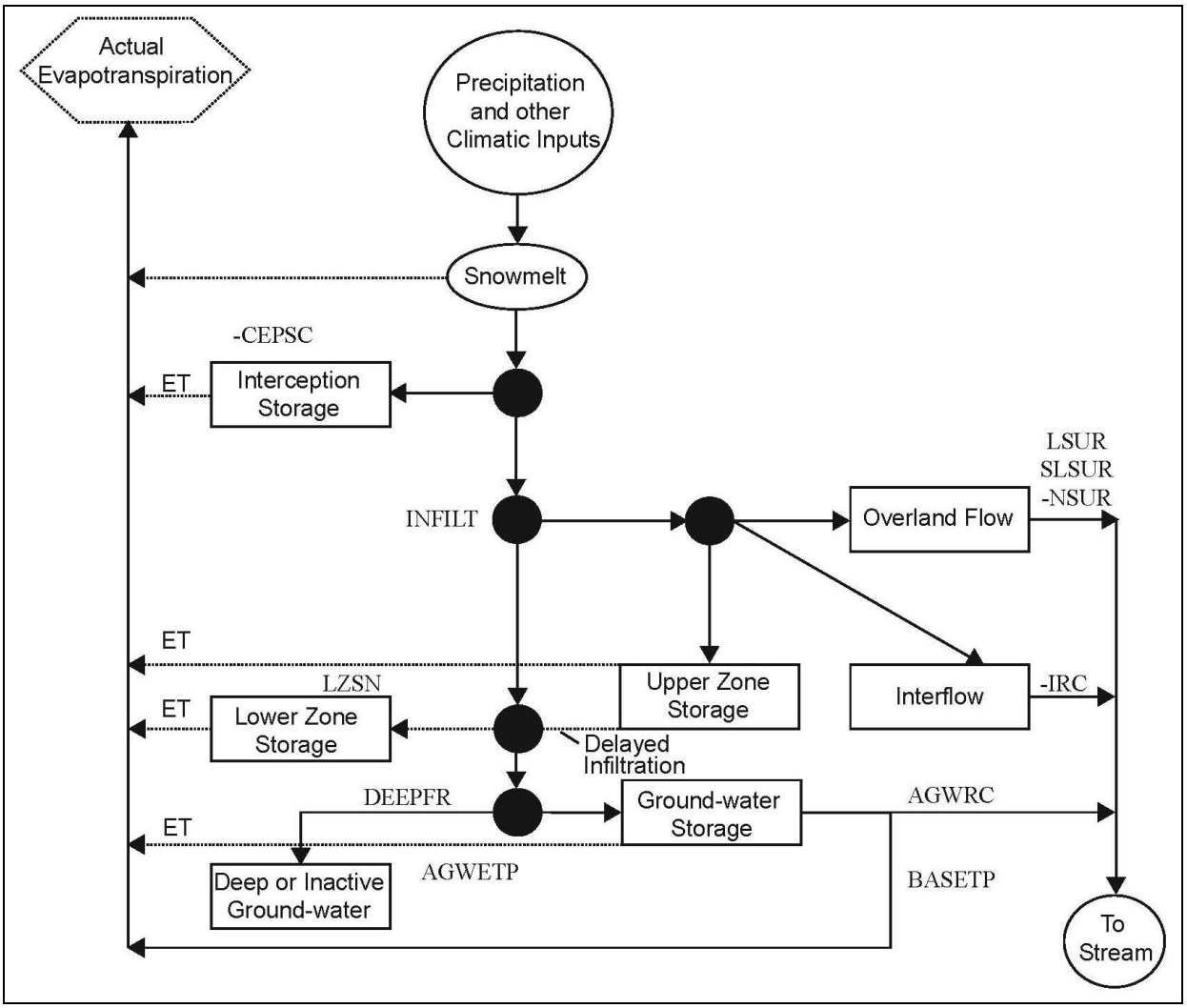

FIGURE 1

HSPF PERLND Water Moisture Schematic (Adapted from HSPF User's Manual)

1.1 PERLND Characteristics

The PERLND parameters shown in Figure 1 are located in the PWATER section of the PERLND block. PWATER, in turn, is divided into four sections, titled PWAT-PARM1, PWAT-PARM2, PWAT-PARM3, and PWAT-PARM4.

- PWAT-PARM1 is a series of flags that specify how various algorithms are to be used to compute hydrologic functions.
- PWAT-PARM2, PWAT-PARM3 and PWAT-PARM4 contain a series of climate, geology,

topography, and vegetation parameters and initial conditions.

Table 1 contains brief descriptions of the HSPF parameters used to characterize pervious land surfaces, along with commonly used ranges of values for these parameters. The parameters that often affect stormwater runoff most (INFILT, LZSN, LZETP) are highlighted in the table below. These highlighted parameters were the focus of our investigation of the range and variation among local HSPF studies and our testing of prospective parameters. The descriptions and parameter ranges in the table were adapted from *EPA BASINS Technical Note 6 – Estimating Hydrologic and Hydraulic Parameters for HSPF (Technical Note 6)*, which is available from the EPA web site, http://www.epa.gov/waterscience/basins/bsnsdocs.html.

TABLE 1
List of PERLND PWATER Parameters, Definitions and Common Range of Values[A]

PWAT-PARM1 – Flags			
Parameter	*Units*	*Description*	*Range of Values*
CSNOFG	None	Flag to use snow simulation data; must be set to if the SNOW simulation algorithms are to be used.	0 or 1
RTOPFG	None	Flag to select overland flow routing method. Set TOPFG=1; This method has been subjected to more widespread application.	1
UZFG	None	Flag to select upper zone inflow computation method Set UZFG=1; This method has been subjected to more widespread application.	1
VCSFG	None	Flag to select constant or monthly-variable interception storage capacity, CEPSC. Monthly value can be varied to represent seasonal changes in foliage cover	0 or 1
VUZFG	None	Flag to select constant or monthly-variable upper zone nominal soil moisture storage, UZSN.	0 or 1
VMNFG	None	Flag to select constant or monthly-variable Manning=s n for overland flow plane, NSUR. .	0 or 1
VIFWFG	None	Flag to select constant or monthly-variable interflow inflow parameter, INTFW. Monthly values are not often used.	0 or 1
VIRCFG	None	Flag to select constant or monthly varied interflow recession parameter, IRC. Monthly values are not often used.	0 or 1
VLEFG	None	Flag to select constant or monthly varied lower zone evapotranspiration (ET) parameter, LZETP.	0 or 1
PWAT-PARM2			
Parameter	*Units*	*Description*	*Range of Values*
FOREST	None	Fraction of land covered by forest that will continue to transpire in winter (i.e. coniferous). This is only relevant if snow is being considered (i.e., CSNOFG=1 in PWATER-PARM1).	0 to 0.95
LZSN	**Inches**	**Lower zone nominal soil moisture storage. This parameter affects the proportion of water going to surface runoff, interflow and active groundwater**	**2 to 15**
INFILT	**in/hr**	**INFILT is the parameter that controls the overall division of the available moisture from precipitation (after interception) into surface runoff. This is NOT equivalent to a field-measured infiltration rate.**	**0.001 to 0.50**
LSUR	Feet	Length of assumed overland flow plane. LSUR approximates the average length of travel for water to reach any drainage path such as streams, swales, ditches, etc.	Estimate from mapping or GIS
SLSUR	ft/ft	Average slope of assumed overland flow path. Average SLSUR values for each land use being simulated can often be estimated directly with GIS capabilities.	Estimate from mapping or GIS
KVARY	1/inches	Groundwater recession flow parameter used to describe non-linear groundwater recession rate	0.0 to 5.0
AGWRC	None	Groundwater recession rate, or ratio of current groundwater discharge to that from 24 hours earlier	0.85 to 0.999
PWAT-PARM3			
Parameter	*Units*	*Description*	*Range of Values*

TABLE 1 List of PERLND PWATER Parameters, Definitions and Common Range of Values[A]			
PETMAX	Deg F	Temperature below which ET will be reduced to 50% of that in the input time series	32 to 48
PETMIN	Deg F	Temperature at and below which ET will be zero. PETMIN represents the temperature threshold where plant transpiration is effectively suspended	30 to 40
INFEXP	None	Exponent that determines how much a deviation from nominal lower zone storage affects the infiltration rate. This parameter is commonly set to a value of 2.	1 to 3
INFILD	None	Ratio of maximum and mean soil infiltration capacities. This parameter is commonly set to a value of 2.	1 to 3
DEEPFR	None	The fraction of infiltrating water that is lost to deep/inactive aquifers with the remaining fraction assigned to active groundwater storage that contributes base flow to the stream.	0.0 to 0.5
BASETP	None	ET by riparian vegetation as active groundwater enters streambed; specified as a fraction of potential ET, which is fulfilled only as outflow exists.	0.0 to 0.2
AGEWTP	None	Fraction of PERLND that is subject to direct evaporation from groundwater storage, e.g. wetlands or marsh areas.	0.0 to 0.2
PWAT-PARM4			
Parameter	*Units*	*Description*	*Range of Values*
CEPSC	inches	Amount of rainfall, in inches, which is retained by vegetation, never reaches the land surface, and is eventually evaporated.	0.01 to 0.40
UZSN	inches	Nominal upper zone soil moisture storage. UZSN is related to land surface characteristics, topography, and LZSN.	0.05 to 2.0
NSUR	None	Manning's friction coefficient, n, for overland flow plane.	0.02 to 0.50
INTFW	None	Coefficient that determines the amount of water that enters the ground from surface detention storage and becomes interflow	1.0 to 10.0
IRC	None	Interflow recession coefficient IRC is the ratio of the current daily interflow discharge to the interflow discharge on the previous day.	0.3 to 0.85
LZETP	**None**	**Index to lower zone evapotranspiration LZETP affects ET from the lower zone, which represents the primary soil moisture storage and root zone of the soil profile.**	**0.1 to 0.9**

A. The parameter descriptions and ranges were obtained from the EPA BASINS Technical Note 6.

2. Available Studies and HSPF Parameter Sources

Brown and Caldwell collected and examined published Southern California studies that used HSPF to perform hydrologic modeling. We previously summarized this effort in the technical memorandum entitled *Summary of HSPF Modeling Reports in Southern California*, dated May 2009. Whenever possible, we also collected the HSPF input files that were used in these studies. We examined studies of the following models and study areas:

- **Santa Monica Bay Watershed** - The Southern California Coastal Water Research Project (SCCWRP) and Tetra Tech created HSPF models to simulate hydrologic processes and pollutant loadings to Santa Monica Bay. The specific parameter values were selected by calibrating an HSPF model to flow monitoring data in the Santa Monica Bay watershed, specifically on Malibu Creek. The values represent a composite of the various upstream soils and land uses.

- **Calleguas Creek** - This project was a pilot study to evaluate the use of HSPF as a management tool for comprehensive watershed assessment within the climatic, physiographic, and topographic conditions of Ventura County. The Calleguas Creek model, developed by Aqua Terra Consultants, simulates watershed hydrology using a combination of six different land use categories, topographic data and soils data.

- **San Diego Hydrology Model (SDHM)** - The San Diego Hydrology Model (SDHM) uses a graphical user interface and pre-selected HSPF parameters to simulate stormwater runoff from development sites and size stormwater control facilities to mitigate the impacts of land use changes. SDHM includes HSPF parameters for common soil and land use combinations. The SDHM user's manual is available in the download section of Clear Creek Solutions' web site, http://www.clearcreeksolutions.com/SearchResults.asp?Cat=17.

We also examined other HSPF input sources for relevant information:

- **EPA BASINS Technical Note 6** - The EPA publication (July 2000) is a very useful guide that describes key HSPF parameters and suggests initial values. This technical note provides BASINS users with guidance in how to estimate the input parameters in the ATEMP, SNOW, PWATER, IWATER, HYDR, and ADCALC portions of the HSPF model.

- **Western Washington Hydrology Model (WWHM)** was developed by Clear Creek Solutions for the Washington Department of Ecology to size stormwater control facilities in western Washington. The model runs HSPF to generate over 40 years of hourly runoff data. The interface and range of input types are generally similar to the SDHM.

- **Calabazas Creek** - In 1997, Aqua Terra Consultants used HSPF to study multipurpose design of detention facilities in Calabazas Creek watershed for the Santa Clara Valley Water District.

3. Range of Available Southern California HSPF Parameters

Brown and Caldwell has compiled and assessed the similarities and variations among the PERLND parameters used for the Santa Monica Bay, Calleguas Creek and SDHM work efforts. For reference, BC also compiled the parameters contained in EPA BASINS Technical Note 6, WWHM version 3, and the Contra Costa HMP. Table 2 lists the minimum, maximum and average values of the PERLND PWATER parameters for each study.

It is difficult to make a direct comparison among the parameters used in previous studies, because these modeling efforts examined entire watersheds with varying levels of development, reservoirs and regulation, and water demands and usages. However, focusing on the general range of specific parameter can be informative. For example, the Santa Monica Bay and Calleguas Creek model files use generally similar values for the key parameters, such as INFILT and LZSN (lower zone storage nominal), while the Santa Monica study used a substantially higher value of LZETP (lower zone evapotranspiration potential). The SDHM, which specifies parameters for ranges of soils, land uses and slopes, has INFILT, LZSN and LZETP parameters that are in the same range as the Santa Monica Bay and Calleguas Creek models.

TABLE 2

Compilation of PERLND Parameters

		Southern California HSPF Research							General HSPF Research											Contra Costa HSPF Research						
		Santa Monica Bay	Calleguas			SDHM			Tech Note 6				WWHM v.3 (moderate slopes)						Calabazas Creek				Contra Costa HMP		
		Value	Min	Max	Avg	Min	Max	Avg	Typical		Full Range		NRCS Group C			NRCS Group A/B			Developed		Open Space		Min	Max	Avg
									Min	Max	Min	Max	Forest	Grass	Pasture	Forest	Grass	Pasture	Min	Max	Min	Max			
PWAT_PARM2	**Units**																									
FOREST	none	0	0	0	0	N/A	N/A	N/A	0	0.5	0	0.95	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0	0	0
LZSN	inches	9.8	3	12.5	8.7	3.5	5.2	4.5	3	8	2	15	5	5	5	4.5	4.5	4.5	7	7	7	7	7	7	7
INFILT	in/hr	0.04	0.02	0.2	0.11	0.02	0.10	0.05	0.01	0.25	0.001	0.5	2	1.5	0.8	0.08	0.06	0.03	0.03	0.03	0.03	0.03	0.3	0.03	0.1595
LSUR	feet	201	150	400	319	200.0	400.0	312.5	200	500	100	700	400	400	400	400	400	400	200	250	150	200	660	660	660
SLSUR	ft/ft	0.03	0.00	0.30	0.11	0.1	0.3	0.1	0.01	0.15	0.001	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.0065	0.0533	0.068	0.28	0.1	0.1	0.1
KVARY	1/inches	3.0	0.5	1	0.61	0.8	3.0	1.5	0	3	0	5	0.3	0.3	0.3	0.5	0.5	0.5	0	0	0	0	0	0	0
AGWRC	none	0.92	0.80	1.00	0.91	1.0	1.0	1.0	0.92	0.99	0.85	0.999	0.996	0.996	0.996	0.996	0.996	0.996	0.8	0.95	0.8	0.95	0.95	0.95	0.95
PWAT_PARM3																										
PETMAX (F)	F	35	40	40	40	NA	NA	NA	35	45	32	48	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	40	40	40
PETMIN (F)	F	30	35	35	35.0	NA	NA	NA	30	35	30	40	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	35	35	35
INFEXP	none	2	2	2	2	2.0	3.0	2.3	2	2	1	3	2	2	2	2	2	2	2	2	2	2	2	2	2
INFILD	none	2	2	2	2	2.0	2.0	2.0	2	2	1	3	2	2	2	2	2	2	2	2	2	2	2	2	2
DEEPFR	none	0.4	0	0.8	0.67	0.0	0.0	0.0	0	0.2	0	0.5	0	0	0	0	0	0	0.1	0.45	0.1	0.45	0.45	0.1	0.275
BASETP	none	0.05	0	0.26	0.05	0.0	0.0	0.0	0	0.05	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0
AGWETP	none	0.05	0	0	0	0.0	0.0	0.0	0	0.05	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0
PWAT_PARM4																										
CEPSC	inches	0.10	0.06	0.12	0.08	0.10	0.19	0.13	0.03	0.20	0.01	0.40	0.2	0.15	0.1	0.2	0.15	0.1	0.0	0.0	0.0	0.0	0.1	0.02	0.07
UZSN	inches	1.18	0.50	0.80	0.59	0.20	0.50	0.31	0.1	1	0.05	2	0.5	0.5	0.5	0.43	0.35	0.22	0.4	0.4	0.6	0.6	0.5	0.5	0.5
NSUR	none	0.20	0.15	0.25	0.18	0.20	0.35	0.27	0.15	0.35	0.02	0.5	0.35	0.3	0.25	0.35	0.3	0.25	0.1	0.2	0.4	0.4	0.3	0.3	0.3
INTFW	none	1.50	1.00	1.80	1.35	0.35	1.00	0.81	1	3	1	10	0	0	0	6	6	6	0.4	0.4	0.5	0.5	0.4	0.4	0.4
IRC	none	0.70	0.20	0.60	0.35	0.30	0.80	0.46	0.50	0.70	0.30	0.85	0.70	0.70	0.70	0.43	0.43	0.43	0.30	0.30	0.40	0.40	0.30	0.30	0.30
LZETP	none	0.70	0.40	0.50	0.43	0.20	0.69	0.51	0.20	0.70	0.10	0.90	0.70	0.40	0.25	0.70	0.40	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4. Evaluating HSPF Parameter Values

To determine the mix of pre-project conditions to include in the BMP Sizing Calculator, Brown and Caldwell examined the extent of variation among the PERLND parameters among the Santa Monica Bay, Calleguas Creek, and SDHM models.

Figures 2, 3 and 4 show the variation in the INFILT parameter used in the SDHM as function of slope and land cover. The INFILT parameter values clearly vary with slope. However, the INFILT parameter value is the same for the most common pre-project land cover types for new developments in San Diego County – shrub, grass, and dirt. The INFILT parameter value is higher for forest and lower for urban (i.e., compacted soils and irrigated landscapes), but these do not represent pre-project conditions that will be commonly managed by the BMP Sizing Calculator.

- Since the INFILT parameters are identical across the three most common pre-project land cover types, the modeling effort will focus on a single composite land cover type.
- The INFILT values vary significantly for different slopes. As such, parameter sets will be prepared for low, moderate, and steep slope classifications (5, 10 and 15 percent, respectively). In many cases, LID BMPs will not be feasible in areas with slopes that are steeper than this range. Further, because the pre-sizing analysis would potentially under-estimate pre-project runoff rates from very steep sites, any LID facilities designed in such areas using the BMP Sizing Calculator would be conservatively sized.
- An urban parameter set is not needed for the BMP Sizing Calculator. The *Countywide Model SUSMP* encourages developers to manage runoff from landscaped surfaces using grading and soil amendments that emphasize infiltration to reduce site runoff from landscaped areas without implementing LID BMPs. An urban parameter set can be developed for the automated pond sizing tool, because ponds are expected to capture flows from a combination of impervious and urban landscaped surfaces.

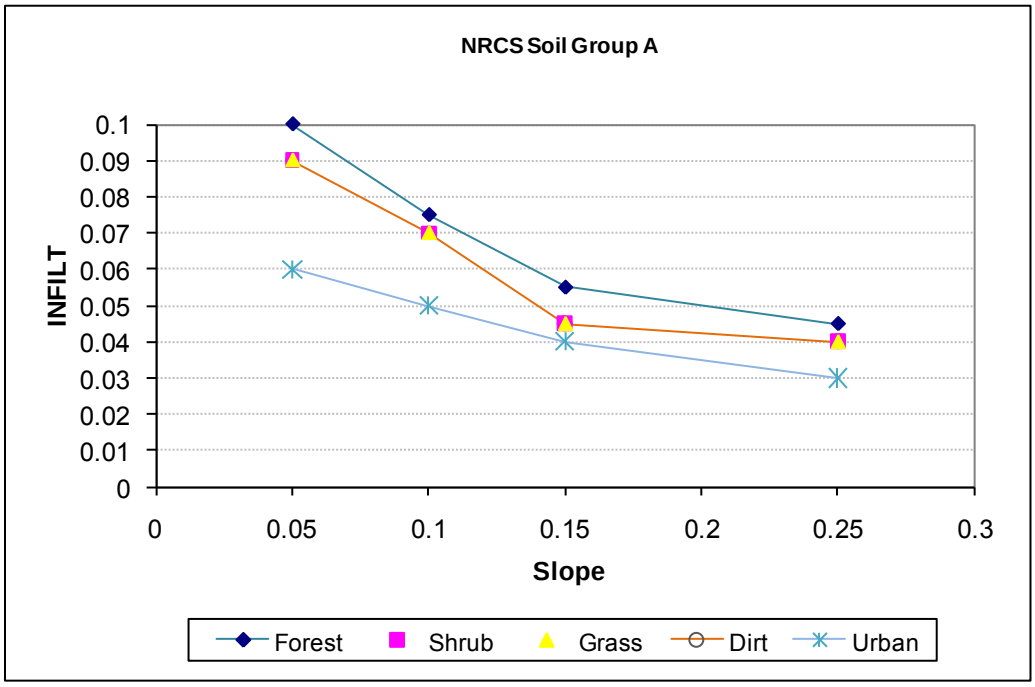

FIGURE 2
SDHM Variation in INFILT Parameter, NRCS Group A Soils

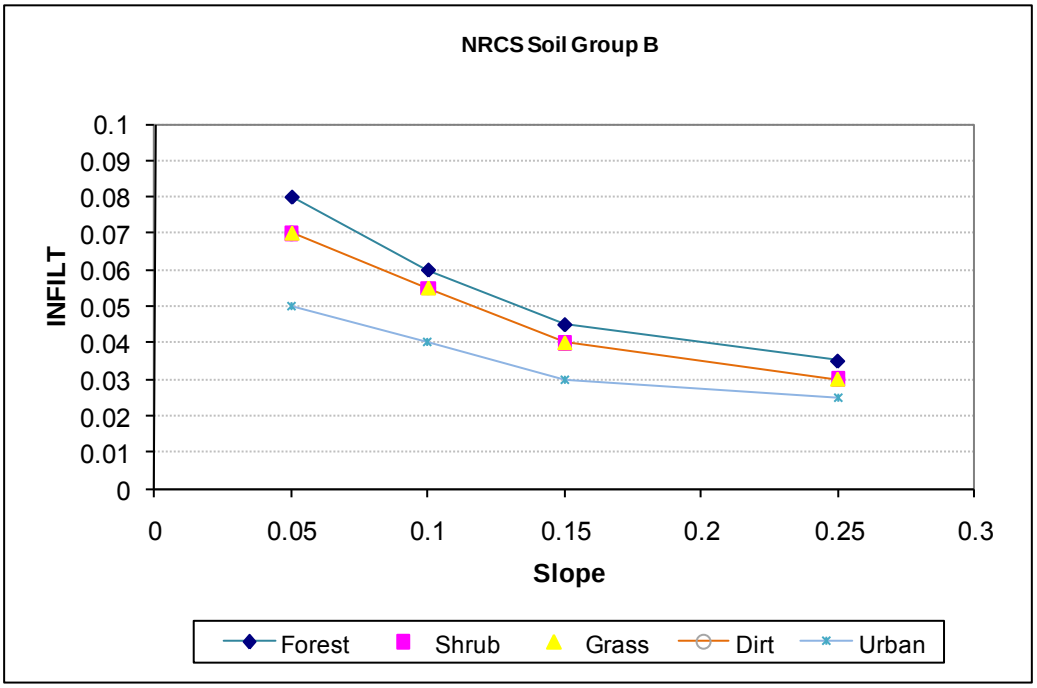

FIGURE 3

SDHM Variation in INFILT Parameter, NRCS Group B Soils

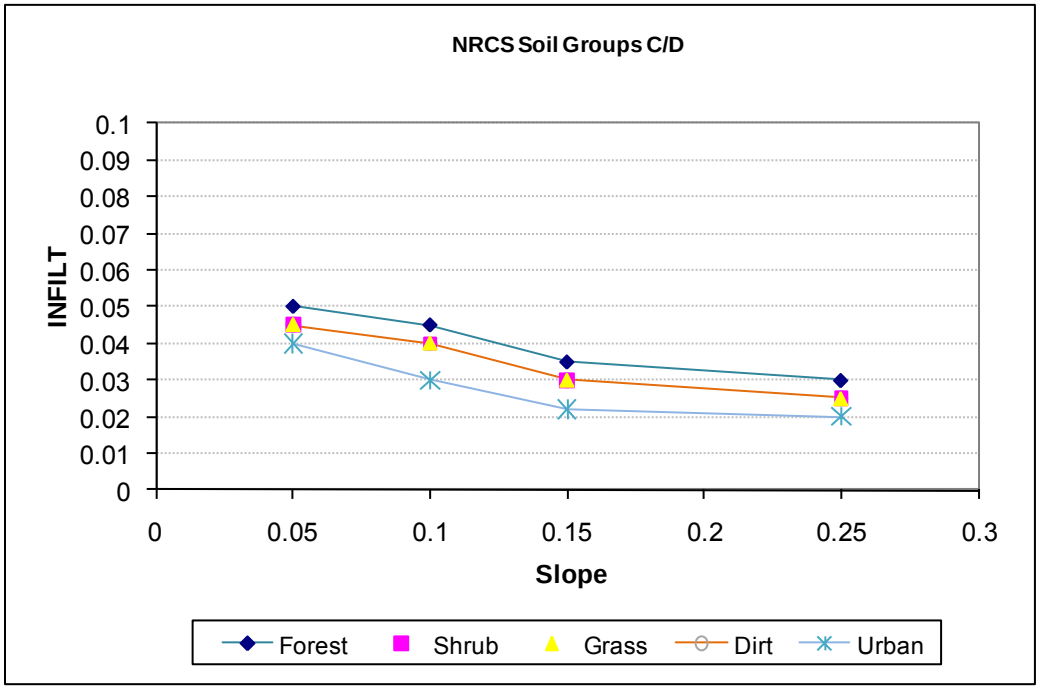

FIGURE 4

SDHM Variation in INFILT Parameter, NRCS Group C/D Soils

Figure 5, 6 and 7 show the SDHM model's assumed variations in the LZSN parameter as a function of slope and land cover type. Similar to the INFILT evaluation above, LZSN values are identical for the most common land cover types that will be incorporated in the BMP Sizing Calculator. These figures further reinforce the intention to focus on a single composite land cover type, while focusing on the differences in runoff generation potential associated with different soils and slopes.

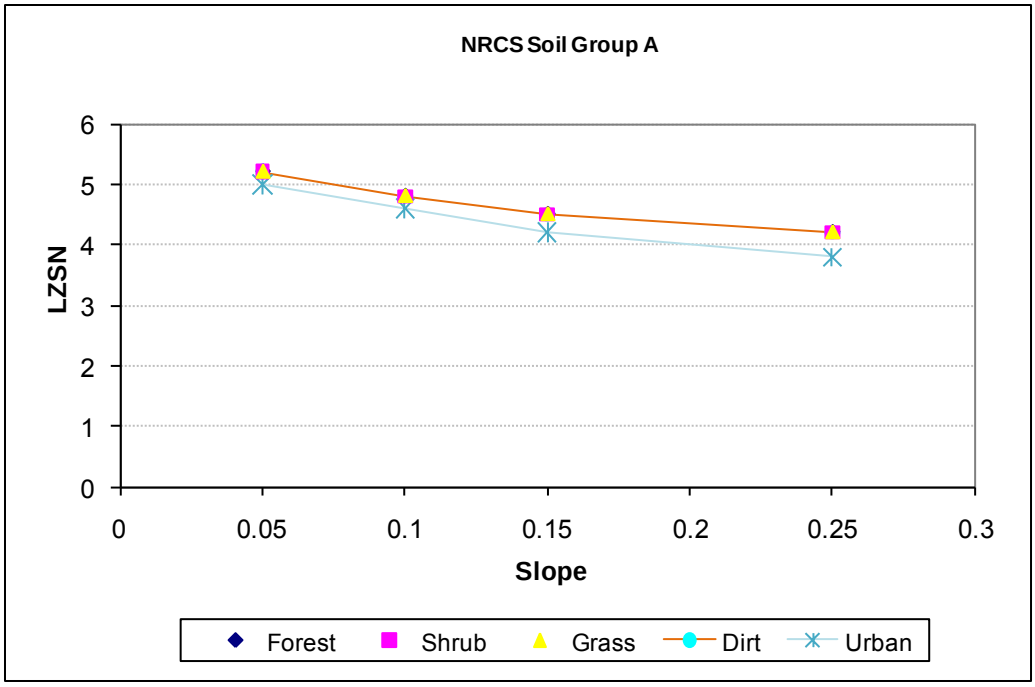

FIGURE 5

SDHM Variation in LZSN Parameter, NRCS Group A Soils

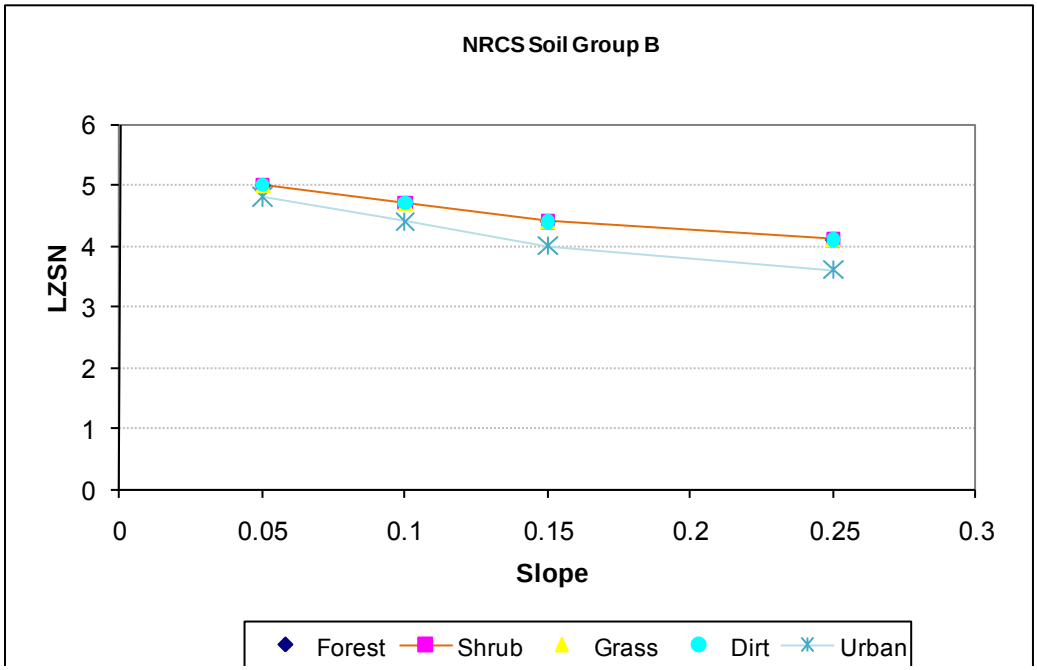

FIGURE 6

SDHM Variation in LZSN Parameter, NRCS Group B Soils

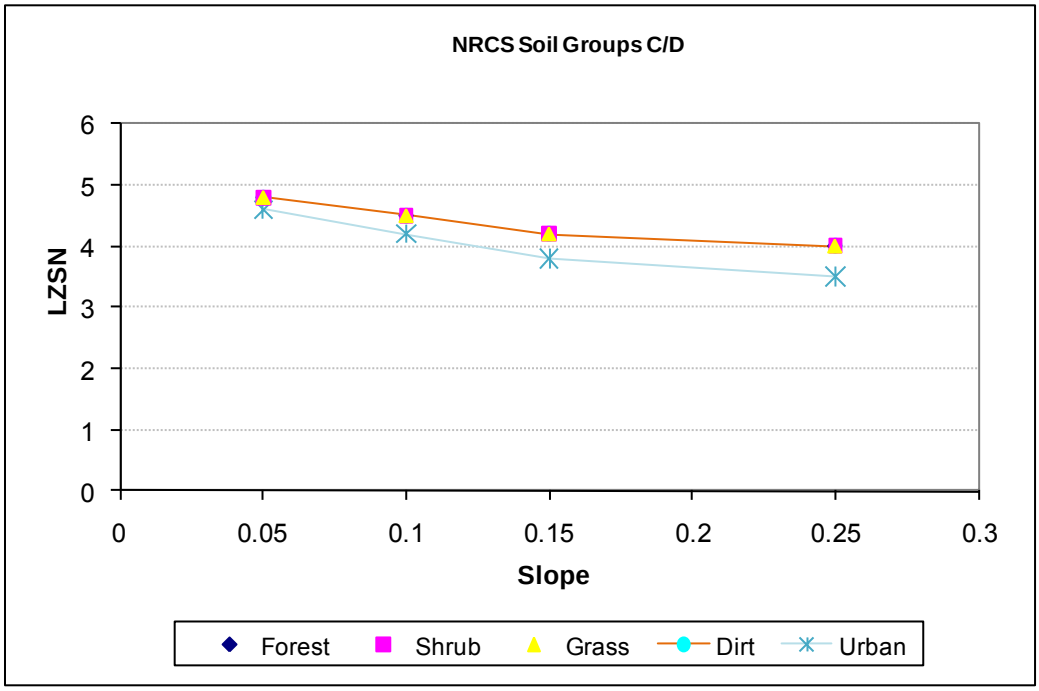

FIGURE 7

SDHM Variation in LZSN Parameter, NRCS Group C/D Soils

5. Recommended HSPF PERLND Parameters

The following recommended HSPF PERLND parameter values have been developed to use for LID pre-sizing factor analysis that will be included in the BMP Sizing Calculator. The 12 parameter sets cover the four NRCS soil groups and three separate slopes. The precise values were obtained by combining the Santa Monica Bay, Calleguas Creek, and SDHM parameter sets.

TABLE 3

Recommended HSPF PERLND Parameters for BMP Modeling

		Group A			Group B			Group C			Group D		
		5%	10%	15%	5%	10%	15%	5%	10%	15%	5%	10%	15%
PWAT_PARM2	**Units**												
FOREST	None	0	0	0	0	0	0	0	0	0	0	0	0
LZSN	inches	5.2	4.8	4.5	5.0	4.7	4.4	4.8	4.5	4.2	4.8	4.5	4.2
INFILT	in/hr	0.090	0.070	0.045	0.070	0.055	0.040	0.050	0.040	0.032	0.040	0.030	0.040
LSUR	Feet	200	200	200	200	200	200	200	200	200	200	200	200
SLSUR	ft/ft	0.05	0.1	0.15	0.05	0.1	0.15	0.05	0.1	0.15	0.05	0.1	0.15
KVARY	1/inches	3	3	3	3	3	3	3	3	3	3	3	3
AGWRC	None	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
PWAT_PARM3													
PETMAX (F)	F	35	35	35	35	35	35	35	35	35	35	35	35
PETMIN (F)	F	30	30	30	30	30	30	30	30	30	30	30	30
INFEXP	None	2	2	2	2	2	2	2	2	2	2	2	2
INFILD	None	2	2	2	2	2	2	2	2	2	2	2	2
DEEPFR	None	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
BASETP	None	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
AGEWTP	None	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
PWAT_PARM4													
CEPSC	inches	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
UZSN	inches	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
NSUR	None	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
INTFW	None	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
IRC	None	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
LZETP	None	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

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Project No: 133904

San Diego Hydromodification Management Plan

Subject: Responses to Comments on HMP Modeling Approach and BMP Configurations

Date: April 23, 2010

To: Sara Agahi, P.E. – County of San Diego

From: Eric Mosolgo, P.E. – Brown and Caldwell
Tony Dubin, P.E. – Brown and Caldwell

This draft technical memorandum summarizes the review comments received regarding the HMP Modeling Approach and BMP Configurations Draft Technical Memorandum (dated March 2, 2010) and Brown and Caldwell's (BC's) responses to these comments.

Review comments were received from the following groups:

- San Diego County Flood Control - Anthony Barry
- Clear Creek Solutions - Doug Beyerlein and Joe Brascher
- West Consultants - Marty Teal
- Hunsaker & Associates - Luis Parra

Table 1 below provides a summary of each comment, the corresponding page location from the originial Draft Technical Memorandum, and Brown and Caldwell's response.

Limitations:

This document was prepared solely for the County of San Diego in accordance with professional standards at the time the services were performed and in accordance with the contract between the County of San Diego and Brown and Caldwell. This document is governed by the specific scope of work authorized by the County of San Diego; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work.

No.	Reviewer	Page	Comment	Response
1	Anthony Barry, San Diego County	7	It is mentioned on page 7 that the vegetation types are not "sufficiently variable among developable lands to require separate scenarios". This statement should be further justified in a manner similar to the effects of porosity in the last bullet on page 8.	We made the decision to focus on one land cover type for the following reason: 1) We assume the vast majority of projects regulated by the HMP flow control standard will be in previously undeveloped areas with scrub vegetation. Conversely, many of the areas with "landscape/grass" as a pre-project land cover may not be covered by the flow control requirements, because these projects would be small or located in urban areas that qualify for some type of exemption. 2) We examined the range HSPF PERLND parameter values used in previous Southern CA studies and values included in the SDHM software – in particular the INFILT parameter. The parameter values were less variable for different land cover types than we expected, and this makes it likely that the variation in land cover type would have little impact on the computed LID BMP sizes. 3) The modeling "pre-sizing" analysis used to compute the sizing factors for the Sizing Calculator requires us to constrain or limit the variability of input parameters as much as possible. Because scrub/shrub vegetation will be encountered in most of the development projects, we think this is a good place to start with HSPF simulations and the Sizing Calculator. The County and its Copermittees could add more land cover types, BMPs or other features in V2.0 of the Sizing Calculator.

No.	Reviewer	Page	Comment	Response
2	Anthony Barry, San Diego County	11	Is the BMP area discussed in the second paragraph of Section 3.1.2 considered to be pervious area in the modeling? If so, and alterations to the standard (modeled) design are allowed (as suggested in the last paragraph on page 12), the depth of a BMP could be increased and the plan area decreased. This could allow an increase in the actual impervious area above what was considered in the modeling, without requiring the appropriate increase in required BMP volume. FOLLOW-UP COMMENT: After reviewing the response to my second comment (#2 on Page 3 of the response document) and looking back at the Modeling Approach, I discovered that the BMP area is modeled as being pervious as outlined in the 5th bullet on page 8 (of the document dated March 2, 2010), which states that there is flow out of the bottom of the basin (percolation) equal to the rate of hydraulic conductivity. It seems logical that significant reductions in the BMP area would also significantly reduce the area available for this outflow, and thereby increase the necessary volume. If this were not the case you would have to wonder if the percolation has any effect at all, and if it doesn't, why is it included in the modeling?	The BMPs are modeled using "FTABLEs" in HSPF, which detail stage-area-volume-discharge relationships. The model allows rainfall to occur directly on the BMP (as would happen in real life). The Sizing Calculator contains a "check" to ensure that the total contributing watershed area to the mitigation facility plus the mitigation facility area equates to the total project area. If a development engineer incorporates a narrow/deep ponding layer, the computed drainage management area (DMA) tributary to the BMP must accurately reflect the entire paved area draining to the BMP. We suggest allowing development engineers to vary the configuration of the surface ponding layer to better fit site constraints (e.g., wider/shallower to limit trip hazards; narrower/deeper to limit at-grade footprint). However, the sizing factor is based on the plan area of the growing medium underneath. For the Contra Costa HMP, we tested the sensitivity of BMP sizes to different ponding layer configurations and found that as long as the recommended volume is provided, wide/shallow, deep/narrow surface ponding layer configurations performed similarly enough not to impact BMP sizing factors. RESPONSE TO FOLLOW-UP COMMENT: As discussed by phone, all of the infiltration that occurs beneath the BMP is managed in the FTABLE (see Q Perc column in Figure 5), and not through the hydrologic elements of the HSPF model.
3	Anthony Barry, San Diego County	17	If vegetated bioswales are for water quality only, and do not provide flow control (as mentioned on page 17), why are they being included? Details on how to design a vegetated swale are covered in the CASQA BMP handbook.	This "treatment only" option has been proposed in response to a request from the Copermittees. The Sizing Calculator will allow users to size BMPs to meet either the "water quality treatment only" OR "flow control + treatment" requirement. The vegetated bioswale option will only be available as a selection in the Sizing Calculator if the user chooses "water quality treatment only" as the project design goal.

No.	Reviewer	Page	Comment	Response
4	Doug Beyerlein, Joe Brascher; Clear Creek Solutions	7	Only one land cover vegetation type is offered: scrub, shrub. Different vegetation types change the pre-development runoff. The user should be given more vegetation type options.	See response to comment #1.
5	Doug Beyerlein, Joe Brascher; Clear Creek Solutions	7	The sizing calculator assumes no increase in pervious runoff with development. Runoff from pervious surfaces can and does increase with development due to soil compaction from construction activities, the replacement of native vegetation with urban vegetation, and the addition of irrigation. These effects should be included in the sizing of BMP facilities.	The Countywide Model SUSMP adequately addresses this issue with its requirements for managing runoff from developed/pervious areas. For example, the SUSMP directs project proponents to control pervious runoff as much as possible using grading patterns, soil amendments, etc., so that these areas do not contribute runoff to paved areas and do not increase overall site runoff (relative to pre-project conditions). If a pervious area does drain to a paved area, and then into a BMP, this area must be accounted for within the Sizing Calculator to ensure the BMP is appropriately sized.
6	Doug Beyerlein, Joe Brascher; Clear Creek Solutions	N/A	The HSPF parameter values selected for the BMP sizing calculator are critical in the computation of the existing and development runoff and the sizing of BMP facilities. However, we have had no opportunity to review and comment on these parameter values.	We will issue a separate technical memorandum detailing the selection of HSPF model parameters.
7	Doug Beyerlein, Joe Brascher; Clear Creek Solutions	N/A	We have had no opportunity to review and comment on the HSPF FTABLEs used to represent different BMP facilities nor their associated HSPF UCI files. Nor have we had the opportunity to review and comment on the assumptions used in the construction of the HSPF FTABLEs and UCI files that produce the facility sizing results reported by the BMP sizing calculator.	The soil physics and key assumptions used to route water through the BMPs are described in Appendix A. This will be distributed to the TAC.
8	Marty Teal, West Consultants	2	Will it be obvious which of the various lower control threshold values someone is supposed to use/analyze?	Yes. The critical flow calculator allows a project proponent to determine which lower control threshold will apply to a specific project site. The critical flow calculator will be included in the overall BMP Sizing Calculator.
9	Marty Teal, West Consultants	2	Will the Sizing Calculator automatically determine/report whether a proposed BMP will meet the peak flow and flow duration performance requirement?	Yes. The Sizing Calculator will compute and report a BMP's minimize required size to meet the HMP stormwater control performance requirements.

No.	Reviewer	Page	Comment	Response
10	Marty Teal, West Consultants	8	Page 8 states, "Infiltration and soil water movement is a 1-dimensional flux in the vertical direction (neglecting lateral flows is a conservative assumption)." Why is neglecting lateral flows a conservative assumption?	If we assumed water would move laterally out of the BMP, the BMP would have a higher capacity to capture and mitigate stormwater flows.
11	Luis Parra, Hunsaker	7	The model does not include enough variability of vegetation cover to characterize the expected variation on infiltration. Among the most important vegetation type excluded, grass in fair to good condition comes to mind, as many of the developed areas will occur in this type of existing vegetation.	See response to comment #1.
12	Luis Parra, Hunsaker	9	Figure 3 is wrong and does not correspond with the one presented in page 78 of the Countywide Model SUSMP. The French drain should be placed on top, with only few inches on gravel above the top of the pipe, and the gravel below. This way, water retained below the French drain will be incorporated into the underground media.	Figure 3 was included simply to describe the function of LID BMPs. It could be replaced with Figure 6, which is consistent with the Countywide Model SUSMP.
13	Luis Parra, Hunsaker	9-11	As the hydraulic conductivity of the amended soil is the flow constraining factor (and less than the conductivity of the gravel) the only way that gravel on top makes sense is if an orifice constraining the flow in the French drain is used. This aspect, however, does not exclude the possibility of having some retention below the French drain. For instance, in a soil Type D with a hydraulic saturated conductivity of 0.1 in/hr, the equivalent of 7.2 in of ponding can be placed below the invert elevation of the French drain. With an assumed porosity of 0.4, this corresponds to an additional retention depth of 18" below the French drain. The model should allow retention as a function of the hydraulic conductivity of the bottom soil.	The gravel layer is proposed below the amended soil layer. We will follow up with reviewer to clarify this comment.

No.	Reviewer	Page	Comment	Response
14	Luis Parra, Hunsaker	N/A	Water table constraints should be included in the model. For example, it should be recommended that the water table must be at a given depth below the bottom of the gravel to be sure that the vertical assumption is valid.	The Countywide Model SUSMP describes specific site conditions that affect the feasibility of LID BMPs (e.g., steep slopes, high groundwater). Furthermore, the HMP Decision Matrix requires applicants to complete a geotechnical investigation which would identify such design constraints. A project applicant would first need to determine whether these constraints apply. If not, the project proponent could use the Sizing Calculator to plan BMPs. The Sizing Calculator will not apply in high groundwater conditions.
15	Luis Parra, Hunsaker	9	It is not clear to me if growing medium as a maximum limit of 1.5 ft. The user should be able to increase this depth. As a matter of fact, the Maryland Manual (the one that initiated the bio-retention revolution) suggests using at least 2 ft of amended soil. The user should have the option to increase this depth up to 3-4 ft.	A project proponent could specify a deeper growing medium. However, to pre-size BMPs for the Sizing Calculator we need to limit the number of potential BMP configurations. Other design scenarios can be modeled through the preparation of continuous simulation hydrologic models such as HSPF.
16	Luis Parra, Hunsaker	9	Van Genuchen relations are mentioned in page 9 but never shown.	The Van Genuchten relations are included in Appendix A. This document will be distributed to the reviewers and the TAC.
17	Luis Parra, Hunsaker	9-10	Neglecting lateral percolation and limiting infiltration to the saturated hydraulic conductivity of the existing soil is a reflection of simplicity and building upon conservative assumptions rather than a reality. Also neglecting the influence of the water pressure of the gravel in the infiltration occurring at the bottom soil is another conservative assumption not discussed. I would suggest to allow for adding an increase infiltration dimensionless factor if measurements demonstrate that the discharge is actually much less than what the model predicts.	The conservative assumptions detailed in the HMP Modeling Approach memo serve as a hedge against real-world installation problems, occasional BMP failures, etc., so that the integrated effectiveness of distributed BMP performance is consistent with the requirements of the NPDES permit. The accuracy of the sizing factors will be measured by the Copermittees' monitoring program, which will be conducted over the ensuing 5 years and beyond. If the monitoring results indicate deviations from the sizing factor predictions, then adjustments to the sizing factors will be proposed.

No.	Reviewer	Page	Comment	Response
18	Luis Parra, Hunsaker	12	The user should have flexibility to determine design parameters of the bio-retention: ponding depth (it can be more than 10 inches, no reason why this has to be the limit); growing medium (it can be more than 18" and as a matter of fact many references recommend at least 2 to 3 ft); storage layer: it can be more than 30" and it is associated with the possibility of the Bio-retention to be able to drain in 72 hrs. Also remember the possibility to add gravel below the invert of the French drain for retention purposes and groundwater recharge purposes.	Regarding ponding depth comment: The selection of a maximum ponding depth is a policy decision. Because bioretention is often installed in pedestrian-friendly areas, these systems often have limited ponding depth to eliminate trip hazards. Regarding growing medium and gravel comment: see response to comment #15.
19	Luis Parra, Hunsaker	12	Drawdown considerations for the bio-retention should be included to determine the maximum depth of the combination of ponding, amended soil, and gravel than can drain in 72 hrs.	Vector control is a major benefit of stormwater LID. Conventionally, drawdown considerations only apply to the surface ponding layer of bioretention devices and not the below ground layers. The surface ponding layer will fully drain within a few hours of the end of a storm event. The sizing calculator will include drawdown calculations.
20	Luis Parra, Hunsaker	12	It is not clear in page 12 if the other option of conversion is valid: the example describes a situation where the design engineer can convert the ponding layer with half the depth but twice the area, and actually design engineers are more interested in doing exactly the opposite: half the area and twice the depth. I am assuming that this is also a valid option.	The Countywide Model SUSMP specifies the allowable configurations for bioretention BMPs.
21	Luis Parra, Hunsaker	13	Comments 2 and 3 (#12 and #13 in this table) are also applicable to figure 6 of page 13.	The figures on pages 77 and 78 of the Countywide Model SUSMP should be modified to show the underdrain pipe at or near the bottom of the storage layer (i.e., the gravel layer).
22	Luis Parra, Hunsaker	N/A	There is no opportunity to make comments in hidden parameters or assumptions made by the program, but to trust blindly on the results. Unfortunately the engineer will become more of a technician running a black-box program than an engineer using criteria an experience to come up with a good design.	The Sizing Calculator is a simple-to-use tool that allows engineers to quickly size stormwater BMPs based on detailed "pre-sizing" modeling exercise (performed by Brown and Caldwell). Project proponents could perform their own hydrologic and hydraulic modeling analyses to size modified BMP designs, if desired.

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Draft Technical Memorandum

Project Title: San Diego County Hydromodification Management Plan

Project No: 133904

San Diego County Hydromodification Management Plan (HMP)

Subject: Description of Automated Pond Sizing Procedure

Date: May 6, 2010

To: Sara Agahi, San Diego County

From: Tony Dubin, Brown and Caldwell
Eric Mosolgo, Brown and Caldwell

This memorandum describes the automated pond sizing procedure that Brown and Caldwell (BC) is currently developing to support the implementation of the San Diego HMP. The purpose of the automated pond sizing procedure is to provide both project proponents and municipal review staff with a technically sound yet streamlined method for sizing stormwater ponds that meet the performance requirements of the HMP.

Pond Sizing Procedure

The automated pond sizing procedure will be built into the BMP Sizing Calculator software to allow project proponents to select detention ponds as the method of stormwater runoff control. The general process will work as follows:

1. The project proponent will enter information about the area tributary to the proposed detention pond for the pre-project and post-project conditions. The information will include drainage area, soil types, slopes, and land cover information (e.g., scrub land, landscaping, impervious).

2. The BMP Sizing Calculator software will construct pre-project and post-project (unmitigated) long-term runoff time series data that correspond to the site conditions (i.e., the information described in the item #1 above). The time series will be created through a pre-modeling exercise that involves running HSPF with real, historical rainfall data and developing long-term, unit area hydrographs for each combination of soils, slopes, and land covers.

3. The project proponent will next enter an initial configuration for the detention pond, including area, depth and side slopes. Alternatively, the user could supply a stage-storage-discharge table. The user will also enter preferences for how the automated pond sizing procedure should iteratively adjust the pond configuration if the initial configuration does not meet the HMP's performance requirement for flow duration and peak flow control. The user will not need to supply any information about the outlet control structure, because the automated pond sizing algorithm will use a pre-defined configuration that includes 2 flow control orifices and an overflow weir (sizes of the outflow facilities will be determined by the pond sizing algorithm).

4. The software will route the post-project unmitigated, long-term runoff time series through the detention pond. The reservoir routing routine will compute the following quantities for each hourly time step:
    - stormwater inflow
    - water depth
    - pond exfiltration
    - pond outflow through the outlet control structure

    The pond outflows will form the "post-project mitigated" time series that will be compared to the pre-project conditions.
5. The software will compare the pond outflow **flow durations** and **peak flows** with the pre-project flow durations and peak flows to determine if the pond configuration meets the performance requirements of the HMP.
6. If the current configuration does not meet the HMP performance requirements, the automated pond sizing procedure will apply the user's stated preference for modifying the pond configuration (see item #3 above) and perform the reservoir routing and statistical post-processing calculations again (and again) until the pond is properly sized and meets HMP requirements.

Time Series Data

As described above, the automated pond sizing procedure will prepare pre-project and post-project time series for the area tributary to the proposed pond, and then determine how large the pond must be to mitigate the impacts of development or redevelopment activities. The site-specific time series will be developed by adding together the component time series data that describe the different parts of the project area (e.g., 10-acres impervious *time series* + 5 acres Group D soils and scrub vegetation with moderate slopes *time series* + 12 acres Group D soils with urban/landscaped cover *time series*).

The component runoff time series will be developed by running HSPF simulations for each of the 12 scenario conditions described in the *HMP Modeling Approach and BMP Configurations* technical memo dated March 2, 2010 (see Section 2.2 of the technical memo). Runoff time series will also be developed corresponding to four (4) "urban" landscaped conditions describing landscaped areas with compacted soils that would be typical of urban and suburban-style development.

These landscaped cover types are necessary for the automated pond sizing procedure, because it is not feasible for site developments that include large ponds for stormwater control to segregate runoff from pervious and impervious surfaces (in the way that LID-focused developments typically separate contributions from pervious and impervious sources).

Table 1 below lists the pervious site conditions that will be available for the automated pond sizing procedure.

TABLE 1
HSPF Scenarios for Characterizing Pervious Site Conditions

Scenario No.	NRCS Soil Group	Land Cover	Slope
1	A	Scrub, Shrub	Low (<5%)
2	A	Scrub, Shrub	Moderate (10%)
3	A	Scrub, Shrub	Steep (>15%)
4	B	Scrub, Shrub	Low (<5%)
5	B	Scrub, Shrub	Moderate (10%)
6	B	Scrub, Shrub	Steep (>15%)
7	C	Scrub, Shrub	Low (<5%)
8	C	Scrub, Shrub	Moderate (10%)
9	C	Scrub, Shrub	Steep (>15%)
10	D	Scrub, Shrub	Low (<5%)
11	D	Scrub, Shrub	Moderate (10%)
12	D	Scrub, Shrub	Steep (>15%)
13	A	Urban/Landscaped	Moderate (10%)
14	B	Urban/Landscaped	Moderate (10%)
15	C	Urban/Landscaped	Moderate (10%)
16	D	Urban/Landscaped	Moderate (10%)

Pond Configuration Preferences

After describing the pre-project and post-project conditions based on local soils, slopes and land covers, the project proponent will describe an initial pond configuration and preferences for modifying the configuration during the automated sizing process.

Since each project site has its unique constraints on pond configurations, the user should be allowed to express preferences with regard to configuration modification. To minimize the pond footprint area, engineers commonly provide the required storage volume by constructing a deeper pond. However, site specific constraints, community concerns, and municipal regulations could require an engineer to set a maximum depth for a pond. Potential concerns associated with pond depths include public safety, drawdown times, vector control, or aesthetics, among others.

Figure 1 below shows how preferences will be incorporated into the iterative pond sizing process. Specifically, the figure illustrates how the automated pond sizing procedure could test an initial configuration, iteratively test increasing pond depths, and finally test increasing pond areas until a solution is found that meets the flow duration and peak flow performance requirements of the HMP.

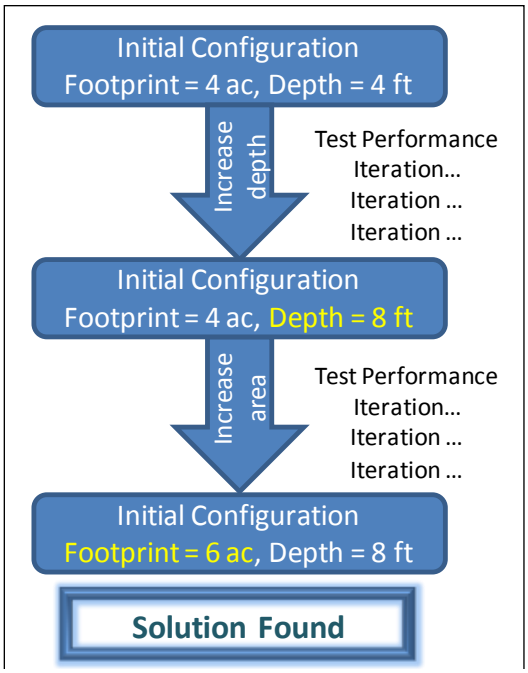

FIGURE 1

Illustration of Pond Configuration Preferences for Automated Iterative Sizing

BROWN AND CALDWELL

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Draft Technical Memorandum

Project Title: San Diego County Hydromodification Management Plan

Project No: 133904

San Diego County Hydromodification Management Plan (HMP)

Subject: Rainfall and Evapotranspiration Data for BMP Sizing Calculator

Date: May 20, 2010

To: Sara Agahi, San Diego County

From: Eric Mosolgo, Brown and Caldwell
Tony Dubin, Brown and Caldwell

This memorandum describes the rainfall and evapotranspiration data that Brown and Caldwell (BC) is using to develop BMP sizing factors and pond sizing time series data for incorporation in the San Diego BMP Sizing Calculator. The purpose of the BMP Sizing Calculator is to provide both project proponents and municipal review staff with a technically sound yet streamlined method for sizing stormwater facilities that meet the performance requirements of the HMP.

Rainfall Data

Standards developed as part of this HMP to control runoff peak flows and durations are based on a continuous simulation of runoff using local rainfall data. To provide for clear climatic designation between coastal, foothill and mountain areas of the County, and to distinguish between the major watershed units, historical records for a series of 18 rainfall data stations located throughout San Diego County were compiled and quality controlled for analysis.

Long-term hourly rainfall records have been prepared for the 18 rainfall stations. These rainfall record files are located on the *Project Clean Water* web site for public use (www.projectcleanwater.org). Sources of the rainfall data include ALERT data from the County of San Diego (which extend back to 1982), the California Climatic Data Archive, National Oceanic and Atmospheric Administration (NOAA), the National Climatic Data Center, and the Western Regional Climate Center.

Gauges were selected based on minimum continuous simulation modeling requirements including the following:

1. Since the selected precipitation gauge data set should be located near the project site to ensure that long-term rainfall records are similar to the anticipated rainfall patterns for the site, gauges were selected in proximty to areas planned for future development and redevelopment.
2. Recording frequency for the gauge data set should be hourly (or more frequent).
3. The gauge rainfall record should extend for the entire length of the record. Where the gauge record length is less than 35 years, then adjacent gauge records were used to extend the rainfall record to at least 35 years.

4. Use of the most applicable long-term rainfall gauge data, as opposed to the scaling of rainfall patterns solely from Lindbergh Field, is required to account for the diverse rainfall patterns across San Diego County.

Precipitation gauges summarized in Table 1 below all have recording frequencies of one hour and recording data ranges of at least 35 years.

TABLE 1
Rainfall Station Summary

Station	Elevation	Watershed
Bonita	120	Sweetwater River
Encinitas	242	San Elijo Lagoon and Batiquitos Lagoon and ocean outlets
Escondido	645	Escondido Creek
Fallbrook	675	San Luis Rey River (near ridge with Santa Margarita River watershed)
Fashion Valley	20	Lower San Diego River
Flinn Springs	880	San Diego River
Kearny Mesa	425	San Diego River (near ridge with San Clemente Canyon watershed)
Lake Cuyamaca	4,590	Upper San Diego River
Lake Heneshaw	2,990	Upper San Luis Rey River
Lake Wohlford	1,490	Upper Escondido Creek
Lindbergh Field	Near Sea Level	Coastal – San Diego Bay
Lower Otay Reservoir	491	Otay River
Oceanside	30	San Luis Rey River
Poway	440	Los Penasquitos Canyon
Ramona	1,450	Upper San Dieguito River
San Onofre	162	North County Coastal – Pacific Ocean
San Vicente Reservoir	663	San Diego River
Santee	300	San Diego River

For a given project location, the following factors should be considered in the selection of the appropriate rainfall data set when developing continuous simulation hydrologic models.

1. In most cases, the rainfall data set in closest proximity to the project site will be the appropriate choice. A rainfall station map is included in Figure 1 of this technical memo and has been posted to the *Project Clean Water* web site for public use.
2. In some cases, the rainfall data set in closest proximity to the project site may not be the most applicable data set. Such a scenario could involve a data set with an elevation significantly different from the project site. In addition to a simple elevation comparison, the project proponent may also consult with the San Diego County's average annual precipitation isopluvial map, which is provided in the San Diego County Hydrology Manual (2003). Review of this map could provide an initial estimate as to whether the project site is in a similar rainfall zone as compared to the rainfall station. Generally, average annual precipitation totals in San Diego County increase with increasing elevation.
3. Where possible, rainfall data sets should be chosen so that the data set and the project location are both located in the same topographic zone (coastal, foothill, mountain) and/or major watershed unit (Upper San Luis Rey, Lower San Luis Rey, Upper San Diego River, Lower San Diego River, etc.).

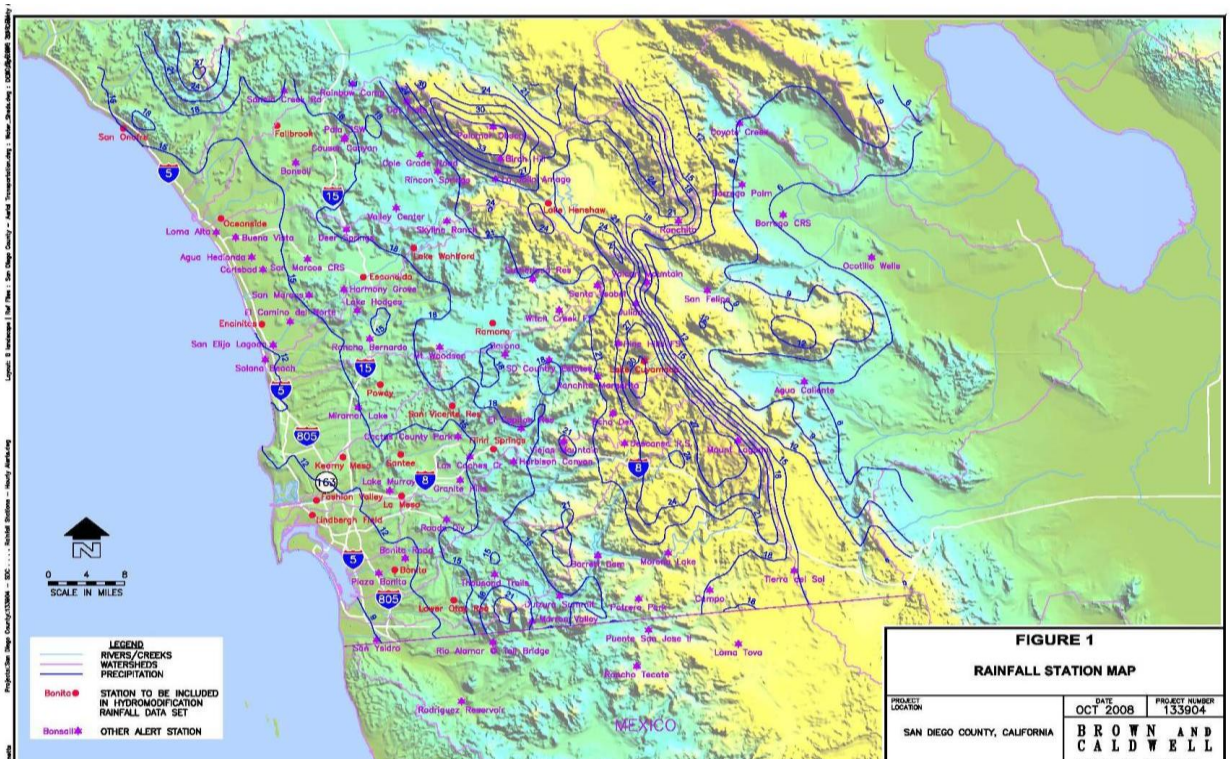

FIGURE 1

Rainfall Station Map

The BMP Sizing Calculator will automate the rainfall gauge selection process considering the factors detailed in this technical memo. For the purposes of the sizing factor modeling development effort, four (4) of the rainfall data sets were considered for analysis. The selected rainfall data sets include:

1. Lindbergh Field (coastal area, San Diego Bay watershed, central San Diego County, elevation near sea level)
2. Oceanside (coastal area, San Luis Rey River watershed, northern San Diego County, elevation = 30 feet)
3. Lower Otay Reservoir (inland valley area, Otay River watershed, southern San Diego County, elevation = 491 feet)
4. Ramona (mountain area, San Dieguito River watershed, eastern San Diego County, elevation = 1,450 feet)

To account for topographic, geographic and climatic variability across San Diego County, scaling factors will be developed for each of the (4) rainfall stations listed above. Projects will be assigned to a "rainfall basin" corresponding to one of the (4) rainfall stations. Then, rainfall data will be scaled based upon either mean annual precipitation of single-event isopluvial data (such as the 2-year, 24-hour or 85th percentile, 24-hour rainfall totals) differences as compared to the selected rainfall station.

Evapotranspiration Data

Known data sources for evaporation and evapotranspiration data in San Diego County are listed below.

1. California Irrigation Management and Information System web site – evapotranspiration stations include San Diego, Oceanside, Escondido, Ramona, Otay Lakes, Miramar, Torrey Pines, and Borrego Springs.
2. Historical Reservoir Level and Evaporation Data for Lake Heneshaw.
3. Historical Evaporation Data from City of San Diego Reservoirs.
4. Historical Evaporation Data from Helix Water District for Lake Cuyamaca.

Table 2 below summarizes available evaporation and evapotranspiration data sources in San Diego County. Most of the available data are located close to reservoirs in the inland valley and mountain areas of the County. Monthly evaporation records are available for multiple reservoirs within the County. Evapotranspiration sensing data are generally collected in agricultural zones.

The California Irrigation Management Information Systems web site (www.cimis.water.ca.gov/cimis/data.jsp) provides access to real-time and summarized evapotranspiration data (ETo) throughout California. For the San Diego region, average evapotranspiration values are summarized for the coastal and foothill zones of San Diego County.

TABLE 2
Summary of Evaporation and Evapotranspiration Data for San Diego County

Station Name ID	Data Type	Data Source	Recording Frequency	Start Date	End Date
Barratt Lake	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Chula Vista	Pan Evaporation	Western Regional Climate Center	Monthly Averages	1948	2005
El Capitain Reservoir	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Escondido / 74	Evapotranspiration	CIMIS	Monthly	1988	1998
Escondido / 153	Evapotranspiration	CIMIS	Monthly	1999	2008
Lake Cuyamaca	Pan Evaporation	Helix Water District	Monthly	1985	2006
Lake Heneshaw	Pan Evaporation	County of San Diego	Daily	1999	2005
Lake Heneshaw	Pan Evaporation	County of San Diego	Monthly	1957	2008
Lake Hodges	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Lake Jennings	Pan Evaporation	Helix Water District	Monthly	1985	2006
Lake Murray	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Lake Sutherland	Pan Evaporation	City of San Diego Water Department	Monthly	1954	2008
Lower Otay Reservoir	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Lower Otay / 147	Evapotranspiration	CIMIS	Monthly	1999	2008
Miramar Lake	Pan Evaporation	City of San Diego Water Department	Monthly	1960	2008
Miramar Lake / 150	Evapotranspiration	CIMIS	Monthly	1999	2008

TABLE 2
Summary of Evaporation and Evapotranspiration Data for San Diego County

Station Name ID	Data Type	Data Source	Recording Frequency	Start Date	End Date
Morena Lake	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Oceanside / 49	Evapotranspiration	CIMIS	Monthly	1986	2003
Ramona / 98	Evapotranspiration	CIMIS	Monthly	1991	1998
San Diego / 45	Evapotranspiration	CIMIS	Monthly	1985	1989
San Diego / 66	Evapotranspiration	CIMIS	Monthly	1989	2001
San Diego II / 184	Evapotranspiration	CIMIS	Monthly	2002	2008
San Vicente Reservoir	Pan Evaporation	City of San Diego Water Department	Monthly	1950	2008
Torrey Pines / 173	Evapotranspiration	CIMIS	Monthly	2000	2008

For the purposes of the sizing factor modeling development effort, the four (4) rainfall data sets were associated with evapotranspiration/evaporation data as detailed below.

1. Lindbergh Field (San Diego/45, San Diego/66, San Diego II/184, Chula Vista, Lake Murray and Torrey Pines/173)
2. Oceanside (Oceanside/49, Lake Hodges, Lake Heneshaw)
3. Lower Otay Reservoir (Lower Otay Reservoir, Lower Otay/147)
4. Ramona (Ramona / 98, Lake Hodges, San Vicente Reservoir)

Appendix 5D – Consolidated Monitoring Plan
Volume II, Quality Assurance Project Plan

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VOLUME II:

QUALITY ASSURANCE PROJECT PLAN

Updates and key revisions to this QAPP under existing programs are presented in the format of blue or red (errata) underlined or strikeout text for clarity and review. Global "un-highlighted" revisions include standardization of terms, clarification of text, and other minor editorial corrections. Other Global "un-highlighted" revisions include updates that result from the onset adoption of a new Permit (see previous CMP version for old requirements). Refer to the Monitoring Annual Report(s) for updates to the Special Studies Workplans, which are separate from this CMP. The Permittees will proceed with the monitoring program in accordance with the guidance provided herein.

RIVERSIDE COUNTY
WATERSHED PROTECTION

VOLUME II:

QUALITY ASSURANCE PROJECT PLAN

Riverside County Flood Control and
Water Conservation District
1995 Market Street
Riverside, CA 92501

Errata January 2019
Rev. 5 October 2018
Rev 4. October 2017
Errata October 2014
Rev 3. July 2014
Rev 2. November 2013
Rev 1. November 2012

GROUP A ELEMENTS: PROJECT MANAGEMENT

1. TITLE AND APPROVAL SHEETS

Quality Assurance Project Plan

Project Name:	Riverside County Flood Control and Water Conservation District Consolidated Monitoring Program
Date:	October 1, 2018 January 22, 2019 (Errata)
Name of Responsible Organization:	Riverside County Flood Control and Water Conservation District

PROGRAM ORGANIZATION:

Title	Name	Signature	Date
District Chief of Watershed Protection Division	Edwin Quinonez	Edwin Quinonez	1/22/19
District Watershed Monitoring Section Manager	Rebekah Guill		1/22/19
District Monitoring Program Manager	TBD*		

*The Section Manager will act as the Monitoring Program Manager in the interim.

GROUP A ELEMENTS: PROJECT MANAGEMENT

1. TITLE AND APPROVAL SHEETS

Quality Assurance Project Plan

Project Name:	Riverside County Flood Control and Water Conservation District Consolidated Monitoring Program
Date:	October 1, 2018 (Revision)
Name of Responsible Organization:	Riverside County Flood Control and Water Conservation District

PROGRAM ORGANIZATION:

Title	Name	Signature	Date
District Chief of Watershed Protection Division	Edwin Quinonez	Edwin Quinonez	10/1/18
District Watershed Monitoring Section Manager	Rebekah Guill ~~Kris Flanigan~~	Rebekah Guill	10/1/18
District Monitoring Program Manager	TBD* ~~Rebekah Guill~~		

*The Section Manager will act as the Monitoring Program Manager in the interim.

APPROVAL SIGNATURES - SMR

REGIONAL WATER QUALITY CONTROL BOARD:

Title	Name	Signature	Date
RWQCB – San Diego Executive Officer	David W. Gibson		
RWQCB – San Diego QA Officer			

APPROVAL SIGNATURES - SAR

REGIONAL WATER QUALITY CONTROL BOARD:

Title	Name	Signature	Date
RWQCB – Santa Ana Executive Officer	~~Kurt V. Berchtold~~ Hope A. Smythe		
RWQCB – Santa Ana QA Officer			

APPROVAL SIGNATURES - WWR

REGIONAL WATER QUALITY CONTROL BOARD:

Title	Name	Signature	Date
RWQCB – Colorado River Basin Executive Officer	~~Jose Angel~~ Paula Rasmussen		
RWQCB – Colorado River Basin QA Officer			

Below is an example of the Consultant Approval and Responsibilities Form. Forms are required to be signed by each consultant working with the District and Co-Permittees to implement and adhere to the requirements set forth in the Consolidated Monitoring Plan (CMP). Signed and completed forms are available in Appendix O.

Consultant Approval and Responsibilities Form

Riverside County Quality Assurance Project Plan for Water Quality Monitoring

Contractor Name:

Address	
County Monitoring Project Name and Elements	
District Agreement Number and Approval Date	
Project Manager	
Signature	
Phone Number	
E-mail	
Quality Assurance Officer	
Signature	
Phone Number	
E-mail	

The Contractor's Project Manager is responsible for implementing monitoring activities and data management in accordance with the requirements of this Quality Assurance Project Plan (QAPP) and the corresponding elements of a Project's Monitoring Plan. The Contractor's Quality Assurance (QA) Officer is responsible for quality assurance and quality control procedures for sampling and data management procedures in this QAPP. The Contractor's QA officer will review and assess procedures during the project against QAPP requirements. The Contractor's Project Manager will report all findings to the District's Watershed Monitoring Section Manager and/or District's Project Contact (may vary by watershed/assignment), including all requests for corrective action. The District may stop monitoring activities, if there are significant deviations from required practices or if there is evidence of a systematic failure.

The Contractor will be responsible for ensuring QAPP/Monitoring Plan compliance by subcontractors hired on a single or various elements of the Monitoring Project named above.

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ACRONYMS AND ABBREVIATIONS

BMI	Benthic Macroinvertebrate Index
BMP	Best Management Practice
BOD	Biological Oxygen Demand
CASQA	California Association of Stormwater Quality Agencies
CCC	Criteria Continuous Concentration
CEDEN	California Environmental Data Exchange Network
cfs	cubic feet per second
CMC	Criteria Maximum Concentration
CMP	Consolidated Monitoring Program for Water Quality Monitoring
COC	Chains of Custody
CPOM	Coarse Particulate Organic Matter
CSBP	California State Bioassessment Protocol
CTR	California Toxics Rule
District	Riverside County Flood Control and Water Conservation District
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EDD	Electronic Data Deliverable
EPT taxa	Ephemeroptera, Plecoptera and Trichoptera taxa
FY	Fiscal Year
GIS	Geographical Information System
HSA	Hydrologic Sub-Area
HU	Hydrologic Unit
IAH	High Priority Inland Aquatic Habitat
IBI	Southern California Index of Biological Integrity
IC/ID	Illicit Connection/Illegal Discharge
ID	Identification
IDDE	Illicit Discharge Detection and Elimination
JRMP	Jurisdictional Runoff Management Plan
KiWQM	Kisters Water Quality Module
LCS	Laboratory Control Sample
LESJWA	Lake Elsinore/San Jacinto Watershed Agency
LID	Low Impact Development
MDL	Method Detection Limit
mg/L	milligram per liter
mL	milliliters
ML	State Board Minimum Level
MLS	Mass Loading Station
MRP	Monitoring and Reporting Program
MS4	Municipal Separate Storm Sewer System
NAL	Non-Stormwater Action Level
ng/L	nanograms per liter
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
Permittees	County of Riverside, the incorporated Cities, and Riverside County Flood Control and Water Conservation District
pH	Measurement of hydrogen ion concentration (i.e. acidity or alkalinity)
PHab	Physical habitat assessment
PoP	Probability of Precipitation
QAPP	Quality Assurance Project Plan

QAPrP	Quality Assurance Program Plan
QC	Quality Control
QPS	Quantitative Precipitation Statement
RL	Reporting Limits
RWB	Reachwide Benthos
SAL	Stormwater Action Level
San Diego Water Board	San Diego Regional Water Quality Control Board
SAR	Santa Ana Region
SAWPA	Santa Ana Watershed Protection Authority
SCCWRP	Southern California Watershed Research Project
SMC	Southern California Stormwater Monitoring Coalition
SMR	Santa Margarita Region
SMRNIG	Santa Margarita River Nutrient Initiative Group
SOP	Standard Operating Procedure
SRM	Standard Reference Materials
State Board MLs	State Board Minimum Levels or RLs
SWAMP	Surface Water Ambient Monitoring Program
SWQTF	Stormwater Quality Standards Task Force
TIE	Toxicity Identification Evaluation
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbon
TRE	Toxicity Reduction Evaluation
Triad	Water quality assessment using chemistry, toxicity, and bioassessment evidence
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WER	Water Effects Ratio
WQIP	Water Quality Improvement Plan
WQO	Water Quality Objective
WWR	Whitewater River Region
µg/L	microgram per liter

REVISIONS

Volume III Version	Date	Summary of Revisions
Original	October 2012	Development of a Consolidated Monitoring Plan for compliance with the MS4 Permits.
Revision 1	November 2012	The CMP (Volume II) was revised to reflect programmatic adjustments, which included: • Global revisions to formatting and standardization of terms; and • Updates of key staff assignments.
Revision 2	November 2013	As a result of lessons learned during the previous year, the CMP (Volume II) was revised to reflect programmatic adjustments. Updates included: • Global revisions to provide standardization and clarity; • Updates of key staff assignments; • Analytical methods updates; • Updates to sampling and QA/QC schedules (Tables 10-1 and 14-1); • Clarification of wet weather monitoring mobilization within the wet season; and • Improvements to sampling and QA/QC procedures.
Revision 3	July 2014	As a result of lessons learned during the previous year, the CMP (Volume II) was revised to reflect programmatic adjustments. Updates included: • Decapitalization of commonly used terms; • Clarification of key staff assignments and roles; • Reference to updated SWAMP SOPs (QAPP Attachment E); • Further analytical methods updates; • Updates to narrative relevant to bioassessment/ stream assessment programs; • Updates to sampling schedules and program tables (Tables 10-1, 10-2, 10-3, 11-1, 11-2, and 11-3) • Updated references to the WWR MS4 Permit; and.
Errata	October 2014	Revision of the QA/QC field sampling procedures for consistency with the SMR Monitoring Program (pp. 54, 67, and 68)
Errata	August 2016	Revisions to Watershed Monitoring staff (pgs. 10-14, 18, 30, 47) as well as methods for pesticides. (pgs. 22-26).
Revision 4	October 2017	Updates to program contacts and monitoring program details as needed for compliance with the most current SWAMP and MS4 Permit information.
Revision 5	October 2018	Updates to the constituent lists for inclusion of most current CWA 303(d) Listings, clarification of hydromodification monitoring program, updates to reflect current special studies, and updates of key staff assignments.
Errata	January 2019	Minor updates to include reference to a new Long-Term Receiving Water monitoring station in the Upper SMR portion of the Watershed Management Area.

3. DISTRIBUTION LIST OF APPROVED QAPP

Table 3-1: Approved QAPP Distribution List

Title:	Name (Affiliation)	No. of Copies*
San Diego Regional Water Quality Control Board Executive Officer	David W. Gibson	1
Santa Ana Regional Water Quality Control Board Executive Officer	~~Kurt V. Berchtold~~ Hope A. Smythe	1
Colorado River Regional Water Quality Control Board Executive Officer	~~Jose Angel~~ Paula Rasmussen	1
District Chief of Watershed Protection Division	Edwin Quinonez	1
District's Watershed Monitoring Section Manager/ QA Officer	Rebekah Guill ~~Kris Flanigan~~	1
District Monitoring Program Manager**	Rebekah Guill	1
Consultant Project Managers	Project Manager	1 (each)

*Subsequent updates of the QAPP are included in the most current monitoring annual reports.
**The Section Manager will act as the Monitoring Program Manager in the interim.

The QAPP may also be accessed online from the District's NPDES/Municipal Stormwater Management Program webpage (http://rcflood.org/NPDES/Monitoring.aspx).

4. PROJECT/TASK ORGANIZATION

4.1 Involved Parties and Roles

The Riverside County Flood Control and Water Conservation District (District) serves as the Principal Permittee for Santa Ana Regional Water Quality Control Board (Santa Ana Regional Board) Order Number R8-2010-0033 and San Diego Regional Water Quality Control Board (San Diego Regional Board) Order Number R9-2013-0001, as amended by Order Nos. R9-2015-0001 and R9-2015-0100, and serves as a Co-Principal Permittee with the County of Riverside for Colorado River Regional Water Quality Control Board (Colorado River Regional Board) Order Number R7-2013-0011. Table 4-1 provides a list of the three applicable Municipal Separate Storm Sewer System (MS4) permits issued by the respective Regional Boards and the designated Co-Permittees, including the County of Riverside, the incorporated Cities, and the Riverside County Flood Control and Water Conservation District. As Principal Permittee, the District is responsible for administering the required monitoring programs, including processing contracts and service agreements for laboratory, consulting and interagency services in accordance with the MS4 Permit requirements. Under past and current rounds of MS4 permits, the District has also been responsible for collecting samples required under the MS4 permits, ensuring that the samples are analyzed at a certified laboratory and analyzing the resulting data. Co-Permittees may also conduct monitoring activities, such as water quality sampling and field reconnaissance, either under the umbrella of the Consolidated Monitoring Program (CMP) or due to MS4 permit-specific monitoring requirements.

Table 4-1: List of NPDES MS4 Permits and Permittees

Permit	Principal Permittees	Co-Permittees
Colorado River Regional Board Order No. R7-2013-0011 NPDES Permit No. CAS617002[1]	County of Riverside Riverside County Flood Control and Water Conservation District	City of Banning City of Cathedral City City of Coachella City of Desert Hot Springs City of Indian Wells City of Indio City of La Quinta City of Palm Desert City of Palm Springs City of Rancho Mirage Coachella Valley Water District

Table 4-1 List of NPDES Permits and Permittees (continued)

Permit	Principal Permittee	Co-Permittees
Santa Ana Regional Board Order No. R8-2010-0033 NPDES Permit No. CAS618033[1]	Riverside County Flood Control and Water Conservation District	City of Beaumont City of Calimesa City of Canyon Lake City of Corona City of Eastvale City of Hemet City of Jurupa Valley City of Lake Elsinore City of Menifee[1] City of Moreno Valley City of Murrieta[2] City of Norco City of Perris City of Riverside City of San Jacinto City of Wildomar[2] County of Riverside
San Diego Regional Board Order No. R9-2013-0001, As Amended by Order Nos. R(-2015-0001 and R9-2015-0100 NPDES Permit No. CAS0109266[1]	Riverside County Flood Control and Water Conservation District	City of Menifee[2] City of Murrieta[3] City of Temecula City of Wildomar[3] County of Riverside

[1] Although the Order is expired, the Regional Board has directed the Permittees to continue implementation of the requirements therein until a new Order is adopted.
[2] The City of Menifee is solely regulated by the Santa Ana Regional Board, however, the City of Menifee is also a participating party under the implementation of the Water Quality Improvement Plan of the San Diego Regional Permit.
[3] The Cities of Murrieta and Wildomar are solely regulated by the San Diego Regional Board.

Rebekah Guill is the District's Monitoring Program Manager and has the responsibility for the following:

- Oversight of all Monitoring Program work items, coordinating participating entities and collection of data, reviewing project data, and reporting the monitoring results per MS4 permit requirements.
- Oversight of field data collection and compliance with monitoring procedures in this Quality Assurance Project Plan (QAPP).
- Compilation of all monitoring data and developing the Annual Monitoring Reports. Submitting the Annual Monitoring Reports to the Watershed Coordinators for inclusion in the comprehensive Annual Report and timely submittal to the respective Regional Boards.
- Oversight and coordination of monitoring and laboratory consultants and their respective projects.

Rebekah Guill ~~Kris Flanigan,~~ the District's Watershed Monitoring Section Manager, is designated as the Quality Assurance (QA) Officer for this Monitoring Program. As such, he is responsible for California Environmental Quality Act (CEQA) compliance and QA/QC management of data collected under the CMP.

The Annual Monitoring Reports will be provided to the MS4 Permit Manager responsible for Annual Report submissions to the Regional Boards. Matt Yeager is the MS4 Permit Manager for the Santa

Margarita Region (SMR) and is responsible for submitting the SMR Annual Report to the San Diego Regional Board. Andrea Gonzalez is the MS4 Permit Manager for the Santa Ana Region (SAR) and is responsible for submitting the SAR Annual Report to the Santa Ana Regional Board. Aldo Licitra is the MS4 Permit Manager for the Whitewater River Region (WWR) and is responsible for submitting the WWR Annual Report to the Colorado River Regional Board.

Abigail Suter ~~Kris Flanigan~~ is the District's Database Manager and is responsible for maintaining an accurate and complete data set in the District's ~~Hydstra©~~ Kisters database. Abigail Suter ~~Penny Nanney~~ is also the District's Data Manager and is responsible for managing the NPDES Section's Water Quality Data and assisting with quality control and quality assurance of all incoming data as well as the generation of data deliverables in various formats as needed to support the programs including Excel Electronic Data Deliverable (EDD) format and SWAMP compatible EDD format.

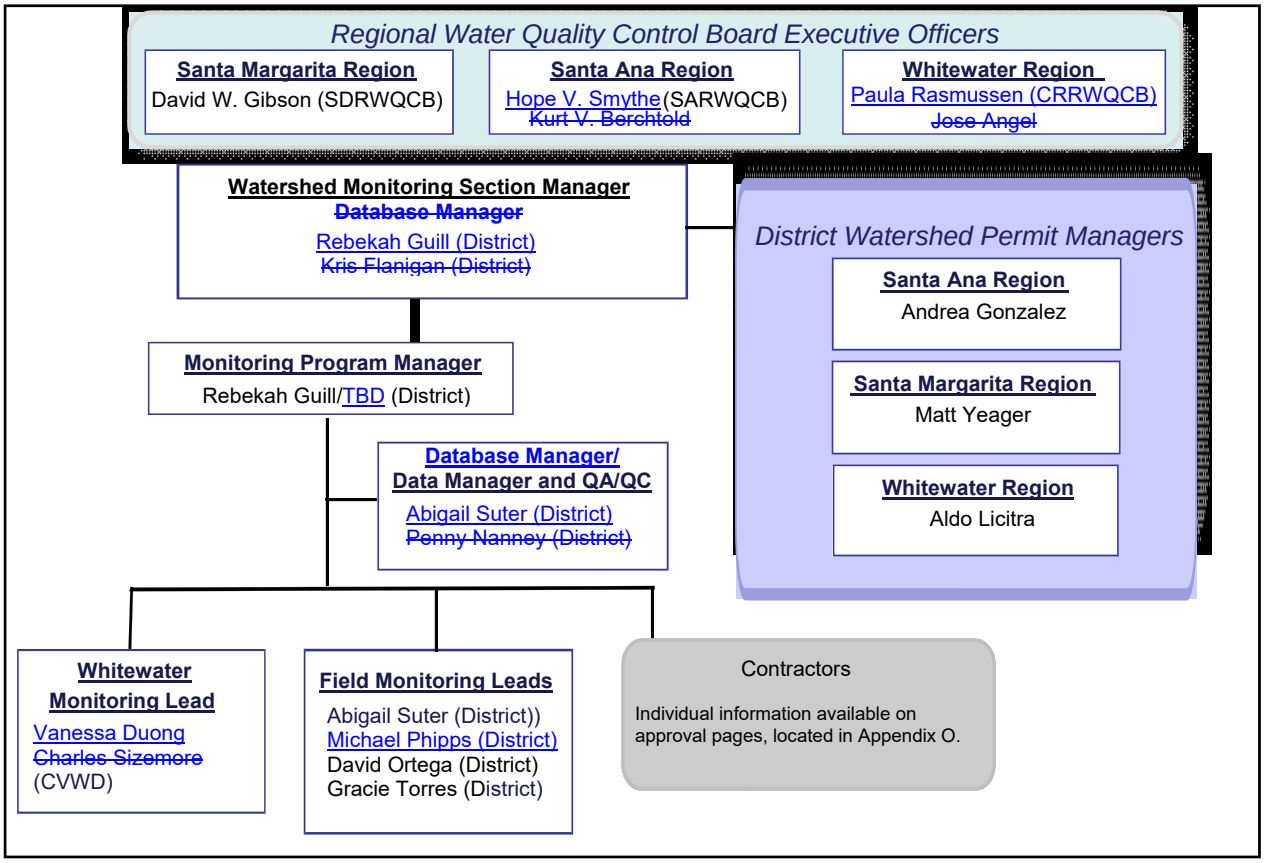
Consultant roles and responsibilities are available on the consultant approval pages in Appendix O.

Table 4-2: Program Personnel – Contact Information

Name	Organizational Affiliation	Title	Contact Information
David W. Gibson	San Diego Regional Board	Executive Officer	9174 Sky Park Court, Suite 100 San Diego, CA 92123-4340 Ph: 858.467.2952 (main) E-mail: dgibson@waterboards.ca.gov
~~Kurt V. Berchtold~~ Hope A. Smythe	Santa Ana Regional Board	Executive Officer	3737 Main Street, Suite 500 Riverside, CA 92501-3348 Ph: 951.782.4130 (main) 951.782.4493 (direct) E-mail: ~~kberchtold@waterboards.ca.gov~~ Hope.Smythe@waterboards.ca.gov
~~Jose Angel~~	Colorado River Regional Board	Executive Officer	73-720 Fred Waring Drive, Suite 100 Palm Desert, CA 92260 Ph: 760.346.7491 (main) E-mail: Jose.Angel@waterboards.ca.gov Paula.Rasmussen@waterboards.ca.gov
Edwin Quinonez	District	Chief of Watershed Protection Division	Ph: 951.955.1273 E-mail: eequinon@RIVCO.ORG
Rebekah Guill ~~Kris Flanigan~~	District	Watershed Monitoring Section Manager/ Monitoring Program Manager (Interim)	Ph: 951.955.2901 E-mail: rguill@RIVCO.org ~~Ph: 951.955.1346~~ ~~Email: kflaniga@riveo.org~~
TBD	District	Monitoring Program Manager	Ph: TBD E-mail: TBD
Abigail Suter	District	Database Manager/ Data Manager and QA/QC/ Field Monitoring Lead	Ph. 951.955.1734 E-mail: adsuter@RIVCO.org

Name	Organizational Affiliation	Title	Contact Information
Michael Phipps	District	Mobilization Technician/ Field Monitoring Lead/ Data QA/QC Support	Ph: 951.955.01263 E-mail: mjphipps@RIVCO.org
~~Penny Nanney~~	~~District~~	~~Data Manager and QA/QC~~	~~Ph: 951.955.1325~~ ~~E-Mail: pnanney@RIVCO.ORG~~ ~~pnanney@rcflood.org~~
David Ortega	District	IC/ID Officer/ Field Monitoring Lead	Ph. 951.955.4390 E-mail: djortega@RIVCO.org ~~djortega@rcflood.org~~
Vanessa Duong ~~Charles Sizemore~~	Coachella Valley Water District	Monitoring Program Manager	Ph: 760.398.2661 ext. 2782 E-mail: VDuong@cvwd.org ~~CSizemore@cvwd.org~~
Gracie Torres	District	Field Monitoring Lead ~~/Lab Manager~~	Ph: 951.955.0836 E-mail: graciela@RIVCO.org

Figure 4-1: Project Organizational Chart



4.2 Watershed Monitoring Section Manager's Role

Rebekah Guill ~~Kris Flanigan~~ is the District's Watershed Monitoring Section Manager. The Watershed Monitoring Section Manager's role is to establish the quality assurance and quality control procedures in this QAPP as part of the overall project, and to review and assess all procedures during the project against QAPP requirements. The District's Watershed Monitoring Section Manager, through the Monitoring Program Manager, will work closely with the consultants and laboratories to implement this project in compliance with the requirements of the QAPP. The District's Watershed Monitoring Section Manager and/or the District's Monitoring Program Manager may stop any actions, including those conducted by any laboratory or consultant if there are significant deviations from required practices or if there is evidence of a systematic failure.

4.3 Persons Responsible for QAPP Update and Maintenance

The District's Watershed Monitoring Section Manager and the Monitoring Program Manager are responsible for maintaining, revising, and updating this QAPP. The Watershed Monitoring Section Manager and Monitoring Program Manager will jointly be responsible for making the changes and making sure these updates are provided to each of the participating agencies.

5. PROBLEM DEFINITION/BACKGROUND

5.1 Problem Statement

According to the MS4 Permits for the SMR, SAR and WWR, the discharge of pollutants and/or increased flows from MS4s may threaten or impair beneficial uses or adversely affect human health. A number of receiving waterbodies within the Permittees' collective jurisdictional boundaries are listed as impaired on the Clean Water Act 40 CFR Section 303(d) list. Table 5-1 provides a summary of the ~~2010 303(d)~~ corresponding Clean Water Act 303(d) listings of impaired waterbodies by watershed and receiving water. The Permittees developed a Consolidated Program for Water Quality Monitoring (CMP) within their collective jurisdictional boundaries to meet the requirements of the MS4 Permits and manage the quality of urban runoff. The CMP has been implemented by the Permittees since 1994. The CMP is designed to characterize the potential sources and nature of discharges from urban land uses in order to develop effective management measures to protect the receiving waterbodies. ~~In April of 2017 the Santa Ana Regional Water Quality Board approved Order No. R8-2017-0013 with recommendations to the 303(d) list. This order has been sent to the State Water Board and upon their approval this list will be submitted to the U.S. EPA for approval. These anticipated changes, including delisting's, are shown in Table 5-2.~~

Table 5-1: Clean Water Act ~~2014/2016~~ 303(d) List

CWA ~~2010~~ 303(d) List		
Watershed	**Receiving Waterbody**	**Impairing Pollutants**
Santa Margarita Region (SMR) (by sub-area) 2014/2016 Integrated Report		
De Luz (HSA 902.21)	De Luz Creek	Iron Manganese Nitrogen Sulfates
Gavilan (HSA 902.22)	Sandia Creek	Iron Sulfates TDS Aluminum Ammonia (Unionized) Manganese Nitrogen Selenium Silver
	Santa Margarita River (Upper)	Phosphorus Toxicity Indicator Bacteria • *Enterococcus* Iron Manganese Nitrogen
Murrieta (HSA 902.32)	Long Canyon	Chlorpyrifos Iron Manganese Nitrogen Phosphorus ~~Fecal Coliform~~
French (HSA 902.33)	Warm Springs Creek	Chlorpyrifos Indicator Bacteria • *E.coli* • Fecal Coliform Iron Manganese Phosphorus ~~Total~~ Nitrogen ~~as N~~

Table 5-1 Clean Water Act ~~2014/2016~~ 303(d) List (continued)

2010 303(d) List		
Watershed	**Receiving Waterbody**	**Impairing Pollutants**
Santa Margarita Region (SMR) (by sub-area) 2014/2016 Integrated Report		
Gertrudis (HSA 902.42)	Santa Gertrudis Creek	Chlorpyrifos Copper Iron Manganese Phosphorus Nitrogen Indicator Bacteria ~~*E.coli*~~ ~~Fecal Coliform~~
Pauba (HSA 902.51)	Temecula Creek	Chlorpyrifos Copper Phosphorus TDS Toxicity Indicator Bacteria • *E.coli* • Fecal Coliform
	Redhawk Channel	Chlorpyrifos Copper Diazinon Indicator Bacteria • *E.coli* • Fecal Coliform Iron Manganese Nitrogen Phosphorus TDS
Wolf (HSA 902.52)	Murrieta Creek	Phosphorus Chlorpyrifos Copper Iron Manganese Nitrogen Toxicity Indicator Bacteria • Fecal Coliform
Lower Ysidora (HSA 902.11)	Santa Margarita River (Lower) [1]	Phosphorus Nitrogen Benthic Community Effects Chlorpyrifos Toxicity Indicator Bacteria ~~Enterococcus~~ ~~Fecal Coliform~~
	Santa Margarita Lagoon[1]	Eutrophic
Gavilan (HSA 902.22)	Rainbow Creek[1]	Iron Sulfates TDS Aluminum Nitrogen Phosphorus

2010 303(d) List		
Watershed	**Receiving Waterbody**	**Impairing Pollutants**
Santa Ana Region (SAR) 2014/2016 Integrated Report		
Middle Santa Ana River (HA Split 801.20)	~~Santa Ana River, Reach 2~~	~~Pathogens~~
	Santa Ana River, Reach 3	Copper ~~(wet only)~~ Lead Indicator Bacteria ~~Pathogens~~
	Santa Ana River, Reach 4	Indicator Bacteria ~~Pathogens~~
Perris Valley (HA 802.10)	Canyon Lake	~~Pathogens~~ Nutrients
Elsinore Valley (HA 802.30)	Lake Elsinore	PCBs Nutrients Organic Enrichment/Low DO Toxicity DDT ~~Sediment Toxicity~~ ~~Unknown Toxicity~~
~~Gilman Hot Springs (HSA 802.21)~~	~~Lake Fulmor~~	~~Pathogens~~
~~Temescal (HSA 801.25)~~	~~Temescal Creek, Reach 1~~	~~pH~~
Prado Basin Management Zone (HSA 801.21)	Prado Flood Control Basin	pH
Arlington (HSA 801.26)	Goldenstar Creek	Indicator Bacteria
Whitewater Region (WWR) 2010 Integrated Report		
Coachella HA 719.40	Coachella Valley Storm Water Channel	DDT* Dieldrin* PCBs* Toxaphene* Pathogens** Nitrogen, Total Ammonia Toxicity *Only applies to the 2 mile area from Lincoln Street to the Salton Sea. **Only applies to the 17 mile area from Dillion Road to the Salton Sea.

This table will be revised to reflect updates to the 303(d) List.

1. Waterbodies outside of Riverside County but within the watershed management area and applicable to the Riverside Permittees under the new Regional Permit.

~~Table 5-2: Proposed Santa Ana 2016 303(d) List~~

~~Watershed~~	~~Receiving Waterbody~~	~~Impairing Pollutants~~	~~Proposed Changes~~
~~Middle Santa Ana River HA Split 801.20~~	~~Santa Ana River, Reach 2~~	~~Pathogens~~	~~Delisted~~
	~~Santa Ana River, Reach 3~~	~~Copper (wet only)~~ ~~Lead~~	~~Delisted~~
~~Elsinore Valley HA 802.30~~	~~Lake Elsinore~~	~~DDT~~	~~New Listing~~
~~Gilman Hot Springs HSA 802.21~~	~~Lake Fulmor~~	~~Pathogens~~	~~Delisted~~

5.2 Decisions or Outcomes

The CMP is designed to assess the condition of the receiving waters, monitor pollutants in storm and non-stormwater effluent from the MS4, and conduct special studies to address Conditions of Concern. The CMP is intended to meet the following goals:

1. Assess compliance with Order Nos. R7-2013-0011, R8-2010-0033, and R9-2013-0001, as amended by Order Nos. R9-2015-0001 and R9-2015-0100;
2. Measure and improve the effectiveness of the Permittees' runoff management programs;
3. Assess the chemical, physical, and biological impacts to receiving waters resulting from MS4 discharges;
4. Characterize stormwater discharges;
5. Identify sources of specific pollutants;
6. Prioritize drainage and sub-drainage areas that need management actions;
7. Detect and eliminate IC/IDs to the MS4;
8. Assess the overall health of receiving waters; and
9. Provide information to implement required BMP improvements.

The goal of the MS4 Urban Runoff Program is to manage the quality of urban runoff to prevent impacts to receiving waters within the Permittees' collective jurisdictions. The CMP approach is driven by the following management questions:

1. Are conditions in receiving waters protective, or likely to be protective, of beneficial uses?
2. What is the extent and magnitude of the current or potential receiving water problems?
3. What is the relative MS4 discharge contribution to the receiving water problem(s)?
4. What are the sources of MS4 discharge that contribute to the receiving water problem(s)?
5. Are conditions in the receiving water getting better or worse?

This information will be provided to the Regional Boards in the Permittee's Monitoring Annual Reports. The Permittees participate in the Regional Watershed Monitoring Program which aims to address the following questions:

- What is the condition of streams in Southern California?
- What are the major stressors to aquatic life?
- Are conditions in locations of special interest getting better or worse?

The goal of this QAPP is to:

- Identify roles and responsibilities.
- Outline the monitoring programs implemented as part of the CMP in accordance with MS4 Permit requirements.
- Standardize the methods and procedures used by multiple entities implementing the CMP activities.
- Define quality assurance and control standards to generate data of consistent and known quality.
- Schedule the timeline for program implementation and deliverables to facilitate timely submittals.

5.3 Water Quality or Regulatory Criteria

Water quality or regulatory criteria will be used to initiate source investigations, further assessment of related Pollutants-of-Concern or Highest Priority Water Quality Conditions as applicable, and possible management strategies. These objectives will vary by Region, therefore, the numerical and narrative Water Quality Objectives WQOs) or other applicable criteria are provided in the individual SMR, SAR and WWR Monitoring Plans (Volumes III, IV and V, respectively).

6. PROJECT/TASK DESCRIPTION

6.1 Work Statement and Produced Products

As provided in the MS4 Permit Monitoring and Reporting Programs (MRPs), the monitoring programs include monitoring of receiving waters, MS4 discharge monitoring, and Illicit Connection/Illegal Discharge (IC/ID) monitoring, and various watershed-specific special studies. Additionally, all regions will continue to participate in regional monitoring programs such as Southern California Monitoring Coalition (SMC), the California Stormwater Quality Association (CASQA), and/or other regional groups or efforts.

Santa Margarita Region
The SMR Monitoring Programs include:

- Receiving Water Monitoring
  - Wet Weather
  - Dry Weather
  - Bioassessment
  - Hydromodification
  - Follow up Approach and Actions
  - Regional Programs
  - Sediment Quality

- MS4 Outfall Monitoring
  - Wet Weather
  - Dry Weather Field Screening
  - Non-Storm Water Persistent Flow MS4 Discharge

- Special Studies
  - WMA Special Study – SMRNIG Nutrient Initiative Study (In-kind Support Monitoring)
  - San Diego Region Special Study – SMC CLEAN
  - ~~Reference Stream Study~~ BIGHT 18'
  - Hydromodification
  - Regional Bioassessment Monitoring
  - Other Special Efforts (i.e., Intercalibrations, Reference Stream Study, etc.)

- IC/ID Program (Refer to local JRMPs)

Santa Ana Region
The SAR Monitoring Programs includes:

- Receiving Water Monitoring:
  - Receiving Water Monitoring
  - Water Column Toxicity
  - Bioassessments
  - Toxicity Identification Evaluation (TIE)/Toxicity Reduction Evaluation (TRE)

- MS4/Outfall Monitoring
  - Mass Emission Station Monitoring
  - Illicit Connection/Illegal Discharge (IC/ID) Monitoring

- Special Studies

- Middle Santa Ana River Bacterial Indicator TMDL Monitoring
- Lake Elsinore and Canyon Lake TMDL Monitoring
- Hydromodification
- Low Impact Development (LID) BMP Monitoring
- Regional Bioassessment Monitoring

Whitewater Region

The WWR Monitoring Programs includes:

- Receiving Water Monitoring
- MS4 Outfall and Illicit Connection/Illegal Discharge (IC/ID) Monitoring
- Special Studies (e.g., SMC projects)

6.2 Constituents to be Monitored and Measurement Techniques

Samples will be analyzed for conventional chemistry constituents, nutrients, metals, petroleum products, pesticides, organics and volatile organic compounds. Table 6-1 provides a master list of *in-situ* field parameters and associated units inclusive of all MS4 permits and monitoring programs. A master constituent list is provided in Table 6-2 providing constituents, target Reporting Limits (RL) and analytical method requirements inclusive of all three MS4 permits and monitoring programs. The District selected the most conservative RLs to meet or exceed the requirements of all the MS4 permits and to apply to all monitoring programs covered by this CMP. The MS4 permit-specific Monitoring Plans provided in Volumes II, III, and IV contain constituent lists tailored to each permit and monitoring program requirements. Inclusion of constituents in this master list does not imply that all constituents be analyzed in any given program; the master list includes all constituents that have the potential to be analyzed.

Project RLs have been set to reflect project-specific objectives, and are based on analytical methods, method detection limit (MDLs), or expected levels of target analytes, in accordance with the Surface Water Ambient Monitoring Program (SWAMP) (SWAMP, 2008). Per the SWAMP QAPrP (SWAMP, 2008), if a project's RLs exceed those presented in Appendix C of the SWAMP QAPrP there is no need to obtain a waiver.

SWAMP was developed to document ambient water quality conditions in surface waters and was not developed to monitor effluents or discharges covered under the MS4 permits and waste discharge requirements (SWAMP, 2008). SWAMP RLs are most applicable to the dry weather monitoring programs conducted in receiving waterbodies within the Regions. The wet weather event data and MS4 data are expected to have a different range of target analytes than dry weather data from receiving water stations. RLs in this table represent the State Board Minimum Level (ML) RLs, which are required under the MRP for constituents listed as Priority Pollutants in the California Toxics Rule (CTR), and SWAMP recommended RLs. The analytical laboratory will attempt to improve upon these RLs, and will provide a written explanation for any failure to meet them. Standard Method RLs will be used when no required RL is available.

Table 6-1: Master List of *In-situ* Field Parameters

Hydstra©	Parameter[a]	Units	Method
1435	Conductivity	µS/cm	Field Meter/SM 4500-O
1705/ 1710	Dissolved Oxygen	mg/L	Field Meter/SM 4500 H+B Lab method
1200/ 1205	pH	pH units	Field Meter/SM2510 B Lab method
1655	Temperature	°Celsius	Field Meter/SM2550 B
1690/ 1695 ~~810~~	Turbidity	NTU	Field Meter/SM2130B Lab method
1176	Total Residual Chlorine	mg/L	Field Meter/ SM 4500 Cl G Lab method

In-situ field parameters will be measured using a hand held meter. However, in the case of instrument malfunction, field crews may request the laboratory to analyze selected constituents using the methods listed.

Table 6-2: Master List of Analytical Constituents

Hydstra© No.	Constituent	Units	Method[1]	State Board ML	SWAMP Target RL	District Target RL
	Field Parameters					
1435	Dissolved Oxygen, field	mg/l	Field Meter/SM 4500-O	None	None	0.5
1705	pH, field	pH units	Field Meter/SM 4500 H+B	None	None	0-14
1200	Specific Conductance, field	µmhos/cm	Field Meter/SM 2510 B	None	2.5	2.5
1655	Temperature, field	°Celsius	Field Meter/SM 2550 B	None	None	None
1690	Turbidity, field	NTU	Field Meter/SM 2130B	None	1.0	0.5
	Conventionals, Nutrients, and Hydrocarbons					
1051	Ammonia as Nitrogen	mg/L	EPA 350.1 / EPA 350.3 / EPA 351.2 /SM 4500 NH3	None	0.02	0.02
1425	Biological Oxygen Demand (5 day)	mg/L	EPA 405.1 / SM 5210 B	None	2.0	2.0
1430	Chemical Oxygen Demand	mg/L	EPA 410.1-.4 / SM 5220 D	None	3.0	3.0
1195	Color	Units	SM 2120 B	None	None	3.0
1490	Dissolved Phosphorus	mg/L	EPA 365.2 / SM 4500 P B E	0.1	0.01	0.01
1154	Dissolved Organic Carbon	mg/L	EPA 415.1 / SM 5310 B	None	1.0	1.0
2300	Ethylene Glycol	mg/L	Colorimetric / EPA 8015 B	None	None	10
1225	Detergents - Methylene Blue Actives (MBAS)	mg/L	SM 5540 C	None	None	0.5
1340	Nitrate, as N	mg/L	EPA 300.0	None	0.01	0.01
1345	Nitrite, as N	mg/L	EPA 300.0 / SM 4500 NO2 B	None	0.01	0.01

Table 6-2: Master List of Analytical Constituents (continued)

Hydstra© No.	Constituent	Units	Method[1]	State Board ML	SWAMP Target RL	District Target RL
1360	Nitrogen, Total Kjeldahl (as N)	mg/L	EPA 351.2	None	0.5	0.5
1355	Nitrogen, Total	mg/L	Calculation	None	0.2	0.2
1365	Nitrogen, Total Inorganic	mg/L	Calculation	None	0.2	0.2
1350	Nitrogen, Total Organic	mg/L	Calculation	None	0.2	0.2
1380	Oil and Grease	mg/L	EPA 1664 A	None	1.4	1.4
1480	Ortho Phosphorus	mg/L	SM 4500 P E	None	0.01	0.01
1640	Sulfate	mg/L	EPA 300.0A / SM 54500-SO4 E	1.0	1.0	1.0
1625	Total Dissolved Solids	mg/L	SM 2540 C / EPA 160.1	None	10	10
1155	Total Organic Carbon	mg/L	SM 5310 B	None	1.0	1.0
1265	Total Hardness (as $CaCO_3$)	mg/L	SM 2340B/ EPA 200.7	None	1	1.0
1485	Total Phosphorus	mg/L	SM 4500-P B E	None	0.2	0.2
1500	Total Potassium	mg/L	EPA 200.7	None	1.0	1.0
1630	Total Suspended Solids	mg/L	SM 2540 D / EPA 160.2	None	2.0	2.0
1272	Diesel Range Hydrocarbons[2]	mg/L	EPA 8015 M	None	None	5.0
1273	Gasoline Range Hydrocarbons[2]	mg/L	EPA 8015 M	None	None	0.05
	Metals (Total / Dissolved)					
1040/ 1041	Aluminum	µg/L	EPA 200.7	None	0.15	0.15
1065 /1064	Antimony	µg/L	EPA 200.8	0.5	0.2	0.2
1070 /1071	Arsenic	µg/L	EPA 200.8/ EPA 1632	2.0	0.3	0.3
1090 /1088	Barium	µg/L	EPA 200.8	None	None	1.0
1120 /1119	Beryllium	µg/L	EPA 200.8	0.5	None	0.5
1135 /1136	Boron	µg/L	EPA 200.7/200.8	None	10	10
1145 /1148	Cadmium	µg/L	EPA 200.8	0.25	0.03	0.03
1185 /1184	Chromium, Hexavalent	µg/L	EPA 218.6/ EPA 200.8	None	0.9	0.9
1180 /1181	Chromium, Total	µg/L	EPA 200.8	0.5	0.3	0.3
1186 /1187	Chromium, Trivalent	µg/L	Calculation/ EPA 200.8	None	None	0.1
1210 /1209	Copper	µg/L	EPA 200.8	0.5	0.1	0.1
1285 /1284	Iron	µg/L	EPA 200.7/ EPA 300.0A/6010A	None	100	20
1290 /1287	Lead	µg/L	EPA 200.8	0.5	2	0.5

Table 6-2: Master List of Analytical Constituents (continued)

Hydstra© No.	Constituent	Units	Method[1]	State Board ML	SWAMP Target RL	District Target RL
1305 /1298	Manganese	µg/L	EPA 200.8	1.0	60	10
1310 /1316	Mercury	µg/L	EPA 200.8	0.5	0.002	0.002
1320 /1319	Nickel	µg/L	EPA 200.8	1.0	0.6	0.6
1520 /1521	Selenium	µg/L	EPA 200.8	2.0	1.0	1.0
1535 /1534	Silver	µg/L	EPA 200.8	0.25	0.45	0.25
1665 /1666	Thallium	µg/L	EPA 200.8	1.0	1.0	1.0
1700 /1701	Zinc	µg/L	EPA 200.8	1.0	0.7	0.7
	Microbiology					
1077	*Escherichia coli*	MPN/100mL	SM 9221 E	None	2	2
1087	*Enterococcus*	MPN/100mL	SM 9230B /EPA 1600	None	1	1
1075	Fecal Coliform	MPN/100mL	SM 9221 E	None	2	2
1080	Fecal Streptococci	MPN/100mL	SM 9230B	None	None	2
1085	Total Coliform	MPN/100mL	SM 9221 B	None	2	2
	Semi-Volatile Compounds[3]					
1131	Bis(2-Ethylhexyl)Phthalate	µg/L	EPA 625C SIM	5	10	5
	Organics, PAHs[3]					
1097	Benzo(b)Fluoranthene	µg/L	EPA 625C SIM/ EPA 8270 SIM	None	10	10
1098	Benzo(ghi)Perylene	µg/L	EPA 625C SIM/ EPA 8270 SIM	5	10	5
2240	Chrysene	µg/L	EPA 625C SIM/ EPA 8270 SIM	10	0.005	0.005
1245	Fluoranthene	µg/L	EPA 625C SIM/ EPA 8270 SIM	1	10	1
1250	Fluorene	µg/L	EPA 625C SIM/ EPA 8270 SIM	10	10	10
2335	Indeno(1,2,3-cd)Pyrene	µg/L	EPA 625C SIM/ EPA 8270 SIM	10	0.005	0.005
1315	Naphthalene	µg/L	EPA 625C SIM/ EPA 8270 SIM	1	10	1
1455	Phenanthrene	µg/L	EPA 625C SIM/ EPA 8270 SIM	5	10	5
1505	Pyrene	µg/L	EPA 625C SIM/ EPA 8270 SIM	10	10	10

Table 6-2: Master List of Analytical Constituents (continued)

Hydstra© No.	Constituent	Units	Method[1]	State Board ML	SWAMP Target RL	District Target RL
	Pesticides[3]					
1073	Aspon	µg/L	EPA 8270M-OP	None	NA	0.05
1068	Azinphos-ethyl	µg/L	EPA 8270M-OP	None	0.08	0.08
1069	Azinphos-methyl	µg/L	EPA 8270M-OP	None	0.2	0.2
1153	Carbophenothion	µg/L	EPA 8270M-OP	None	0.1	0.1
1163	Chlorfenvinphos	µg/L	EPA 8270M-OP	None	0.05	0.05
1174	Chlorpyrifos	µg/L	EPA 8270M-OP	None	0.05	0.05
1179	Chlorpyrifos methyl	µg/L	EPA 8270M-OP	None	0.05	0.05
1214	Ciodrin (Crotoxyphos)	µg/L	EPA 8270M-OP	None	None	0.05
1213	Coumaphos	µg/L	EPA 8270M-OP	None	0.4	0.4
1219	Demeton-S	µg/L	EPA 8270M-OP	None	0.1	0.1
1227	Diazinon	µg/L	EPA 8270M-OP	None	0.05	0.05
1314	Dibrom (Naled)	µg/L	EPA 8270M-OP	None	75	0.05
1229	Dichlofenthion	µg/L	EPA 8270M-OP	None	0.05	0.05
1239	Dichlorvos	µg/L	EPA 8270M-OP	None	0.6	0.6
1226	Dicrotophos	µg/L	EPA 8270M-OP	None	10	10
1221	Dimethoate	µg/L	EPA 8270M-OP	None	0.2	0.2
1223	Dioxathion	µg/L	EPA 8270M-OP	None	NA	0.05
1224	Disulfoton	µg/L	EPA 8270M-OP	None	0.1	0.1
1242	Ethion	µg/L	EPA 8270M-OP	None	0.05	0.05
1244	Ethyl Parathion	µg/L	EPA 8270M-OP	None	None	0.05
1246	Famphur	µg/L	EPA 8270M-OP	None	0.05	0.05
1247	Fenitrothion	µg/L	EPA 8270M-OP	None	0.05	0.05
1248	Fensulfothion	µg/L	EPA 8270M-OP	None	0.2	0.2
1249	Fenthion (Mercaptophos)	µg/L	EPA 8270M-OP	None	0.05	0.05
1256	Fonophos (Dyfonate)	µg/L	EPA 8270M-OP	None	0.05	0.05
1291	Leptophos	µg/L	EPA 8270M-OP	None	0.05	0.05
1301	Malathion	µg/L	EPA 8270M-OP	None	0.1	0.1
1302	Merphos	µg/L	EPA 8270M-OP	None	0.05	0.05
1304	Mevinphos	µg/L	EPA 8270M-OP	None	0.05	0.05

Table 6-2: Master List of Analytical Constituents (continued)

Hydstra© No.	Constituent	Units	Method[1]	State Board ML	SWAMP Target RL	District Target RL
	Pesticides					
1303	Methyl Parathion	µg/L	EPA 8270M-OP	None	None	0.05
1461	Phorate	µg/L	EPA 8270M-OP	None	0.1	0.1
1463	Phosmet	µg/L	EPA 8270M-OP	None	0.2	0.2
1464	Phosphamidon	µg/L	EPA 8270M-OP	None	100	0.05
1243	Prophos (Ethoprop)	µg/L	EPA 8270M-OP	None	0.1	0.1
1651	Sulfotep	µg/L	EPA 8270M-OP	None	0.05	0.05
1132	Sulprofos (Bolstar)	µg/L	EPA 8270M-OP	None	0.2	0.2
1663	Terbufos	µg/L	EPA 8270M-OP	None	0.05	0.05
1633	Tetrachlorvinphos (Stirifos)	µg/L	EPA 8270M-OP	None	None	0.05
1672	Thionzin (Thionazin)	µg/L	EPA 8270M-OP	None	0.05	0.05
1673	Tokuthion	µg/L	EPA 8270M-OP	None	0.05	0.05
1687	Trichlorfon	µg/L	EPA 8270M-OP	None	NA	0.05
1688	Trichloronate	µg/L	EPA 8270M-OP	None	0.05	0.05
2135	4,4'-DDD	µg/L	EPA 608M	0.05	0.002	0.002
2140	4,4'-DDE	µg/L	EPA 608M	0.05	0.002	0.002
2145	4,4'-DDT	µg/L	EPA 608M	0.01	0.002	0.002
1013	Aldrin	µg/L	EPA 608M	0.005	0.002	0.002
2170	alpha-BHC (alpha-HCH)	µg/L	EPA 608M	0.01	0.002	0.002
2270	alpha-Endosulfan (Endosulfan I)	µg/L	EPA 608M	0.02	0.002	0.002
2210	beta-BHC (beta-HCH)	µg/L	EPA 608M	0.005	0.002	0.002
2265	beta-Endosulfan (Endosulfan II)	µg/L	EPA 608M	0.01	0.002	0.002
2215	Chlordane	µg/L	EPA 608M	0.1	0.002	0.002
1174	Chlorpyrifos	µg/L	EPA 8270M-OP	None	0.05	0.05
2250	delta-BHC (delta-HCH)	µg/L	EPA 608M	0.005	0.002	0.002
1715	Diazinon	µg/L	EPA 8270M-OP	None	0.05	0.05
1233	Dieldrin	µg/L	EPA 608M	0.01	0.002	0.002
2275	Endosulfan Sulfate	µg/L	EPA 608M	0.05	0.002	0.002
2285	Endrin	µg/L	EPA 608M	0.01	0.002	0.002
2280	Endrin Aldehyde	µg/L	EPA 608M	0.01	0.002	0.002
1292	gamma-BHC (lindane) (gamma-HCH)	µg/L	EPA 608M	0.02	0.002	0.002

Table 6-2: Master List of Analytical Constituents (continued)

Hydstra© No.	Constituent	Units	Method[1]	State Board ML	SWAMP Target RL	District Target RL
	Pesticides					
2310	Heptachlor	µg/L	EPA 608M	0.01	0.002	0.002
2305	Heptachlor Epoxide	µg/L	EPA 608M	0.01	0.002	0.002
1681	Toxaphene	µg/L	EPA 608M	0.5	0.75	0.5
	Polychlorinated Biphenyls (PCBs)					
2175	Aroclor-1016	µg/L	EPA 608M	0.5	0.002	0.002
2180	Aroclor -1221	µg/L	EPA 608M	0.5	0.002	0.002
2185	Aroclor -1232	µg/L	EPA 608M	0.5	0.002	0.002
2190	Aroclor -1242	µg/L	EPA 608M	0.5	0.002	0.002
2195	Aroclor -1248	µg/L	EPA 608M	0.5	0.002	0.002
2200	Aroclor -1254	µg/L	EPA 608M	0.5	0.002	0.002
2205	Aroclor -1260	µg/L	EPA 608M	0.5	0.002	0.002
	Pyrethroids					
2412	Bifenthrin	ng/L	EPA 1660M-Pyrethroids	None	0.002	0.002
2414	Cyfluthrin	ng/L	EPA 1660M-Pyrethroids	None	0.005	0.005
2428	Cyhalothrin-lambda	ng/L	EPA 1660M-Pyrethroids	None	0.0005	0.0005
2416	Cypermethrin	ng/L	EPA 1660M-Pyrethroids	None	0.005	0.005
2418	Danitol (Fenpropathrin)	ng/L	EPA 1660M-Pyrethroids	None	0.002	0.002
2420	Deltamethrin	ng/L	EPA 1660M-Pyrethroids	None	0.005	0.005
2422	Esfenvalerate	ng/L	EPA 1660M-Pyrethroids	None	0.002	0.002
2424	Fenvalerate	ng/L	EPA 1660M-Pyrethroids	None	0.002	0.002
2429	Permethrin, -cis	ng/L	EPA 1660M-Pyrethroids	None	0.005	
2431	Permethrin, -trans	ng/L	EPA 1660M-Pyrethroids	None	0.01	
2430	Permethrin, TOTAL	ng/L	EPA 1660M-Pyrethroids	None	None	0.005

Table 6-2: Master List of Analytical Constituents (continued)

Hydstra© No.	Constituent	Units	Method[1]	State Board ML	SWAMP Target RL	District Target RL
	Volatiles					
2000	1,1,1-Trichloroethane	µg/L	EPA 624	2	5	2
2005	1,1,2,2-Tetrachloroethane	µg/L	EPA 624	1	5	1
2010	1,1,2-Trichloroethane	µg/L	EPA 624	2	5	2
2015	1,1-Dichloroethane	µg/L	EPA 624	1	5	1
2040	1,2-Dichloroethane	µg/L	EPA 624	2	5	2
2045	1,2-Dichloropropane	µg/L	EPA 624	1	5	1
2030	1,2-Dichlorobenzene	µg/L	EPA 624	2	5	2
2055	1,3-Dichlorobenzene	µg/L	EPA 624	2	5	2
2060	1,4-Dichlorobenzene	µg/L	EPA 624	2	5	2
1682	1,2-Trans-Dichloroethylene	µg/L	EPA 624	1	5	1
2105	2-Chloroethylvinyl Ether	µg/L	EPA 624	1	None	1
1092	Benzene	µg/L	EPA 624	2	5	2
1142	Bromoform	µg/L	EPA 624	2	5	2
1156	Carbon Tetrachloride	µg/L	EPA 624	2	5	2
2220	Chlorobenzene	µg/L	EPA 624	2	5	2
1231	Chlorodibromomethane	µg/L	EPA 624	2	5	2
2230	Chloroform	µg/L	EPA 624	2	5	2
1141	Dichlorobromomethane	µg/L	EPA 624	2	5	2
2290	Ethylbenzene	µg/L	EPA 624	2	5	2
2235	Methyl Chloride	µg/L	EPA 624	2	0.1	0.1
1661	Tetrachloroethylene	µg/L	EPA 624	2	5	2
1671	Toluene	µg/L	EPA 624	2	5	2
1684	Trichloroethylene	µg/L	EPA 624	2	5	2

Table 6-2: Master List of Analytical Constituents (continued)

Hydstra© No.	Constituent	Units	Method[1]	State Board ML	SWAMP Target RL	District Target RL
	Other Toxic Pollutants					
1215	Cyanide, total	µg/L	SM 4500 CNE	5.0	None	5.0
1460	Phenols, total	µg/L	EPA 420.4	None	None	0.02
	Toxicity					
2506	*Ceriodaphnia dubia,* acute	% survival	EPA-821-R-02-012	None	None	None
2505	*Ceriodaphnia dubia,* chronic	% survival	EPA-821-R-02-013	None	None	None
2401	*Pimephales promelas*, acute	% survival	EPA-821-R-02-012	None	None	None
--	*Pimephales promelas,* chronic	% survival/ growth	EPA-821-R-02-013	None	None	None
2400	*Hyalella azteca*, acute	% survival	EPA-821-R-02-012	None	None	None
--	*Hyalella azteca,* chronic	% survival/ growth	EPA-821-R-02-013	None	None	None
2403	*Pseudokirchneriella subcapitata,* chronic	% growth	EPA-821-R-02-013	None	None	None
	Biological					
--	Riparian Condition (CRAM)	--	SWAMP	--	--	--
--	Physical Habitat (PHAB)	--	SWAMP	--	--	--
--	Benthic Macroinvertebrates Taxonomy	--	SWAMP	--	--	--
--	Periphyton (algae): Ash-free dry mass	--	SWAMP	--	--	--
--	Periphyton (algae): Chlorophyll-a	--	SWAMP	--	--	--
--	Periphyton (algae): Taxonomy (diatoms)	--	SWAMP	--	--	--
--	Periphyton (algae): Taxonomy (soft body)	--	SWAMP	--	--	--

[1] Or ELAP certified laboratory recommended equivalent method may be used.
[2] Method for Total Petroleum Hydrocarbons now analyzed and reported as Gasoline, and Diesel, range hydrocarbons.
[3] During the 2013-2014 Annual Report development, the District performed an extensive analysis to conservatively identify parameters that could be removed from monitoring based on Permit criteria (MRP Section III.E.1(b)(iv)) with additional discussions and guidance received from the Regional Board the following year. Constituents with analytical detection limits that were above corresponding CTR/Basin Plan WQOs or MSGP benchmarks (current 2008 MSGP) were not removed. The updated monitoring lists were implemented in the 2015-2016 monitoring year and included 170 constituents for the receiving water stations and from 132 to 167 constituents for the MS4 outfall stations (varying between events and event types).

6.3 Program Schedule

Table 6-3 presents a schedule for the CMP workplans, monitoring and data deliverables, and reports including completion dates and frequency of submittal. Program deliverables are described in Section 21 of this document and in further detail in the Monitoring Plans provided in Volumes II, III and IV of the CMP.

Table 6-3: Program Schedule Timeline

Submittal	Completion Date	Frequency
SMR Reports and Plans		
Report Of Waste Discharge	December 27, 2017	One Time
Regional Monitoring Assessment Report	December 27, 2017	One Time
Transitional Monitoring Assessment Report	January 31, 2018	One Time
Water Quality Improvement Plan	January 5, 2018	One Time
Water Quality Improvement Plan Annual Reports	January 31	Annual
SAR Reports and Plans		
Report Of Waste Discharge	July 29, 2014	One Time
Annual Monitoring Report	November 30	Annual
WWR Reports and Plans		
Report Of Waste Discharge	December 23, 2017	One Time
Trash Amendment Assessment Report	December 1, 2018	One Time
Annual Monitoring Report	March 1	Annual
Monitoring and Data Deliverables		
Monitoring Deliverables include Post-storm Tech Memos and Post-event Tech Memos	Within 10 days of monitoring activity	Per event
Analytical Laboratory Reports and EDDs	Within 3 weeks of sample receipt *(BMI data within 6 weeks of sample receipt)*	Per event
Annual Data Deliverable	Submit with Annual Reports	Annual

6.4 Geographical Setting

The District is comprised of 2,700 square miles with three distinct watersheds, the Santa Margarita River, the Santa Ana River and the Whitewater River. Each watershed is governed by a separate Regional Water Quality Control Board (San Diego, Santa Ana, and Colorado River Basin, respectively) and MS4 permits. The District extends from the northwest portion of Riverside County east to Desert Hot Springs and Palm Springs, and south to San Diego County through the Temecula area, and has jurisdiction over the western 40% of Riverside County.

The Santa Margarita River Watershed within the Permittee's jurisdiction is located in the south to southwest portion of the District, and is referred to as the Santa Margarita Region (SMR). The Lower Santa Margarita Watershed, located in the northern portion of San Diego County, including Camp Pendleton, is governed by a separate MS4 permit and not within the Permittee's jurisdiction. The SMR is the portion of the watershed upstream of the confluence of Murrieta and Temecula Creeks and is located in the south and southwest portions of the District. The SMR encompasses 576 square miles and includes five municipalities within Riverside County. Assessor's parcel data shows that land uses are predominately non-urban, comprising over 80% of the SMR (this does not take into account reference siting criteria for monitoring sites pursuant to the 2010 Order). As of August 1, 2016, the population of Riverside County was about 2.35 million. About 13% of the population, or 310,000 people, reside in the SMR. Roughly

22% of that population lives in unincorporated areas, with the rest residing in the cities of Menifee, Murrieta, Temecula and Wildomar.

The Santa Ana River Watershed within the Permittees' jurisdiction is located in the northwestern corner of Riverside County, and is referred to as the Santa Ana Region (SAR). The SAR is bounded on the south by the SMR, on the east by the Salton Sea Watershed, on the southwest by Orange County and on the northwest by San Bernardino County. The SAR, including the San Jacinto River subwatershed, encompasses 1,603 square miles (22 % of the 7,300 square miles within Riverside County) and includes 12 of the 24 municipalities within Riverside County. About 1,531,350 (65% of the Riverside County population) live within the SAR - approximately 1,316,900 persons residing within the 15 municipalities and an additional 214,450 persons residing in the unincorporated area.

The Whitewater River Watershed within the Co-Permittees' jurisdiction is located in the eastern portion of the District, and is referred to as the Whitewater River Region (WWR). The WWR is bound by the San Gorgonio Pass and extends southeast through the urbanized areas of Coachella Valley to the Salton Sea. The San Jacinto Mountains bound the Coachella Valley in the southwest, and the San Gorgonio Mountains, Indio Hills and Mecca Hills bound the Coachella Valley in the northeast. The generally northwest to southeast trending drainage area of the Coachella Valley is part of the Salton Basin, a large low-lying area within the Colorado Desert. The majority of the valley drains to the Whitewater River and its tributaries, which discharge into the northern portion of the Salton Sea. The WWR encompasses 350 square miles and includes 13 municipalities within Riverside County. Land uses are predominately non-urban, comprising over 60% of the watershed and do not fall under the jurisdiction of the District under the 2013 WWR Permit. Urban land uses, such as residential, commercial and industrial, encompass 3.5% of the WWR. As of 2016, the population of the urbanized areas of the WWR was approximately 480,000, with roughly 78,000 of that population residing in unincorporated areas of Riverside County.

6.5 Constraints

There are access, safety, and time constraints for site selection and implementation of sampling activities covered under the CMP:

- Special Studies: Special studies that require separate Quality Assurance Plans will be included in their individual Work Plans and/or as an addendum to this QAPP.
- Monitoring Program Updates: New monitoring programs will require field reconnaissance to identify sample locations representative of the targeted conditions. Appendix C of the QAPP will be updated to include the sample locations, GPS coordinates and site description.
- Permission to install equipment from the jurisdiction's Operations and Maintenance Department: Installation of equipment must not interfere with the functional operations of the surrounding facility or activity.
- Coordination with the Department of Fish and Wildlife: If sampling sites are located within a restricted access Department of Fish and Wildlife park or property then the field team must acquire the necessary permit(s) to remove samples from creeks and/or surrounding habitat, to access the property, and to install permanent or semi-permanent equipment.
- Compliance with black-out periods established by the California Department of Fish and Wildlife and/or established periods of sensitivity (i.e., nesting, mating, and spawning) of endangered species that have been determined to inhabit sampling areas.
- Coordination with city or private property owners: The Field Monitoring Coordinator will work with the District to contact cities and/or private property owners to make the necessary arrangements to sample.
- Unsafe or hazardous sampling conditions: Safety concerns will be addressed on a site-by-site basis to avoid sampling in unsafe conditions. Due to the hazard of flash flooding in the WWR, sampling will be conducted when there is sufficient sunlight and no sampling will occur when there is a flash flood warning or watch.
- Wet weather monitoring events will not take typically take place during recognized District and laboratory holiday closures. Please refer to Section 10.3 Staffing for a list of closure dates.

7. QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

Field and laboratory data quality objectives have been selected to specify an acceptable range of quantity and quality of data to support the program objectives. The data quality categories are described below. Data quality objectives for all laboratory testing are for accuracy, precision and completeness. . Field data quality objectives are provided in Table 7-2 and analytical data quality objectives are provided in Table 7-3.

Accuracy is the closeness or agreement of the test response to the true or reference value. Accuracy will be determined by measuring one or more analytes selected from performance testing samples or standard solutions from sources other than those used for calibration. The accuracy of chemical measurements will be checked by performing tests on standards prior to and/or during sample analysis at the laboratory. The concentration of the standards will be unknown to the analyst until after measurements are determined.

Recovery is the accuracy of an analytical test measured against a known analyte addition to a sample, such as with a matrix spike. Recovery measurements will be determined by laboratory spiking of a replicate sample with a known analyte concentration at two times the original sample concentration when possible. If recoveries are not within the accepted criteria, including the respective laboratory's acceptance criteria, the sample shall be reprocessed for re-analysis.

For this program, accuracy will be measured by method blanks, matrix spikes, Standard Reference Materials (SRM) and laboratory control samples. For microbiology, positive and negative controls will be used to assess accuracy.

Precision describes how well repeated measurements agree. Precision measurements will be determined on laboratory replicates. Precision objectives apply to replicate/split samples collected during field sampling and laboratory analysis as part of Quality Control requirements. For this program, precision will be measured by matrix spikes duplicates, laboratory duplicates and field duplicates.

Completeness is the number of analyses generating useable data for each analysis divided by the number of samples collected for that analysis. The method used under this QAPP to determine completeness is a comparison of the number of measurements anticipated to be collected against the number of measurements actually collected that meet their respective data quality objectives. It is expected that 90 percent of all measurements will be taken as anticipated, including accounting for adverse weather conditions, safety concerns and equipment problems.

SWAMP Target RLs, when available, are included to account for method sensitivity in addition to State Board MLs. Laboratory RLs may also be utilized when they are more stringent than those recommended by SWAMP. The analytical laboratory will attempt to improve upon these RLs, and will provide a written explanation for any failure to meet them. Standard Method RLs will be used when no required RL is available. Specific data quality objectives are presented in Tables 7-2 and 7-3.

Table 7-2: Data Quality Objectives for Field Measurements

Group	Parameter	Unit	Accuracy	Precision	Range	Completeness
Field Parameters	Conductivity	µS/cm	±3%	±1%	0-9.99%	90%
	Dissolved Oxygen	mg/L	±0.2 or ±2% air	0.1 or ±1% air	0-19.99 or 0-199% saturated air	90%

Group	Parameter	Unit	Accuracy	Precision	Range	Completeness
	pH	pH units	±0.1	±0.05	0-14	90%
	Temperature	°Celsius	±1	±0.3	0-55	90%
	Turbidity	NTU	±5	±3	0-800	90%

Note: SWAMP requirement present, recommendations only.

Table 7-3: Data Quality Objectives for Laboratory Analyses

Group	Constituent	Units	Accuracy	Precision (% RPD)	Recovery	Completeness
General Chemistry (Water Analysis)	All Constituents	Varied	80-120	0-25	80-120%	90%
Metals (Water Analysis)	Total and Dissolved Trace Metals	µg/L	50-155%	0-25	75-125%	90%
Microbiology (Water Analysis)	All Constituents	Varied	NA	0-25	NA	90%
Nutrients (Water Analysis)	All Constituents	mg/l	70-130%	0-25	80-120%	90%
Organics (Water Analysis)	Polynuclear Aromatic Hydrocarbons, Pesticides, and PCBs	ng/L	50-150	0-25	10-210%	90%
	Volatiles	µg/L	50-150	0-25	10-210%	90%
	Synthetic Pyrethroid Pesticides	ng/L	65-125%	0-25	10-210%	90%
Other Toxicants	All Constituents	µg/L				90%
Toxicity (Water Analysis)	Acute and Chronic	% survival	The Reference Toxicant Test result must fall within 2 standard deviations of the cumulative mean. No statistical difference for lab control water.	NA	NA	90%

Notes:

- Any changes made by the Laboratory related to the data quality objectives will be discussed on a case-by-case basis to determine if data validation is either acceptable by standards of analytical industry practice, or will be reported with the respective Annual Report if determined that the data quality is compromised.
- Target RLs are provided for each constituent in Table 6-2.

8. SPECIAL TRAINING NEEDS/CERTIFICATION

8.1 Specialized Training or Certifications

All primary and secondary monitoring field staff are required to receive training in safety and sampling protocols and procedures prior to engaging in any field activities. Several of the primary and secondary field samplers for the District are also named in the District's Storm Patrol Manual within the listing of the Storm Patrol Assignments. The District's Storm Patrol Manual is updated annually. District field crews typically include lead staff experienced in the monitoring requirements of the permits, and may also be accompanied by support staff and other volunteers as needed. At a minimum, sampling personnel will have completed the following annual training:

- Safety awareness;
- Review of field sampling hazards, safety rules and pre-sampling site visit;
- Sample handling, storage, and transport,
- Document retention,
- Field equipment use and calibration; and
- Sampling Standard Operating Procedures (SOPs) in accordance with the QAPP and Monitoring Plans.

E. S. Babcock and Sons, Inc., Environmental Laboratories (Babcock) is certified for chemical testing by the National Environmental Lab Accreditation Program (NELAP, No. 02101CA) and the California Environmental Laboratory Approval Program (CA ELAP, No. 2698). If any subcontractors are utilized by consultants or laboratories, they too must adhere to the training and certification requirements described.

8.2 Training and Certification Documentation

The District, sampling agencies, monitoring and laboratory consultants will maintain records of training at their respective offices as presented in Table 8-1. Documentation includes the date of the training, the topic and the name of the instructor.

8.3 Training Personnel

Field crews will be properly trained in the use of monitoring equipment and proper sampling techniques in accordance with the QAPP and Monitoring Plans by the District, sampling agencies and monitoring consultants. The respective consultant Project Managers and/or Monitoring Leads are responsible for training field staff prior to field activities and conducting training sessions as needed throughout the course of the program.

Laboratory analysts shall be properly trained in analytical methods and clean analysis techniques.

Table 8-1: Specialized Personnel Training or Certification

Specialized Training Course Title or Description	Training Provider	Personnel Receiving Training/ Organizational Affiliation	Location of Records and Certificates[1]
District Sampling SOPs and Health and Safety Training[2]	District Monitoring Program Manager	District Field Sampling Staff	1995 Market Street Riverside, CA 92501
Agency Sampling SOPs and Health and Safety Training[2]	Agency Project Manager or Monitoring Lead	Agency Field Staff	(see respective Agency approval pages located in Appendix O)
Consultant Sampling SOPs and Health and Safety Training[2]	Consultant Project Manager or Monitoring Lead	Consultant Project Team Field Staff	(see respective Consultant approval pages)
Laboratory Certifications	Laboratory Project Manager	Laboratory Staff	(see respective Consultant approval pages)

[1] Training records are kept at each agency or consultant's respective offices.
[2] See Appendix J for District Health and Safety Procedures.

9. DOCUMENTS AND RECORDS

Ultimately, all electronic data generated by the CMP will be managed and stored by the District. Upon completion of each year's monitoring activities, all data and records will be managed and kept by the District. Copies of records will be maintained for a minimum of five years after project completion. Additional information on document and record retention is contained in Table 9-1 below.

Project plans will be distributed to the participating entities and the District will retain a copy of the final project plans and a record of any amendments conducted throughout the course of the project. Laboratories and the District will store laboratory results and COC forms for five years from the time the annual data deliverable is submitted. All field observations and measurements will be recorded in the field data sheet provided in Appendix B. Field data sheets include sample collection records, field measurements, field observation records, and any deviations from standard sampling protocols. Field data sheets and COCs will be scanned and stored in electronic *.pdf format by the District's Program Manager for a minimum of five years from the time the study is completed. Data records will be maintained by the consultant's Project Team and by the District for a minimum of five years from the time the annual data deliverable is submitted. Project reports will be maintained by the District.

Table 9-1: Document and Record Retention, Archival, and Disposition Information

	Identify Type Needed	Retention	Archival	Disposition
Project Plans	QAPP	District	The District will retain a copy and review after each event.	The District will retain a copy for final disposition.
	Monitoring Plans	District	The District will retain a copy and review after each event.	The District will retain a copy for final disposition.
Analytical Records	Laboratory Reports	District, Laboratory Consultant(s)	The District will retain a copy and review after each event.	The District will retain a copy for final disposition.
	EDD	District, Laboratory Consultant(s)	The District will retain a copy and review after each event.	The District will retain a copy for final disposition.
Data Records	Stream Assessment Data and Hydrology Data	District, Monitoring Consultant(s)	The District will retain a copy and review after each event.	The District will retain a copy for final disposition.
Monitoring Reports	Monitoring Annual Reports	District	The District will retain a copy and review after each event.	The District will retain a copy for final disposition.
Annual Reports	Annual Reports	District	The District will retain a copy and review after each event.	The District will retain a copy for final disposition.

GROUP B ELEMENTS: DATA GENERATION AND ACQUISITION

10. SAMPLING PROCESS DESIGN

The QAPP describes the purpose, frequency and type of sampling conducted for each monitoring program included in the CMP. Additional details of the sampling process and design are discussed in the SMR, SAR, and WWR Monitoring Plans, provided as Volumes III, IV and V respectively, of the CMP.

10.1 Summary of Monitoring Programs

10.1.1 Santa Margarita Region

On May 8, 2013, the San Diego Regional Water Board adopted a Regional Permit, National Pollutant Discharge Elimination (NPDES) Permit, Order No. R9-2013-0001. The Permit was later amended by Order Nos. R9-2015-0001 (adopted February 11, 2015 and effective April 1, 2015) and R9-2015-0100 (adopted November 18, 2015 and effective January 7, 2016). The adoption of the November 2015 amendment marked the enrollment of the Riverside County Co-Permittees under the Regional Permit.

Included in the new Permit were provisions for development of Water Quality Improvement Plans (WQIP) that Co-Permittees must implement. The WQIP's are designed for restoring water quality and protecting the beneficial uses of waterbodies within each watershed of the San Diego Region. Co-Permittees are responsible for prioritizing water quality conditions and development of strategies that improve the quality of discharges from Municipal Separate Stormwater Sewer Systems (MS4s) and receiving waters. An adaptive monitoring and assessment plan will be relied upon throughout the implementation of the WQIPs developed for each Watershed Management Area (WMA)[1]. These adaptive plans are meant to address the goals set by the Co-Permittees, as well as the water quality and the overall effort placed into the WQIP by the Co-Permittees.

The new Monitoring and Assessment Plan is a required component of the WQIP. This Plan will replace the current plan previously outlined in this volume. The Monitoring and Assessment Plan will take effect once the Regional Board has reviewed and approved the WQIP in its entirety, which is scheduled for early 2018. Until then, the SMR monitoring efforts will be implemented pursuant to the Transitional Monitoring requirements of the Regional Permit, Provision D. 1a, 2, and 3. Both the Transitional Monitoring activities and the approved WQIP Monitoring and Assessment Plan will continue to reference the general procedures and standards outlined in the most current version of the QAPP (CMP Volume II).

The following monitoring programs will be conducted in the SMR to meet the requirements of the MS4 Permit. Additional details of the sampling process and design for the SMR monitoring programs are provided in Volume III of the CMP (i.e., WQIP Monitoring and Assessment Plan). Table 10-1 presents the SMR Sampling Schedule for each monitoring program described in this section including wet and dry weather components, number of events, estimated number of sample locations, sample matrices and the years of implementation.

The SMR Monitoring Program is comprised of the following monitoring components:

[1] Within the Santa Margarita River WMA, the Upper SMR subwatershed area and Middle SMR subwatershed area are within Riverside County, whereas the Lower SMR subwatershed area is within San Diego County. Refer to the WQIP (Section 5) for details of the monitoring conducted by the County of San Diego.

- **Receiving Water Monitoring:** The Receiving Water Monitoring Program is designed to monitor the condition of the receiving waters in each Watershed Management Area (WMA) during dry weather and wet weather. Long-term receiving water monitoring will be conducted during implementation of the WQIP to assess the long-term trends in order to determine if conditions in receiving waters are improving and to evaluate attainment of numeric goals established in Section 3 of the WQIP, as applicable. The Permit requires receiving water monitoring of at least one long-term receiving water monitoring station. Monitoring is required during three wet weather events and three dry weather events per permit term. Both composite and grab sampling regimes will be used for sample collection during dry and wet weather events. Field observations and collection of field monitoring data will be conducted at ~~the~~ two station~~s~~ during all dry and wet weather events.

  The definition of wet weather season is defined as between October 1st and April 30th. In an ephemeral watershed, the first wet weather event of the year that falls under the USEPA recommended criteria may not result in runoff from surrounding lands. Mobilization criteria and guidance for wet weather event monitoring is described in this QAPP and referenced in the Monitoring and Assessment Plan.

- **Hydromodification Monitoring**: The Permit (D.1.c(6)) requires hydromodification monitoring to be conducted as described in the Copermittees' approved Hydromodification Management Plan (HMP), dated April 2016, as well as hydromodification monitoring at each receiving water monitoring station for one dry weather event per permit term.

  HMP Monitoring Program: In accordance with the 2016 HMP as developed under the SMR 2010 Permit, the Co-Permittees are committed to conducting monitoring annually at two pre-selected stations through spring of 2019. To provide a standardized assessment of the presence and condition of vegetation and habitat integrity, relevant attributes of the California Rapid Assessment Method (CRAM) module for riverine wetland (QAPP Appendix P)[2] were applied for the initial site visits the first year of HMP implementation, as applicable to the Middle SMR Subwatershed area. These included the hydrology, physical structure, and biotic structure attributes of the protocol. These attributes evaluate metrics including channel stability, riverine entrenchment ratio, structural patch richness, topographic complexity, and plant community composition and structure. CRAM is a protocol developed and calibrated to be used state-wide and is thereby applicable to the wide variety of ecological and climate regimes present in California.

  Additionally, the hydrologic and sediment supply performance standards established in the 2016 SMR HMP are based on the most recent state of the hydromodification management science[3]. It is generally acknowledged that SCCWRP's formulation of regional standards for hydromodification management may serve as a baseline for development of HMPs for specific regions in Southern California. These hydromodification tools can be viewed on SCCRWPs website[4]. Most of the methods which will be utilized during hydromodification monitoring are borrowed from standardized protocols which are also being applied in the 2015-2019 Stormwater Monitoring Coalition (SMC) Regional Monitoring Program. By using protocols consistent with the SMC Regional Program, the results from the hydromodification monitoring may be compared to other SMC stream conditions. Since the results of the CRAM are not expected to significantly

[2] California Wetland Monitoring Workgroup (CWMW). 2013. California Rapid Assessment Method (CRAM) for Wetlands Version 6.1
[3] Southern California Coastal Water Research Project. Hydromodification Assessment and Management in California. Eric D. Stein; Felicia Federico; Derek B. Booth; Brian P. Bledsoe; Chris Bowles; Zan Rubin; G. Mathias Kondolf and Ashmita Sengupta. Technical Report 667. April 2012
[4] http://www.sccwrp.org/ResearchAreas/Stormwater/AssessmentAndManagementOfHydromodification.aspx

change from year to year, the subsequent years of monitoring under the HMP program include follow-up field survey for evaluating any geomorphologic changes over time. Findings from the HMP monitoring will be reported following completion of the program in October 2019.

Dry *Weather Long-Term Receiving Water Hydromodification Monitoring Program:* In addition to the hydromodification monitoring conducted as described in the Co-Permittees' Hydromodification Management Plan[5] (HMP), the Permit requires hydromodification monitoring for each long-term receiving water station for one dry weather event per Permit term. Hydromodification monitoring is typically scheduled concurrently with dry weather monitoring efforts (refer to the monitoring scheduled in the WQIP). Hydromodification monitoring will include:

- An evaluation of channel conditions;
- Identification of locations of discharge points;
- Assessment of habitat integrity;
- Photo documentation of site conditions;
- Measurement of channel erosion dimensions; and
- Evaluation of the potential causes of erosion and habitat impact as applicable.

In general conformance with the activities conducted under the 2016 HMP and to provide a standardized assessment of the presence and condition of vegetation and habitat integrity, relevant attributes of the CRAM module for riverine wetland (QAPP Appendix P) will be applied. CRAM will be conducted in accordance with State guidelines and quality control standards described within the approved SWAMP SOP's and tools will be used as described on the State Water Boards website[6]. Following completion of the monitoring effort (refer to the WQIP Monitoring and Assessment Plan schedule), data QA/QC, and data assessment, the findings from the Dry Weather Long-Term Receiving Water Hydromodification Monitoring Program will be reported in the subsequent year's WQIP annual report.

- **Follow-up Approach and Actions:** Follow-up analysis is based on a combination of compliance and assessment approaches pursuant to the Regional Permit. Under the compliance approach, chemistry results from receiving waters monitoring stations are compared to compliance and Water Quality Standards as described in Section 2.0. Assessment will be conducted as described in the Monitoring and Assessment Plan of the WQIP. Follow-up actions may include, but are not limited to:
  - Toxicity Identification Evaluation (TIE)/Toxicity Reduction Evaluation (TRE): When there is evidence of chronic toxicity, TIEs may be utilized in the follow-up approach. The purpose of TIEs is to identify the possible cause of toxicity. If chronic toxicity is detected in receiving waters the Co-Permittees must discuss the need for conducting a TIE/TRE in the assessments required under Provision D.4.a.(2) and develop a TIE/TRE plan for incorporation into the WQIP. Once the cause of toxicity has been identified, measures must be implemented to reduce or eliminate the pollutant discharge.
  - Upstream Source Identification Investigations: If needed, a source investigation component may be conducted to facilitate the implementation of source control measures. Upstream source identification investigations will be conducted by the Co-Permittee having jurisdiction on a case-by-case basis. Refer to the actions as further defined in the Co-Permittees' respective Jurisdictional Runoff Management Plans (JRMPs).

[5] Santa Margarita Region Hydromodification Management Plan. April, 2016.
[6] https://www.waterboards.ca.gov/water_issues/programs/swamp/tools.html

- **Regional Monitoring**: Co-Permittees will participate in the regional monitoring programs to meet the requirements of Permit Provision D.1.e (1). Regional monitoring efforts under the Southern California Stormwater Monitoring Coalition (SMC) Regional Monitoring Program and Southern California Bight Regional Monitoring Program are implemented by separate project-specific workplans to meet the goals and needs of each program. Refer to the Monitoring Annual Report for the most current updates and status of the regional monitoring workplans.

- **Wet Weather MS4 Discharge Monitoring:** Five representative major outfalls will be monitored once per year during wet weather events by the Riverside County Co-Permittees within the Middle SMR subwatershed area. There are no major outfalls inventoried within the Upper SMR subwatershed area. The outfalls will continue to be monitored and as new information becomes available the Co-Permittees will consider re-evaluating the monitoring station locations and frequencies, and revising the WQIP, as needed in accordance with the Regional Permit adaptive management process. If upon a scheduled monitoring event, an MS4 outfall is observed to be dry, ponded, or if the minor discharge (i.e., trickle flow) volume is insufficient for obtaining flown measurement the monitored event will be documented with a flow result of zero cfs, and appropriate findings will be documented in the Monitoring Annual and Assessment Report.

- **Dry Weather MS4 Field Screening:** The Regional Permit requires dry weather MS4 outfall discharge field screening monitoring with a frequency based on the number of major outfalls within a Co-Permittee's jurisdiction. Each Riverside County Co-Permittee has less than 125 major MS4 outfalls. The initial requirement for each Co-Permittee is to visually inspect at a minimum of 80 percent of the outfalls twice per year during dry weather conditions. However, the Permit also allows the Co-Permittees to adjust the field screening monitoring frequencies and locations for the MS4 outfalls in its inventory, as needed, to identify and eliminate sources of persistent flow non-stormwater discharges in accordance with the highest priority water quality conditions identified in the WQIP. This adaptive approach is permitted provided that the level of effort (e.g., number of visual inspections performed) is equivalent to the number of visual inspections initially required. The frequencies and locations for the MS4 outfalls which are inspected may be adjusted in accordance with the flexibility allowed in the Regional Permit, as needed. The dry weather field screening of major outfalls will be conducted by the Riverside County Co-Permittees within the Middle SMR subwatershed area. There are no major outfalls inventoried within the Upper SMR subwatershed area.

- **Dry Weather MS4 Discharge Monitoring:** Based on the results of the dry weather MS4 outfall discharge field screening monitoring each Co-Permittee will identify and prioritize a minimum of five of the MS4 outfalls with persistent dry weather non-stormwater flows based on their potential to contribute to the highest priority water quality conditions identified in the WQIP. Station selection will include consideration of other pertinent factors, such as safety conditions, site accessibility, flow vs. ponded observations, tributary influences, etc. Dry weather outfall discharge monitoring will be conducted by the Riverside County Co-Permittees within the Middle SMR subwatershed area. There are no major outfalls inventoried within the Upper SMR subwatershed area. The total 25 representative major outfalls (e.g., outfall stations representing Riverside County Co-Permittees' MS4 discharge) will be monitored at least twice per year until one of the following criteria pursuant to the Regional Permit (Order Section D.2.b.(2)) have been met:
    - Non-stormwater discharges have been eliminated;
    - The source of the persistent non-stormwater discharge flow has been identified as not requiring and NPDES permit;

- Constituents in the non-stormwater discharge persistent flow do not exceed NALs and the flow can be re-prioritized; or
- The source of the flow has been identified as being authorized by a separate NPDES permit.

The outfalls will continue to be monitored and as new information becomes available the Co-Permittees will consider re-evaluating the monitoring station locations and frequencies, and revising the WQIP, as needed in accordance with the Regional Permit adaptive management process. If upon a scheduled monitoring event, an MS4 outfall is observed to be dry, ponded, or if the minor discharge (i.e., trickle flow) volume is insufficient for obtaining flown measurement the monitored event will be documented with a flow result of zero cfs, and appropriate findings will be documented in the Monitoring Annual and Assessment Report.

- **Source Identification/IDDE Monitoring:** MS4 outfall monitoring results will be compared to applicable SALs or NALs, as incorporated into the WQIP, to identify any exceedances and to support in the assessment of the effectiveness of the WQIP priorities and strategies as well as support the detection and elimination of non-stormwater discharges and illicit discharges to the MS4. Follow-up procedures may be initiated upon discovery of a SAL or NAL exceedance in a sample and are further defined in the Co-Permittees' respective Jurisdictional Runoff Management Plans (JRMPs).

- **Special Studies:** The Co-Permittees participate in several special studies for the benefit of their local and regional program efforts.

  WQIP Special Studies:
  Within the term of the 2015 Regional Permit the Co-Permittees will initiate at least two special studies:

  - The special study as relevant to Provision D.3.a.(1), specific to the Watershed Management Area, will include the Santa Margarita River Nutrient Initiative Group (SMRNIG) Nutrient Management Study. SMRNIG which includes cities and counties, utility districts, Caltrans, scientists, tribes, non-governmental organizations (NGOs), United States Geological Survey (USGS), Camp Pendleton, Farm Bureau, and RWQCB staff that periodically meet to focus on nutrient-related issues in the SMR Estuary. The SMRNIG have conducted extensive modeling efforts in support of a Total Maximum Daily Load (TMDL) Alternative for the SMR Estuary for nutrients, and their work has provided valuable insight and scientific information used in the development of the WQIP. With respect to the SMR Copermittees, this WQIP will be a key implementation mechanism for the TMDL Alternative. The Nutrient Numeric Endpoint (NNE) framework, an alternative regulatory approach advocated by SWRCB staff and United States Environmental Protection Agency (USEPA) Region 9, is currently in development. In support of the development of the NNE framework the Copermittees targeted sites for in-kind sampling to provide the study with additional nutrient data, selected in coordination with SCCRWP.
  - The special study as relevant to Provision D.3.a.(2-3), the San Diego Region, will be the SMC CLEAN Study ~~Reference Stream Study~~. Descriptions of these special studies will be provided in the Monitoring and Assessment Plan of the WQIP (included in CMP Volume III by reference only). Details on the status and findings of these special studies will be included in the Annual WQIP Monitoring and Assessment Reports ~~2017 Regional Monitoring Annual Report as part of the ROWD, as well as by reference in the first Transitional Monitoring and Assessment Report~~.

Other Special Studies:

The Co-Permittees participate in additional special studies and efforts relevant to their management programs and implementation:

- The Co-Permittees support the regional laboratory intercalibration study efforts, as well as monitoring field protocols intercalibration exercise facilitated through the SMC. The SMC established a continuing goal of compiling local monitoring data to make region-wide assessments. Therefore, the SMC holds periodic laboratory intercalibration studies to ensure comparability in analytical measurements, as well as holds seasonal field survey/assessment intercalibration exercises to promote comparability of data collection methods and for assurance of data quality.
- The San Diego Regional Reference Stream Study was conceived by the San Diego, Orange County and Riverside Permittees, funded by San Diego and Orange County. The goal of this project was to collect the data necessary to derive reasonable and accurate numeric targets for bacteria, nutrients, and heavy metals by referencing natural, local conditions. The results of this study were used to support the forthcoming reopener of the regionally adopted Bacteria TMDLs and to support numeric targets in future TMDLs for bacteria, nutrients, and metals. For additional details see SCCWRP Technical Report 862[7].

[7] SCCWRP Technical Report 862: Wet and Dry Weather Natural Background Concentrations of Fecal Indicator Bacteria in San Diego, Orange, and Ventura County, California Streams (Tiefenthaler et al., 2015) (http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/862_StreamFIBs.pdf)

Table 10-1: SMR Sampling Schedule

SMR Sampling Program[1]	Program Component	Matrix	Number of Events Per Permit Term (2015 Permit)	*Tentative* Number of Events Per Permit Term (Future Permit)	Estimated Number of Sample Locations	2016-2017[2]	2017-2018[2]	2018-2019[2,3]	2019-2020[3]	2020-2021[3]	2021-2022[3]	2022-2023[3]
Long Term Receiving Water Monitoring[4]	Dry Weather Event	Water	-[2]	3	~~1~~ 2	-[2]	-[2]			3		
	Wet Weather Event	Water	-[2]	3	~~1~~ 2	-[2]	-[2]		3			
	Toxicity	Water	-[2]	3	~~1~~ 2	-[2]	-[2]		3	3		
	Bioassessment	Water, Algae, BMI, Toxicity	-[2]	1	~~1~~ 2	-[2]	-[2]			1		
	Hydromodification	Survey	-[2]	1	~~1~~ 2	-[2]	-[2]			1		
MS4 Outfall Monitoring	Dry Weather Field Screening	Field Observation	4 (2x Annually per station)	10 (2x Annually per station)	80% of all Inventoried major outfalls (2x annually)	2	2	2	2	2	2	2
	Dry Weather Event	Water	0[2]	~10 (2x Annually per station)	25 (min. 5 per Permittee)	-[2]	-[2]	2	2	2	2	2
	Wet Weather Event		2 (1 Annually per station)	5 (1 Annually per station)	25 (min. 5 per Permittee)	1	1	1	1	1	1	1
Regional Monitoring Programs	SMC Regional Monitoring of Southern California Coastal Watersheds	Water, Algae, BMI, Toxicity, Physical habitat	2[5] (1 Annually)	5[5] (1 Annually)	2[5]	1[5]	1[5]	1[5]	1[5]	1[5]	1[5]	1[5]
	Southern California Bight Regional Monitoring	Sediment Quality	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]	-[5]
Special Studies	Refer to the ~~Monitoring~~ Annual WQIP Monitoring and Assessment Reports for the most updated information on WQIP Special Studies workplans and schedules.											

[1] Refer to the WQIP Monitoring and Assessment Plan for complete details on program requirements and schedules. The above table is included herein for reference purposes only.
[2] During the 2016-2017 and the 2017-2018 Monitoring Years the Transitional Monitoring requirements will be implemented until the approval of the WQIP.
[3] During the 2017-2018 Monitoring Year the Regional Permit Term will expire; therefore, the WQIP and the subsequent Monitoring Years may be subject to additional requirements or revisions pursuant to the next issued permit; therefore the schedule presented is subject to change. Refer to the most current approved version of the WQIP Monitoring and Assessment Plan.
[4] Two ~~One~~ long-term receiving water stations within the Riverside County portion of the Watershed Management Area. Additional monitoring location(s) present in San Diego County.
[5] Refer to the Monitoring Annual Reports for the most updated information on Regional Program efforts and associated workplans.

10.1.2 SAR Monitoring Programs

The following monitoring programs are conducted in the SAR to meet the goals of the CMP and requirements of the MS4 Permit. Additional details of the sampling process and design for the SAR monitoring programs are provided in Volume IV of the CMP. Table 10-2 presents the SAR Sampling Schedule for each monitoring program described in this section including wet weather and dry weather monitoring components, number of monitoring events, estimated number of sample locations, sample matrices, and the years of implementation.

The purpose of the SAR Receiving Water Monitoring Program is to characterize the receiving water quality and determine the impacts of urban runoff. The SAR Receiving Water Monitoring Program is comprised of the following four components:

- **Receiving Water Monitoring:** At minimum, two receiving water stations will be monitored during wet weather and dry weather conditions. During two dry weather monitoring events, discrete (grab) samples will be collected at the receiving water stations. During two wet weather monitoring events, flow-weighted composite samples will be collected at receiving water stations. Additionally, samples will be tested for acute and chronic toxicity to meet the requirements of the Water Column Toxicity Monitoring Program.

- **Water Column Toxicity Monitoring:** The purpose of this program is to determine if there may be impacts of urban runoff on toxicity of the receiving waters by testing aquatic species collected from the receiving waters. During two wet weather Events, samples will be analyzed for acute and chronic toxicity. The wet weather monitoring component of the Water Column Toxicity Monitoring Program will be conducted simultaneously with the two receiving water wet weather monitoring events as previously mentioned. During two dry weather monitoring events, receiving water samples will be analyzed for acute and chronic toxicity. According to the SAR Permit, this requirement can be satisfied by participating in regional bioassessment efforts. The follow-up approach is also presented in the SAR Monitoring Plan in Volume IV of the CMP.

- **Bioassessment:** The purpose of the bioassessments is to assess the cumulative impacts of discharges to benthic invertebrates and algae in the receiving waters. Bioassessments are conducted in coordination with the SMC's Regional Bioassessment Monitoring Program. The field effort for the SMC Regional Bioassessment 5-year study (2009-2013) as defined under the 2010 MS4 Permit was completed in 2013. The Final Report is anticipated to be published in 2015. To continue to satisfy the bioassessment requirement of the Permit, the Permittees will continue to participate in and coordinate with the SMC Regional Bioassessment Monitoring effort. Refer to the CMP Volume IV for details of the Bioassessment Program and refer to the Monitoring Annual Report for the most current updates and status of the special studies workplans. Bioassessments will be conducted during the dry weather index period (approximately May-July annually).

- **Hydromodification Monitoring**: The Permit requires hydromodification monitoring at two receiving water sites selected to meet the criteria described in Provision XII.B.5.b. Each hydromodification station will be monitored for at least one event per Permit term. The hydromodification monitoring observations and measurements will be collected within an appropriate domain of analysis. To provide a standardized assessment of the presence and condition of vegetation and habitat integrity, relevant attributes of the California Rapid Assessment Method (CRAM) module for riverine wetland (QAPP Appendix P) will be applied. These included the hydrology, physical structure, and biotic structure attributes of the protocol. These attributes evaluate metrics including channel stability, riverine entrenchment ratio, structural patch richness,

topographic complexity, and plant community composition and structure. CRAM is a protocol developed and calibrated to be used state-wide and is thereby applicable to the wide variety of ecological and climate regimes present in California. When CRAM is conducted, it will be conducted in accordance with State guidelines and quality control standards described within the approved SWAMP SOP's and tools will be used as described on the State Water Boards website[8]. The methods and standards described in the Hydromodification Management Plan Evaluation Program Appendix G of the Watershed Action Plan (2017) are based on the hydromodification susceptibility guidance information developed by SCCWRP. It is generally acknowledged that SCCWRP's formulation of regional standards for hydromodification management may serve as a baseline for development of HMPs for specific regions in Southern California. These hydromodification tools can be viewed on SCCRWPs website[9]. In general, the majority of the methods which will be utilized during hydromodification monitoring are borrowed from standardized protocols which are also being applied in the 2015-2019 Stormwater Monitoring Coalition (SMC) Regional Monitoring Program.

- **Follow up Approach and Actions:** Follow-up analysis is based on a combination of compliance and assessment approaches. Under the compliance approach, chemistry results from receiving waters monitoring stations are compared to compliance and Water Quality Standards as described in Section 2.0. Under the assessment (also referred to as Triad) approach, the chemistry, toxicity and bioassessment lines of evidence are weighed as described in the individual Monitoring Plans provided in Volumes II, III and IV. Follow-up actions include, but are not limited to, additional data collection, Toxicity Identification Evaluations (TIEs) and upstream source identification studies.
  - TIEs: When there is evidence of toxicity, TIEs may be utilized in the follow-up approach. The purpose of TIEs is to identify the possible cause of toxicity. TIEs do not require additional samples to be collected. If there is evidence of toxicity in a sample, then a TIE is conducted on the remaining volume of that sample. Once the cause of toxicity has been identified, measures must be implemented to reduce and/or eliminate the pollutant discharge.
  - TREs: Based on TIE results, a TRE component may be conducted to facilitate the implementation of source control measures. TRE work plans will be developed on a case by case basis.

The purpose of the SAR MS4 Outfall and Mass Emissions Monitoring Program (Core Monitoring Program) is to monitor pollutants in stormwater effluent from the MS4 and to conduct special studies to address areas of concern as they may appear.

- **MS4 Outfall / Mass Emission Station Monitoring:** The MRP requires outfall monitoring at seven MS4 outfall stations, historically referred to as "Core" stations and referred to in the MRP as Mass Emissions Stations. During three wet weather monitoring events and two dry weather monitoring events at the seven MS4 outfall stations, grab samples will be collected and analyzed for the constituents presented in the SAR Monitoring Plan, provided in Volume IV of the CMP.

- **IC/ID Monitoring:** IC/ID monitoring will occur as needed as indicated by Core station outfall monitoring results. Monitoring will consist of field observations and collection of field parameter measurements. If additional follow-up is necessary, source identification will be adaptive and will vary based on the field measurement results of each specific outfall and adjacent land uses suspected to contribute to unauthorized discharges in the MS4.

[8] https://www.waterboards.ca.gov/water_issues/programs/swamp/tools.html
[9] http://www.sccwrp.org/ResearchAreas/Stormwater/AssessmentAndManagementOfHydromodification.aspx

The SAR MS4 Permit requires special studies listed in Section 6.1 of this QAPP to be conducted as part of the CMP. Special studies each contain their own separate workplans, QAPPs, and reporting requirements and frequencies. The SAR special studies are briefly described in the SAR Monitoring Plan provided in Volume IV of the CMP. Refer to the Monitoring Annual Report(s) for updates and status of the special studies.

Table 10-2: SAR Sampling Schedule

SAR Sampling Program	Program Component	Matrix	Number of Events Per Year	Estimated Number of Sample Locations	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018
Receiving Water Monitoring	Dry Weather Event	Water	2	2		X	X	X	X	X	X
	Wet Weather Event	Water	2	2		X	X	X	X	X	X
	Water Column Toxicity – Wet Weather Event	Water	2[(a)]	2		X	X	X	X	X	X
	Water Column Toxicity – Dry	Water	2[(a)]	2	X	X	X	X	X	X	X
	TIEs/TREs	Water	Conditional[(b)]	Conditional[(b)]	X	X	X	X	X	X	X
	Bioassessments (Dry Weather)	Water, Algae, BMI, Toxicity	1	5	X[(c)]	X[(c)]	X[(c)]	X[(c)]	X[(c)]	X[(c)]	X[(c)]
MS4 Outfall Monitoring	Wet Weather Event	Water	3	7	X	X	X	X	X	X	X
	Dry Weather Event		2	7	X	X	X	X	X	X	X
	IC/ID		TBD	TBD	X	X	X	X	X	X	X

(a) Per 2010 MS4 Permit (Appendix 3, III.E.2), to the extent that the toxicity testing is developed as part of the Regional Bioassessment Monitoring, the Permittees may satisfy this requirement by participating in the regional bioassessment effort or conducting toxicity testing consistent with the standardized protocols.

(b) Conditional – Follow up actions and TIEs/TREs are dependent on the results from the associated events and will vary.

(c) Per the 2010 MS4 Permit, bioassessments will be conducted in conjunction with the SMC Regional Bioassessment Program (see Section 10.1.2). The study design may vary by monitoring year. Refer to CMP Volume IV, Section 3.5 for additional details of the Bioassessment Program. Refer to the Monitoring Annual Report for the most current updates and status of the special studies.

10.1.3 WWR Monitoring Programs

The following monitoring programs are conducted in the WWR to meet the goals of the CMP and requirements of the WWR MS4 Permit. Additional details of the sampling process and design for the WWR monitoring programs are provided in Volume V of the CMP. Table 10-3 presents the current WWR Sampling Schedule for each monitoring program described in this section including wet weather and dry weather monitoring components, number of monitoring events, estimated number of sample locations, sample matrices and the years of implementation.

Receiving water monitoring is conducted for purposes of evaluating the health of the perennial portion of the CVSC during dry weather and wet weather conditions. During two dry weather monitoring events, discrete (grab) samples will be collected at one monitoring location. Grab samples will be collected at one monitoring location during two wet weather monitoring events.

Dry weather MS4 outfall monitoring be conducted at monitored sites for purposes of proactively seeking to identify IC/IDs; observed incidents are tracked in respective Permittee IC/ID databases, and are reported in the Monitoring Annual Report. Grab samples and field measurements will be collected at two monitoring locations during two wet weather monitoring events. During four quarterly dry weather IC/ID monitoring events, grab samples and field measurements will be collected at two monitoring locations~~,~~. Source investigations will be conducted by the responsible Permittee where there is evidence of irregular flow or water quality concerns based on the dry weather monitoring event results or observations.

Table 10-3: WWR Sampling Schedule

WWR Sampling Program	Program Component[(a)]	Matrix	Number of Events Per Year	Estimated Number of Sample Locations[(a)]	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018
Receiving Water Monitoring	Dry Weather	Water	2	1	-	X	X	X	X
	Wet Weather Event	Water	2	1	-	X	X	X	X
MS4 Outfall Monitoring	Wet Weather Event	Water	2	2	-	X	X	X	X
	Dry Weather/ Quarterly IC/ID		4	2	-	X	X	X	X

[(a)] Per the monitoring requirements of the 2013 Order, which take effect with the start of the 2014-2015 monitoring year.

10.1.4 Regional Monitoring Program: Applicable to SMR, SAR, and WWR.

The Permittees continually collaborate in regional efforts to tackle issues within Riverside County to those that extend beyond jurisdictional boundaries. The following groups are watershed-specific and, in addition to District staff, the Permittees are represented in the following groups:

- Santa Ana and Santa Margarita Technical Advisory Committees
- Santa Ana/Santa Margarita Management Steering Committee
- Santa Ana Watershed Project Authority (SAWPA)
- Whitewater River Region Desert Task Force
- Lake Elsinore/San Jacinto Watershed Authority (LESJWA)
- Canyon Lake/Lake Elsinore TMDL Task Force
- Stormwater Quality Standards Task Force
- Middle Santa Ana River TMDL Task Force

In general, the Permittees are represented by District staff in the following regional organizations:

- Southern California Stormwater Monitoring Coalition (SMC)
- California Stormwater Quality Association (CASQA)
- American Society of Civil Engineers - Stormwater Committee, San Bernardino/Riverside Counties Branch

10.1.5 Regional Watershed Monitoring Program

The program aims at assessing the regional health of southern California's rivers and streams and is motivated by the State's SWAMP and the Southern California SMC. Permittees of Riverside County's three MS4 Permits are represented on the SMC by the District. The SMC member agencies are:

- Los Angeles Regional Water Quality Control Board
- Santa Ana Regional Water Quality Control Board
- San Diego Regional Water Quality Control Board
- California Department Transportation (CALTRANS)
- City of Long Beach
- City of Los Angeles
- City of San Diego
- County of Orange
- County of San Diego
- San Bernardino County Flood Control District
- Los Angeles County Flood Control District
- Los Angeles County Sanitation District
- Riverside County Flood Control and Water Conservation District (District)
- Southern California Coastal Water Research Project (SCCWRP)
- State Water Resources Control Board (SWRCB)
- Ventura County Watershed Protection District

10.2 Types of Sampling Locations

This section provides a description of the type of sample locations that will be monitored in the different programs. Sample locations are described in each of the watershed-specific Monitoring Plans provided in Volumes III, IV, and V of the CMP. In general, all sites will consider safety and access conditions of each site prior to selection. A comprehensive list including station name, GPS coordinates and a brief description is provided in Appendix C.

Receiving Water Stations:
Receiving water sites are located on the main river systems within each Region. For the SMR, two ~~one~~ long term receiving water stations will be sampled in Riverside County within the Upper and Middle SMR subwatersheds ~~portion~~ of the Watershed Management Area ~~and one long term receiving water station will be sampled in Riverside County within the Middle SMR subwatershed portion of the Watershed Management Area~~ as defined by the Regional Permit. For SAR, the wet weather receiving water stations are located near the southern portion of the Region, but adjacent to a mixture of land uses, including urban areas. The SAR dry weather receiving water stations are located both at the southern of the Region, as well as one located at the northeast border of the Region, providing data for the water quality of the flows entering into Riverside County. For the WWR, one receiving water station~~s~~ is identified in the MS4 Permit.

Reference Station:
Reference Stations are sites that are within a portion of the Watershed similar to the urbanized area but are considered to have minimal influence from urban land uses. Reference Stations will be identified using protocols outlined in "A Qualitative Tool for Assessing the Integrity of Southern California Streams".

Stream Assessment/Bioassessment Stations:
Stream assessments/Bioassessments will be conducted at receiving water and reference stations as outlined in the SMR and SAR Permits. Specific information is contained in the respective Monitoring Plans of this CMP (Volumes III and IV, respectively).

MS4 Outfall Monitoring Locations:
MS4 outfall monitoring locations will be located at the end-of-pipe prior to discharge to receiving waters and as outlined in Volumes III through V. Typically, MS4 sampling locations may include the discharge at the end-of a pipe, a ditch, or a channel. Additional MS4 monitoring locations may be added to ensure that MS4 monitoring locations are representative of urban runoff. According to 40 C.F.R. §122.26(b)(5) the definition of a major outfall is:

> "…a municipal separate storm sewer outfall that discharges from a single pipe with an inside diameter of 36 inches or more or its equivalent (discharge from a single conveyance other than circular pipe which is associated with a drainage area of more than 50 acres); or for municipal separate storm sewers that receive storm water from lands zoned for industrial activity (based on comprehensive zoning plans or the equivalent), an outfall that discharges from a single pipe with an inside diameter of 12 inches or more or from its equivalent (discharge from other than a circular pipe associated with a drainage area of 2 acres or more)."

Outfall stations by program region are described below:

- SMR has 20 hydrologic subareas, seven of which contain MS4 facilities under the jurisdiction of the Riverside County Co-Permittees. Twice a year 80% of outfalls will be field screened for persistent flow determination in accordance with the Regional Permit. Based upon the dry weather MS4 outfall discharge field screening monitoring records available as of the submittal of the WQIP,

each Co-Permittee will identify and prioritize the five MS4 outfalls with persistent flows based on their potential to contribute to the highest priority water quality conditions identified in the WQIP and on the basis of safety and accessibility for conducting non-stormwater persistent flow MS4 outfall discharge monitoring. Modifications to sampling locations and frequencies will be in accordance with the WQIP.

- SAR has seven MS4 outfall stations historically referred to as mass emissions or Core stations, monitoring locations identified in the 2010 MS4 Permit.

- WWR has two outfalls identified in the 2013 MS4 Permit.

10.3 Preparation and Logistics

The following preparation and logistics procedures and guidelines will be incorporated into the implementation of the monitoring programs described above and outlined in Tables 10.1 through 10.3.

Weather Tracking

Weather will be tracked throughout the wet season, typically from October through April, or until all required wet weather monitoring events have been captured. Weather will be continuously monitored by utilizing the resources of the National Weather Service (NWS) as well as local ALERT systems and any other internet resources that could prove beneficial.

Sampling Event Selection Criteria

Sampling for wet weather and dry weather monitoring events will be initiated once criteria specific to each monitoring program has been met, as available in the individual Monitoring Plans located in Volumes III-V, and in accordance with the wet weather mobilization criteria below.

Wet Weather Mobilization Criteria

The definition of Wet Season may differ by Region but, in general, falls between October 1st and May 31st; specific MS4 Permit requirements are discussed in the each respective monitoring plan.

Due to the ephemeral nature of the SMR, SAR, and WWR, the first storm event that falls under the USEPA-recommended criteria may not result in runoff discharges from the MS4s. Based on the District's monitoring experience storm event forecasts of less than 0.5" in 24 hours do not typically result in measureable runoff and often result in false starts.

The representative storm event was derived using average rainfall depths and durations from the USEPA NPDES Storm Water Sampling Guidance Document, Exhibit 2-8, "Rain Zones of the United States"[10]. The derivation is presented in Table 10-4 and summarized below.

- Pursuant to USEPA 833-B-92-001, a representative storm event for the Pacific Southwest is between:
  - 0.27" to 0.81" in depth and
  - within 6 to 18 hours in duration.
- Pursuant to District analysis of local rain gauge data conducted in accordance with USEPA 833-B-92-001, a representative storm event is between:
  - 0.38" to 1.14" in depth and
  - within 6 to 18 hours in duration.

[10] Exhibit 2-8 "Rain Zones of the United States", Pacific Southwest Region. *NPDES Storm Water Sampling Guidance Document*. U.S. EPA Document No. 833-B-92-001.

Table 10-4: Derivation of District Representative Storm

Event Type	Duration (hours)[(a)]	Volume (inches)
Pacific Southwest Average Event	11.6	0.54
50% Average Event	5.8	0.27
150% Average Event	17.4	0.81

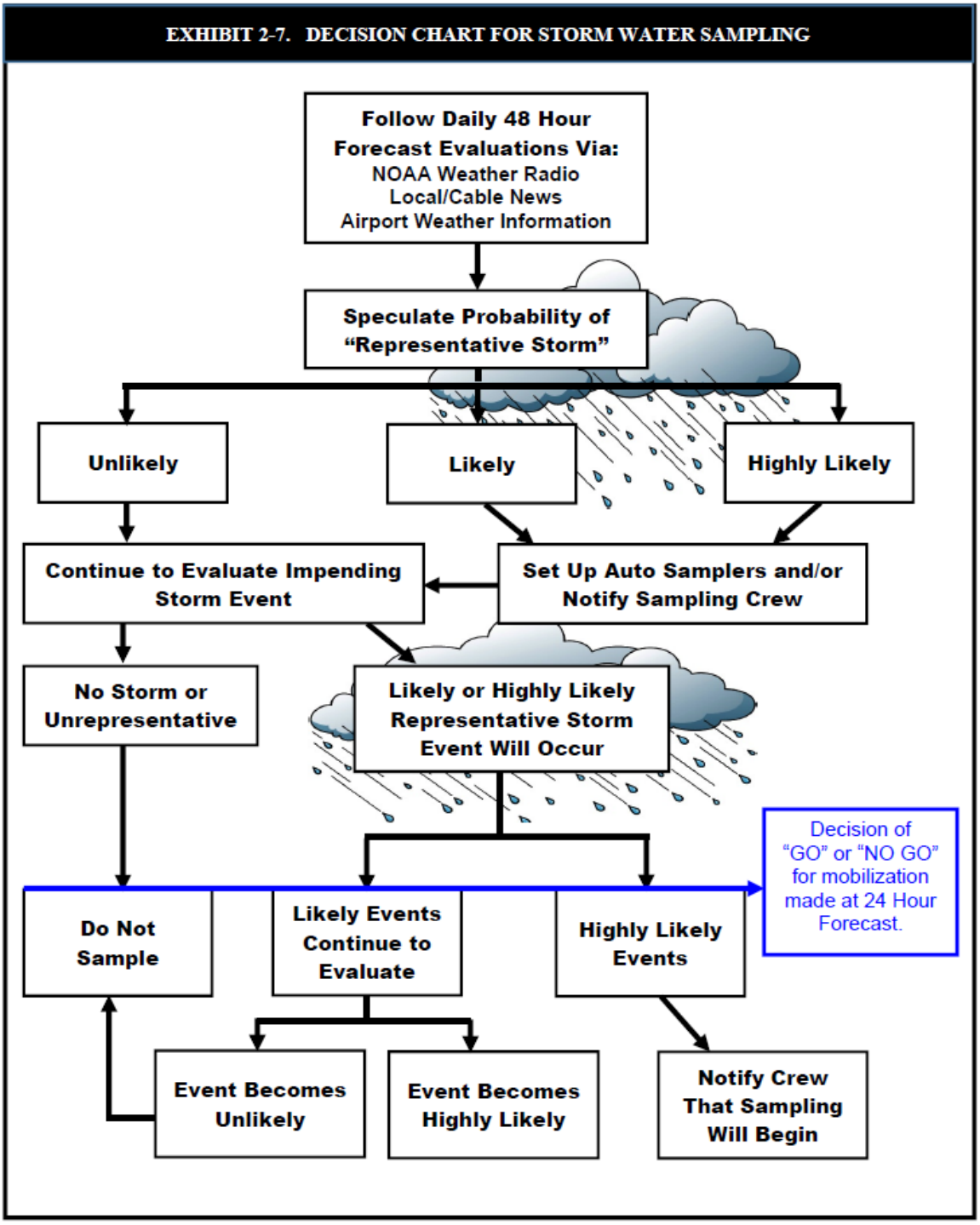
[(a)] In order to simplify the durations above to align with the 6-hour durations issued by the NWS's Qualitative Precipitation Statements, the representative storm for the District's jurisdictional area is 0.27" in 6 hours to 0.81" in 18 hours.

Storm event monitoring will be conducted according to the mobilization criteria below (40 CFR §122.21(g)(7)(ii)):

If a storm event is forecasted by the NWS QPS to be greater than 0.1" within the next 48 hours and there is at least 72 hours between the forecasted event and a previous measurable (>0.1") rainfall event:

- Then District will follow the procedure outlined in Exhibit 2-7 of USEPA NPDES Storm Water Guidance Document (EPA 833-B-92-001), included below as Figure 10-1. This decision chart references the speculation of Representative Storm size.
- Pursuant to NWS standard practice, the term "Likely" in Exhibit 2.7, represents a Probability of Precipitation (PoP) of at least 60%.
- Mobilization will occur when the NWS QPS forecast shows likely rainfall of 0.3" in 6 hours AND/OR 0.5" in 24 hours. This gives the District the greatest chance to sample a representative storm event.
- For mobilization to occur, criteria must be met 24 hours in advance of sampling for coordination with property owners, consultants, and sampling personnel.

Figure 10-1: USEPA Decision Chart for Storm Event Sampling



Staffing

A staffing plan will be prepared prior to each sampling event that designates sampling teams, monitoring locations for each team, field coordinators, and sample coordinators. Monitoring will be performed by teams of at least two field personnel. When necessary, a runner will be utilized to deliver grab samples to the laboratory to ensure that short holding times for constituents are met. Field crews will not be mobilized during or near certain holidays if the mobilization or laboratory analysis should continue through that holiday. This includes the following holidays:

- Presidents Day
- Memorial Day
- Independence Day
- Labor Day
- Thanksgiving and the day after Thanksgiving
- Christmas Eve and Christmas Day
- New Year's Eve and New Year's Day

As microbiology samples require four days of reading, any sampling scheduled within three days prior to a holiday may also cause difficulty and will try to be avoided.

Station Preparation

When mobilization criterion has been met and sampling is to occur, field personnel will perform the following pre-sampling duties to ensure stations are operational:

- Flow monitoring equipment onsite and running (if utilized)
- Automated samplers onsite and running (if utilized)
- Flow or time pacing set (if automated samplers are utilized)
- Sampler trigger set (if automated samplers are utilized)
- Iced bottles/coolers with ice onsite
- Bottle sets assembled
- Field meter calibrated (if *in-situ* field measurements are required)

11. SAMPLING METHODS

This section describes the types of field collection methods and procedures to implement the various monitoring programs described in Tables 10.1 through 10.3. Additional details of the sampling methodology used for each monitoring program are discussed in the SMR, SAR, and WWR Monitoring Plans, provided as Volumes III, IV and V of the CMP, respectively.

Field Observations and Documentation:

Field observations and measurements will be recorded electronically via the Survey 123 application or on a paper field data sheet. Appendix B to this QAPP contains an example of the paper form as well as a guide sheet for using the application. Field observations will be recorded during each monitoring activity in order to put chemical results into context with site conditions at the time of sampling. Field data sheets will be used to record general observations such as weather, debris/trash observed, color and clarity of the water, odor and any other conditions of interest. Whenever possible, any data being recorded will be verified, such as stage, flow meter status and sampler status. Field data sheets will also be used to document any equipment failure that may occur during sampling activities.

The following general information should be entered during each site visit:

- Station ID
- Date and Time
- Monitoring Project Name
- Field Team
- Conveyance Type
- Weather Conditions
- Runoff characteristics
- Flow estimations
- Field measurements
- Equipment condition/calibration (if applicable)
- Equipment failures (if applicable)
- Miscellaneous comments

During wet weather monitoring, additional data will be recorded on the field data sheet at the end of a wet weather monitored event. Data will be logged by a flow meter (if utilized) and will be downloaded after the storm; however, if downloaded data is lost for any reason, the data recorded on the field datasheet acts as a back-up. The following data will be collected at all stations when automatic sampling technologies are utilized:

Total Flow Volume (liters) – Total volume of water that passed the station during the storm
Composite Sample Aliquot Count – Total aliquots attempted, the number of aliquots missed, and the total number of successful aliquots
Total Rain (inches) – Total accumulated rainfall in centimeters since the start of the storm, measured each time the rain bucket tips
Sample Volume (liters) – Total volume of sample collected during the storm

During dry weather monitoring events, monitoring locations may be dry and, therefore, no samples will be collected. If this occurs, a field data sheet will be completed noting the site conditions and characteristics and that no samples were collected and categorized as Visited, Not Sampled. Photographs will also be taken to document the dry conditions. During wet weather, similar documentation procedures will be followed categorizing the effort as a 'false start' if a monitoring location is observed to be dry or the precipitation forecasted did not produce flow sufficient to collect required sample volumes.

***In-situ* Field Measurements:**

In-situ field measurements will vary by program and Region but may include the following list of constituents:

- Conductivity (Specific Conductance, Electronic Conductivity)
- Turbidity
- Dissolved Oxygen (DO)
- Water Temperature
- pH
- Salinity (optional; may be useful for certain types of wastes)
- Oxidation-Reduction Potential (optional; useful if sewage is suspected)
- Chlorine

Field measurements for the constituents listed above are the preferred method under the CMP. *In-situ* field measurements will be collected during composite sample collection (i.e., collected between the first and last composite sample aliquot) or during grab sampling activities, if composite samples are not required. Field measurement values and collection times will be recorded on the field data sheet.

In-situ water quality measurements will be made in the field by placing the probe(s) directly in the water column. A secondary container may be used if the water depth does not allow the probe to be completely

submerged. Probes should be exposed to flow in a representative portion of the stream or discharge. If there is no flow (i.e., ponded) or a secondary container is required to make measurements, the probe should be gently agitated, stir bar feature turned on (if present), particularly when making DO measurements using polarographic (Clark Cell) probes.

If meters fail in the field, the field team will utilize a back-up meter if available or field crews will instruct the laboratory to analyze for the required constituents that were not collected in the field. Modifications will be recorded on the field data sheet and COC accordingly. Additional volume for laboratory analyses of field measurements are accounted for in bottle lists, available in Volumes III through V, requiring no additional sample collection by field crews in the case of a meter failure. All trouble shooting and corrective actions will be recorded in the calibration log and/or field datasheet.

Composite Sampling:

Flow-weighted composite - A composite sample is a series of aliquots collected over the course of a wet weather monitoring event that is weighted by the flow rate. To collect a flow-weighted composite sample an automated sampler is utilized in conjunction with a flow meter to obtain a representative sample. Sample aliquots will be collected according to a sample pacing and programmed during pre-storm preparation. The sample pacing is determined by estimating the volume of runoff from the predicted amount of rainfall, the drainage area and the runoff coefficient. The sample pacing is determined by dividing the total runoff volume by the number of samples needed to satisfy the water volume requirement for analysis. The following equation is used to determine sample pacing:

$$\text{Sample Pacing} = \frac{P \times A \times C}{\text{Number of Aliquots}}$$

Where:
P = inches of rainfall anticipated
A = drainage area
C = runoff coefficient for drainage area

Each field team should be aware of the current status of each of its stations to determine which one will fill a bottle first so they can be onsite before the bottle fills. If the station has been programmed for the accurate amount of rainfall, changing the composite bottle should not be necessary. Pacing settings should take into account the volume of sample required to meet all analytical needs. If pacing changes are required, the bottle must be changed at the time of changing the pacing. The pacing value associated with each bottle must be reported to the analytical laboratory to allow proper sample compositing.

Time-weighted composite - During dry weather sampling, time-weighted composite samples may be collected using automated samplers. To collect a time-weighted composite sample, the sampler will be programmed to collect aliquots at discrete intervals over a specified time period, which varies by dry weather program. If a time-weighted composite is collected over a 24-hour period, aliquots will be collected at the program-specific time interval for the 24-hour monitoring period monitored using automated sampling equipment. When a time-weighted composite is collected over a 1-hour period, a minimum of four aliquots will be collected manually at 15-minute intervals. If the flow conditions of the discharge or stream allow for increased intervals, then the total number of aliquots and time intervals will be recorded on the field datasheet.

Field duplicates will typically not be collected on 24-hour composite samples as this would require a complete and separate second sampling system; however, to facilitate the random selection of stations for QA/QC sampling it may be collected as a full composite duplicate or a composite split for the SMR Monitoring Program in a given monitoring year. Field duplicates may be collected on one-hour composite samples depending on the volume and expected duration of the discharge.

In the event that the automatic samplers fail in the field the following procedures will be implemented to address sampling concerns during a dry weather composite sampling event:

- When scheduled concurrently with stream assessment/bioassessment activities, when possible a grab sample will be collected within the 24-hour window (i.e. prior to the collection of the last aliquot) to ensure that an adequate sample volume is available for required analysis. The collected composite sample will first be analyzed for priority chemistry constituents. The remaining composite sample along with the additional grab sample will be applied as the volume available for other required analysis (e.g. toxicity).
- When the monitoring activities are not scheduled concurrently with stream assessment/ bioassessment activities, the Lead Sampler will determine if the event will be rescheduled, or if the equipment will be promptly reset/replaced in preparation of a second attempt of the 24-hour composite sampling event.

In the event that flows intermittently stop during a dry weather composite sampling event, where flows were assumed to be constant, the Lead Sampler will determine if insufficient volume has been collected for the event based on observations of the site conditions. One of the following procedures will be implemented to address sampling concerns:

- The equipment will be promptly reset or replaced in preparation of a second attempt of the 24-hour composite sampling event (location subject to change). *If applicable to the event, stream assessment/bioassessment activities should be called-off and rescheduled accordingly.*

OR

- When possible, a grab sample will be collected within the 24-hour window (i.e. prior to the collection of the last aliquot) to ensure that an adequate sample volume is available for required analysis. The collected composite sample will first be analyzed for priority chemistry constituents. The remaining composite sample along with the additional grab sample will be applied as the volume available for other required analysis (e.g. toxicity). *If applicable to the event, stream assessment/bioassessment activities will remain on schedule.*

Grab Sampling:

Storm drains will be inspected prior to grab sample collection, and debris will be removed as safe conditions allow. Grab water samples will be collected by inserting the sample container under or down current of the discharge, with the container opening facing upstream. Less accessible sampling points may require the use of grab poles and buckets to collect grab samples. If samples cannot be safely collected directly or with a grab pole samples may be collected with a peristaltic pump using Teflon® and silicone tubing. Grab water samples will be collected as close as possible from the horizontal and vertical center of the channel as safe conditions allow. The following sample handling protocols will be followed when collecting samples to minimize the possibility of contamination:

- Previously unused (new) sample bottles will be employed. Sample bottles and bottle caps will be protected from contact with solvents, dust or other contaminants during storage and bottle handing. Sample bottles will not be reused until the laboratory has cleaned and blanked the containers.
- Field personnel will make an effort, within reason, to prevent large gravel and uncharacteristic floating debris from entering the sample containers. Personnel will also make an effort to not disturb sediments that may be at the bottom of the channel.

- The inside of the sampling container will not be touched to the maximum extent practicable during preparation and sampling activities.
- Vehicle engines will be turned off during sampling activities to minimize exposure of samples to exhaust fumes.
- All samples will be collected in accordance with the "clean sampling" techniques outlined in Appendix D.
- Manual water grab samples will be collected by inserting the transfer container under or down current of the direction of flow, with the container opening facing upstream. For microbiology water grab samples, containers will contain sodium thiosulfate ($Na_2S_2O_3$) to neutralize the impact of chlorine that may be in the stormwater at the immediate time of collection.
- Sample containers with liquid preservatives such as nitric acid will not be overfilled to avoid flushing out the required preservative.
- Once sample containers are filled, they will be promptly placed on bagged ice, in a clean cooler (target temperature 6 degrees Celsius), in the dark and transported to the laboratory for processing to meet holding times.

Benthic Macroinvertebrate Collection:

Benthic Macroinvertebrate (BMI) samples will be collected according to the SWAMP Bioassessment SOP for the Reachwide Benthos Procedure provided in Appendix F. The first step in implementing a stream assessment is to delineate the monitoring reach and the 11 main transects through the following steps; a summary of this process is provided below:

SWAMP's standard BMI (and algae) sampling layout consists of a 150-meter reach or a 250-meter reach, depending upon the average wetted width of the channel. If the average wetted width is less than or equal to 10 meters, use 150 meters for the monitoring reach length. If the average wetted width is greater than 10 meters, use a 250 meter long reach. Features that should not be present within a monitoring reach are: tributaries, "end-of-pipe" outfalls, bridge crossings, changes between natural and man-made channel bottoms, waterfalls, and impoundments (dams and weirs). Try to stay out of the channel as much as possible to avoid disturbing the stream bottom, which could compromise the samples and data that will be collected. Always work starting from the downstream end of the reach, moving upstream.

The monitoring reach will be divided into 11 equidistant main transects that will be arranged perpendicularly to the direction of flow. Main transects are designated "A" through "K". There will also be 10 additional transects (designated "inter-transects"), one between each pair of adjacent main transects, to give a total of 21 transects per monitoring reach. Inter-transects are designated by their nearest upstream and downstream main transects ("AB", "BC", etc.).

The Reachwide Benthos Procedure method can be used to sample any wadeable stream reach. The sampling approach used may vary by individual channel characteristics. For the Reachwide Benthos Procedure method, the BMI sub-sampling positions alternate between left, center, and right portions of the transects, as field personnel proceed upstream from one transect to the next. In high-gradient systems, sampling locations are defined as the points at 25% ("left"), 50% ("center") and 75% ("right") of the wetted width of the stream. Low-gradient streams, characterized as having a slope of 1% or less, comprise the majority of the District's streams monitored under the CMP. In low gradient streams, the Reachwide Benthos Procedure "margin-center-margin" method is utilized where channel substrates are nearly uniform, resulting in low diversity within the majority of the channel.

Algae Sample Collection:

Algae samples, when collected in conjunction with SWAMP bioassessments, must be collected prior to Physical Habitat Assessment data collection to avoid disturbance of the algae. Algae samples will be collected at the 11 main transects utilized in the Physical Habitat Assessment. After collection, the 11 sub-samples will be composited into a single sample per site (sampling reach). Algae sample collection may be used for the following types of data collection, each with specific sub-sampling procedures: collection of samples for taxonomic identification of diatoms and soft-bodied algae; collection of samples for determination of biomass based on chlorophyll *a* and ash-free dry mass; and estimation of percent algal cover. Detailed sampling methods are provided in the SWAMP Algae Field SOP located in Appendix G.

Physical Habitat Assessment:

Physical Habitat Assessment is designed to assess the physical habitat conditions of the stream reach to aid interpretation of the chemical, BMI and algae data and will be implemented according to the full suite Physical Habitat Assessment as described in the SWAMP Bioassessment SOP (Appendix F). Once all BMI and algae samples have been collected at a given transect, Physical Habitat Assessment data collection may begin according to the full Physical Habitat Assessment protocol described in Appendix F.

The Physical Habitat Assessment data to be collected includes the following:

- Wetted width
- Bankfull width
- Bankfull height
- Pebble count: Transect substrates
- Depth
- Particle size class
- Coarse particulate organic Matter
- Algal cover
- Macrophytes
- Dry substrates
- Bank stability
- Human influence
- Densitometer readings (canopy cover)

Sediment Sampling:

Sediment toxicity samples will be collected as a composite along a cross-section of the creek. A surface sample will be collected using a pre-cleaned stainless steel spoon from the top two inches of sediment at locations approximately 25%, 50%, and 75% across the channel. Sediment samples will be collected after the collection of water samples. Samplers should avoid disturbing and cross contamination of surface sediments.

Rainfall:

During wet weather monitoring at stations requiring flow-weighted composites and extended flow monitoring, a tipping bucket rain gauge may be used in conjunction with automated sampling and flow monitoring equipment. A tipping bucket rain gauge is configured with a small "bucket" that holds a known amount of rainfall. When the bucket fills, it tips the water out, momentarily closes a switch, then resets itself and starts the process again. The data logger/controller counts each switch closure to calculate rainfall totals. The rain gauges used for this program tip after every 0.01 inch of rain.

Flow Measurements:

Extended flow monitoring: Stations that require extended flow monitoring will require a temporary installation of flow monitoring equipment and paired automated sampling equipment. Flow rates will be monitored using a flow meter with an ultrasonic sensor. A submerged bubbler may also be installed as a measuring device. The sensor will continuously measure stage (stream height) and relay that information to the flow meter. The flow meter will continuously calculate flow rates by inserting the stage information

into the preprogrammed discharge equation or by utilizing velocity measured by the ultrasonic sensor. Using this system, the flow meter will be able to actuate the automated sampler to achieve a flow-weighted composite sample. Sampling and flow equipment will be monitored manually.

The flow meters will measure and log flow levels, rainfall and sample history. One-minute average flow and rainfall data will be recorded in the flow meters. The flow meters convert instantaneous flow into total runoff volume. Data containing storm and hydrological information is electronically stored in the flow meter, with each monitoring event stored separately. The recorded information includes:

- Flow rates
- Time of peak flow rate
- Cumulative rainfall
- Rainfall intensity
- Discharge volume totals
- Time of each sample
- Success or failure of each sample

Instantaneous flow measurements: Programs that do not require extended flow measurements will take instantaneous flow measurements at the time of sampling. Flow will be estimated using one of the following methods:

Area-Velocity Method

This method is useful when low flows are present. This method requires the physical measurement of the depth (D), and width (W) of flowing water. Estimate the velocity (V) and calculate discharge based on the following equation:

Equation 1: Discharge (ft^3/sec) = Velocity (ft/sec) x Depth (ft) x Width (ft)

Partially-Filled Pipe Method

This method is useful when substantial flow is coming through a pipe or out of an outfall. Measure the water depth and inside pipe diameter and apply the following formula using the partially filled pipe formula chart in Table 10-4.

D = water depth.
d = *inside* pipe diameter.
Calculate D/d.
Find the tabulated (Ta) value on the partially filled pipe formula chart below using the D/d value (i.e., if D/d = 0.263 then Ta =0.1623).
Find the area using the formula: $a = Ta*d^2$.
Multiply area (a) by the water velocity.
Convert to desired value.

Table 10-5: Partially Filled Pipe Tabulated Value (Ta) Chart

Tabulated Value (Ta) as Determined by the Tenths and Hundredths of the Quotient of D/d										
D = Depth of water d = diameter of the pipe Ta = Tabulated Value (i.e. if D/d = 0.263 then Ta = 0.1623)										
D/d	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0013	0.0037	0.0069	0.0105	0.0147	0.0192	0.0242	0.0294	0.0350
0.1	0.0409	0.0470	0.0534	0.0600	0.0668	0.0739	0.0817	0.0885	0.0951	0.1039
0.2	0.1118	0.1199	0.1281	0.1365	0.1440	0.1535	0.1623	0.1711	0.1800	0.1890
0.3	0.1982	0.2074	0.2187	0.2280	0.2355	0.2450	0.2540	0.2642	0.2780	0.2836
0.4	0.2934	0.3032	0.3130	0.3220	0.3328	0.3428	0.3527	0.3627	0.3727	0.3827
0.5	0.3980	0.4030	0.4130	0.4230	0.4330	0.4430	0.4520	0.4620	0.4720	0.4820
0.6	0.4920	0.5020	0.5120	0.5210	0.5310	0.5400	0.5500	0.5590	0.5690	0.5780
0.7	0.5870	0.5960	0.6050	0.6140	0.6230	0.6320	0.6400	0.6490	0.6570	0.6660
0.8	0.6740	0.6810	0.6890	0.6970	0.7040	0.7120	0.7190	0.7250	0.7320	0.7360
0.9	0.7450	0.7500	0.7560	0.7610	0.7660	0.7710	0.7750	0.7790	0.7820	0.7840

Timed Object Method

Drop a floatable object such as a leaf or twig in the water, time (T) how long it takes to move a measured distance (D). Estimate or measure the channel cross-sectional area, then calculate the volumetric flow rate using the following equation:

$$Q = \frac{A*D}{T}$$

United States Geological Survey (USGS) Flow Gauge – Flow may be determined by using an available USGS flow gauge within close proximity of the sample location.

Field Corrective Actions:

Any failures (e.g., instrument failures) that occur during data collection will be the responsibility of the field crew conducting the work. Crews will carry basic spare parts and consumables with them to the field, and will have access to spare parts to be stored at their respective agency. In the case of field instruments, problems will be addressed through instrument cleaning, repair or replacement of parts or the entire instrument, as warranted. If meters fail in the field, field crews will instruct the laboratory to analyze for required constituents that were not collected in the field and will record this modification on the field data sheet, and notify the Program Manager immediately. All trouble shooting and corrective actions will be recorded in the calibration log and/or field datasheet. Records of all repairs or replacements of field instruments will be maintained at the offices of field sampling personnel.

Field QA/QC Sampling:

In addition to the sampling activities summarized in tables 11-1, 11-2, and 11-3, QA/QC samples will be collected on a program-wide basis during each monitoring year in accordance with the SWAMP required frequencies. Refer to Section 14.1 for detailed description of QA/QC sampling.

Table 11-1: SMR Sampling Programs and Sampling Methods

A detailed description of sampling locations and program requirements will be provided in the WQIP Monitoring and Assessment Plan.

Sampling Program (Monitoring Locations)	Program Component	Matrix	Analytical Categories	# of Samples	Type of Sampling
Receiving WaterStation(s)[a] (~~1~~ 2)	Dry Weather	Water	Field Parameters, Chemistry, Microbiology, Toxicity	3	Time-weighted or Flow-weighted[b] Composite and Grab
	Bioassessment[,b]	Water, Algae, BMI	Field Parameters, Chemistry, Microbiology, Toxicity	1	Time-weighted or Flow-weighted[b] Composite and Grab
	Wet Weather Event	Water	Field Parameters, Chemistry, Microbiology, Toxicity	3	Time-weighted or Flow-weighted[b] Composite and Grab
	Hydromodification	N/A	Channel dimensions, Hydrologic and geomorphic conditions, Presence and condition of vegetation and habitat	1	N/A
	Follow up Approach and Actions	Water	No additional analyses are required. Field Parameters, Chemistry and Toxicity, may be collected as part of source investigation.	Conditional[c]	Grabs
MS4 Outfall Stations	Dry Weather Field Screening	N/A	Flow condition	80%	~~N/A~~
	Dry Weather Event	Water	Field Parameters, Chemistry, Microbiology	25[d]	Time-weighted or Flow-weighted[b] Composite and Grab
	Wet Weather Event	Water	Field Parameters, Chemistry, Microbiology	~~25~~5[e]	Time-weighted or Flow-weighted[b] Composite and Grab

(a) ~~Follow up actions and source investigations are dependent on the results from the associated events and will vary each year~~. Refer to WQIP Monitoring and Assessment Plan for program details and frequencies.
(b) Composite technique selected as appropriate for site and event conditions.
(c) Follow up actions and source investigations are dependent on the results from the associated events and will vary each year.
(d) Minimum of five dry weather outfall stations per jurisdiction. Selected from initial screening and prioritization of persistent outfalls pursuant to the Regional Permit.
(e) Minimum of one wet weather outfall station per jurisdiction. Selected per representative landuse criteria pursuant to the Regional Permit.

Table 11-2: SAR Sampling Programs and Sampling Methods

A description of sampling locations is provided in the Monitoring Plan, Volume IV.

Sampling Program (Monitoring Stations)	Program Component	Matrix	Analytical Categories	# of Samples	Type of Sampling
Receiving Water (2)	Dry Weather	Water	Field Parameters, Chemistry, Microbiology, Toxicity[(a)]	4	Grab
	Bioassessment[(b)]	Water, Algae, BMI	Field Parameters, Chemistry, Microbiology, Toxicity[(a)]	4	Grab
	Wet Weather Event	Water	Field Parameters, Chemistry, Microbiology, Toxicity[(a)]	4	Grab
	Water Column Toxicity – Wet Weather Event	Water	Acute and Chronic Toxicity	4[(a)]	Grab
	Water Column Toxicity – Dry Weather	Water	Acute and Chronic Toxicity	4[(a)]	Grab
	Follow up Approach and Actions	Water	No additional analyses are required. Field Parameters, Chemistry and Toxicity, may be collected as part of source investigation.	Conditional[(c)]	Grabs, if necessary
MS4 Outfall Monitoring (7)	Non-stormwater Dry Weather	Water	Field Parameters, Chemistry, Microbiology	14	Grab
	Source ID Monitoring		Conditional[(c)]	Conditional[(c)]	Grab
	Wet Weather Event		Field Parameters, Chemistry, Microbiology	21	Grab
	Source ID Monitoring		Conditional[(c)]	Conditional[(c)]	Grab

(a) Per 2010 MS4 Permit (Appendix 3, III.E.2), the Permittees may satisfy this requirement by participating in the SMC's Regional Monitoring effort or conducting toxicity testing consistent with standardized protocols.

(b) The Regional Bioassessment Monitoring Program, as ~~defined in the 2010 MS4 Permit and~~ coordinated with SMC, typically includes four sample locations unlike the rest of the Receiving Waters Monitoring Program, which has two dry weather sample locations. Refer to Section 10.1.2 herein for a summary of the bioassessment monitoring effort. Refer to CMP Volume IV, Section 3.5 for program details.

(c) Conditional – Follow-up actions and source investigations are dependent on the results from the associated events and will vary each year.

Table 11-3: WWR Sampling Programs and Sampling Methods

A description of sampling locations is provided in the Monitoring Plan, Volume IV.

Sampling Program (Monitoring Stations)[a]	**Program Component**	**Matrix**	**Analytical Categories**	**# of Samples**	**Type of Sampling**
Receiving Water (1)	Dry Weather	Non-Storm Water	Field Parameters, Chemistry, Microbiology	2	Grab or composite
	Wet Weather Event	Storm Water	Field Parameters, Chemistry, Microbiology	1	Grab or composite
MS4 Monitoring (2)	Wet Weather Event	Storm Water	Field Parameters, Chemistry, Microbiology	4	Grab or composite
	Quarterly Dry Weather IC/ID Monitoring	Non-Storm Water	Field Parameters, Chemistry, Microbiology Conditional[b]	8, Conditional[a]	Grab or composite

(a) Conditional – Additional constituent analysis, follow up actions, and source investigations are dependent on the results from the associated monitoring events and may vary each event.

12. SAMPLE HANDLING AND CUSTODY

This section describes the general samples handling and custody procedures used by all field and laboratory personnel.

12.1 Sample Handling Protocols

The laboratory will provide appropriate sample containers for the samples. At the time of sample collection, the sample labels will be completed in the field with the date and time. The Sample IDs will also be entered directly onto the Field Data Sheets (FDS), or into the Survey 123 field data electronic application, and the COC Forms. The COCs will be pre-printed along with the bottle labels when feasible. The COCs will be completed in the field with dates, times and sample team names, and will be cross-checked with the bottles to make sure proper samples have been collected. The COC form for this project is attached in Appendix A.

All samples bottles will be labeled with the following information:

Required	Recommended (in addition)
Sample ID (unique)	Project name
Site ID	Monitoring program
Sample date	Bottle size and type
Sample time	Bottle __ of __
Sampler's initials	Preservative
Grab or Composite	Field tests/remarks/analysis*
Client	

* Analysis may be listed on the bottle or "see attached list" may be referenced on the bottle when a separate list is provided to the laboratory prior to the monitoring event.

The following sample handling protocols will be followed when collecting samples to minimize the possibility of contamination:

- Composite sampling requires multiple automated aliquots to be transferred into a composite bottle. After the aliquots are collected, the bottle will be tightly capped.

- Once sample containers are filled, they will be promptly placed on bagged ice, (target temperature = 6°C) and transported to the laboratory for processing to meet holding times. All necessary pre-processing for analysis, such as filtration and acidification, will take place in the laboratory by certified personnel.

- After the field crew collects and delivers the samples to the laboratory, the laboratory will conduct the analysis within the holding times. These field and laboratory activities will be coordinated to make sure all samples are handled within the proper holding times and analyses are completed within holding times. With composite samples, the start of holding times is considered to be the time that the last aliquot was collected.

- After the laboratory receives the water samples, the certified laboratory technicians will dispense the sample contents into containers that contain the required volume, as specified in individual monitoring programs, available in Volumes III through V. The laboratory will preserve the water

samples using the appropriate preservatives and the laboratory will conduct the analysis within the maximum holding time limits. When applicable, the sample handling and custody procedures described are in compliance with SWAMP SOP, as defined in Appendix E "Collection of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California", as well as the U.S. Geological Survey's recommendations for clean sampling techniques described in Appendix D.

12.2 Sample ID Format

Sample IDs for the monitoring programs under this CMP will follow the same general format to reduce field and laboratory errors and improve data management. The sample IDs will have the same general format that includes the sampling year, event code, last three or four digits of the station ID number, and a two digit sample code. Below are details of the segments of the sample IDs followed by some examples of proper Sample ID labeling:

General Sample ID Format:
[Sample Year] – [Event Code] – [Station Code] – [Sample Code]

Format Detail:

- **Sample Year** – The sample year is the fiscal year in which sampling is taking place. For example, if a sample is collected in October of 2010, that falls within the fiscal year of 2010-2011, therefore the Sample Year for that Sample ID is '1011'.
- **Event Code** – The event code designates if the sample is a wet weather or dry weather monitoring event sample by a 'W' or 'D', respectively. The sequential event number for that season follows the letter. For example, W1 would be the first wet weather event for a given sample year and D2 would be the second dry weather monitoring event for a given sample year.
- **Station Code** – The last three digits of the Station ID as assigned by the District. For example, Temecula Creek Station ID 902LTC777 is contained in the Sample ID as '777' and Warm Springs Channel Station ID 902WMS397 is contained in the Sample ID as '397'.
- **Sample Code** – The sample code designates if the sample is a primary sample, a field duplicate sample, or a field blank sample. The codes are as follows:
  - 01 – Primary Sample
  - 02 – Field Duplicate
  - 03 – Field Blank
  - 04 – Travel (Trip) Blank

General Sample ID Examples:

Ex. 1 SMR Dry Weather Receiving Water
Sample ID: 1718-D1-828-01
(2017-2018 year, 1st Dry Weather monitoring event, ~~Upper~~ Middle Santa Margarita Site 902USM828, Primary Sample)

Ex. 2 SAR Wet Weather QA/QC
Sample ID: 1011-W1-040-03
(2010-2011 year, 1st Wet Weather monitoring event, Corona Storm Drain Site 801CRN040, Field Blank)

Ex. 3 SMR Wet Weather Outfall

Sample ID: 1718-W1-4034-01
(2017-2018 year, 1st Wet Weather monitoring event, Outlet to Warm Springs Creek d/s of Murrieta Hot Springs Rd Site 902MS44034. Primary Sample)

Investigation Sample ID Format:

- **Investigation Station Code** – If samples are collected in response to an IC/ID or as part of a Source Identification Study the following Sample ID convention will be used:

  [Sample Year] – [Event Type = I][Location Identifier = XXX]a-e – [Region Code] – [Sample Code]

  - **Sample Year** – The sample year is the fiscal year in which sampling is taking place, as noted under the general format details above.
  - **Event Type** – The event type designates if the sample is an Investigation (I), either associated with IC/ID response or a Source Investigation effort in support of other compliance activities.
  - **Location Identifier** (random) – The field investigator shall randomly assign a 3-digit alpha-numeric identifier for the location associated with the special investigation (see example below). Furthermore, when samples are collected in response to an IC/ID or as part of a Source Identification Study, samples will be collected on an as-needed basis moving upstream from the original monitoring location. Given that the number of samples for a source identification study is unknown, alpha-numeric sampling code will be followed by an ascending digit to indicate the sample number moving upstream from the original monitoring point. The ascending digits will be denoted by **a, b, c**, etc. within the Sample ID format as shown above. The field investigator must document the corresponding latitude and longitude for each sequential investigation location (i.e., a, b, c, etc.) as appropriate.
  - **Region Code** – The Region Code represents the watershed in which the investigation is being conducted, where '809' is for SAR, '823' is for WWR, '825' is for SMR.
  - **Sample Code** – The sample code designates if the sample is a primary sample, a field duplicate sample, or a field blank sample as defined under the general format details above.

Investigation Sample ID Examples:

Ex. 1 IC/ID Response to Spill
Sample ID: 1718-IDYCa-809-01
(2017-2018 year, Investigation event, Day Creek Channel at 'a' point, SAR, Primary Sample)
Sample ID: 1718-IDYCb-809-01
(2017-2018 year, Investigation event, u/s Day Creek Channel at 'b' point, SAR, Primary Sample)

12.3 Chain-of-Custody Procedures

COCs will be pre-printed along with the bottle labels when feasible. The COCs will contain the same data as the labels, including the name of the laboratory the samples are being submitted to, and, in some cases as needed, even greater detail. The COCs will be completed in the field with dates, times and sample team names, and will be cross-checked with the bottles to make sure proper samples have been collected. The COC form being used for projects under this CMP is attached in Appendix A.

The COC forms for the samples will be transported with the samples to the analytical laboratory. Sampled water will be kept properly chilled and transferred to an analytical laboratory within holding times. When

custody of the samples is transferred to the laboratory courier, the COC will be signed and dated, and a Xerox or *.pdf copy will be sent from the laboratory to the District and/or other monitoring personnel. The COCs will be reviewed by personnel at the receiving laboratories to ensure that no samples have been lost in transport. The laboratories will also verify that each sample has been received and analyzed within holding times.

13. ANALYTICAL METHODS

The majority of constituents for this project will be analyzed using USEPA-required, State Board-required, and/or SWAMP-required methods and RLs. If laboratory-suggested reporting limits are more stringent than those recommended by SWAMP, laboratory-suggested reporting limits will be applied. Table 6-2 summarizes required information regarding analytical methods. For details regarding the QA measure or performance criteria for each analytical method, refer to Sections 7 and 14. The MS4 Permit-specific monitoring plans provided in Volumes III, IV and V contain constituent lists, holding time criteria, and WQOs tailored to each MS4 Permit and monitoring program requirements.

13.1 Laboratory Analysis

The appropriate preservation and preparation methods will be conducted for each parameter. All samples will be analyzed for the listed constituents within their respective hold times. Analyses methods are consistent with those described in the Standard Methods for the Examination of Water and Wastewater (APHA *et al*, 2005) and USEPA Standard Methods. The list of constituents, measurement techniques and RLs are presented in Table 6-2.

13.2 Sample Disposal Procedures

After analysis, including QA/QC procedures, any excess sample will be disposed of by the analytical laboratories.

13.3 Corrective Action Procedures

Corrective action is taken when an analysis is deemed suspect for some reason. The reasons include exceedances of the Relative Percent Difference ranges, recoveries and blanks. The corrective action varies somewhat from analysis to analysis, but the procedure typically involves the following:

- A check of procedures;
- A review of documents and calculations to identify possible errors;
- Correction of errors;
- A re-analysis of the sample extract, if sufficient volume is available, to determine if results can be improved; and
- A complete reprocessing and re-analysis of additional sample material, if sufficient volume is available, and if the holding time has not been exceeded.

Any failures (e.g., instrument failures) that occur during laboratory analyses will be the responsibility of the laboratory conducting the work. The QA Officer at each laboratory has procedures in place to follow when failures occur, and will identify individuals responsible for corrective action and develop appropriate documentation. Any corrective actions taken will be documented in the laboratory's hard copy deliverable or in a Corrective Action Plan. For more information on laboratory QA procedures please refer to their QA Manual available upon request. Laboratory contact information is available in Appendix O.

14. QUALITY CONTROL

This section addresses QA/QC activities associated with both field sampling and laboratory analyses. The field QA/QC samples are used to evaluate potential contamination and sampling error introduced prior to submittal of samples to the analytical laboratory. QA/QC samples will be collected on a program-wide basis during each monitoring year in accordance with the SWAMP required frequencies (Refer to Table 14-1). Laboratory QA/QC activities provide information needed to assess laboratory contamination, analytical precision and analytical accuracy. If any QA/QC standards are not met, the appropriate corrective actions will be taken in accordance with Section 8.3 of this document and the laboratory QA manual, available in Appendix A. Laboratory contact information is available in Appendix O.

14.1 Field Sampling Quality Control

Sampling quality control uses the following field quality control samples used to evaluate sampling error, potential contamination and precision of sampling methodology. The results of the field quality control data will be included with the environmental sample data in lab reports and EDDs (i.e., simple text format and SWAMP compatible format) with the exception of equipment blank results which will be provided separately prior to any sampling activities. Table 14.1 describes the frequency and acceptance limits for each type of field quality control samples.

1. **Field Blanks** – Field blanks verify that field conditions, field sampling activities and air deposition are non-contaminating. A sample bottle is filled with reagent-grade, analyte-free de-ionized water in the field during a sampling event. Field blanks will not be conducted on flow-weighted or 24-hour time-weighted composite samples. Field blanks will be analyzed for the full suite of constituents being analyzed from grab samples for that particular sampling event and/or project (with the exception of toxicity bioassays as DI water is not suitable for organism's survival).
2. **Field Duplicates** – Field duplicates evaluate sampling error introduced by both field sampling and laboratory analyses. Field duplicates are submitted blind to the laboratory. Procedures for collecting field duplicates should be the same as those used for collecting field samples. Duplicates of manual grab samples will be collected by filling two grab sample containers at the same time. Field duplicates will typically not be conducted on flow-weighted or time-weighted composite samples (exception, under the SMR Monitoring Program they may be collected as a full composite duplicate or a composite split from automated samplers and submitted blindly to the lab). Field duplicates will be analyzed for the same suite of analyses as the primary grab samples.
3. **Equipment Blanks** – Equipment blanks verify that the re-usable sampling containers and tubing are contaminant free prior to sampling. If sampling containers or tubing are re-used then equipment/bottles will be cleaned and blanked. When containers are not pre-certified or provided from a laboratory then one container per batch ordered will be blanked prior to use in sample collection. Field blanks will be analyzed for a representative set of constituents.
4. **Travel Blanks** – Travel or trip blanks verify that volatile organic analysis samples are handled and transported from the field to the laboratory without contamination. One volatile organic analysis vial with reagent water free of volatile contaminants is transported to the site in the same cooler as the empty sample containers. The travel blank is handled like a sample but never opened and then returned to the laboratory. Travel blanks will be analyzed for VOCs and/or SVOCs only.

Table 14-1: Program-Wide Field Sampling Quality Control

Field QC Type	Description	Frequency	Acceptance Limits[a]
Equipment or Container Blanks[b]	Used to verify that re-usable containers and equipment are not contaminated.	Once per batch of equipment	Concentrations should be below the RL.
Field Blank[c]	Used to verify field conditions	Amount equal to 5% of all program samples	Concentrations should be below the RL.
Field Duplicate[c]	Used to evaluate sampling error	Amount equal to 5% of all program samples	Relative Percent Difference range of 0-25%.
Travel (Trip) Blank[d]	Used to verify that VOCs are properly handled/transported	For VOCs/SVOCs only Amount equal to 5% of all program samples	Concentrations should be below the RL.

(a) Acceptance limits are not applicable if the concentration of either the primary or duplicate sample is less than the RL.
(b) If contamination is detected in field equipment blanks, equipment will be decontaminated a second time and analysis will be redone as necessary to resolve the issue.
(c) Field Blanks are not required for flow-weighted composites or time-weighted composites or toxicity bioassays. Field Duplicates are typically not used for composites; however, under the SMR Monitoring Program they may be collected as a full composite duplicate or a composite split from the automated samplers.
(d) Travel (Trip) Blanks only apply to samples being analyzed for VOCs or SVOC's (e.g. SAR Monitoring Program).

14.2 Laboratory Quality Control Analyses

Laboratory quality control analyses will include the use of laboratory replicates, method blanks, MS/MSDs, laboratory control samples and Standard Reference Materials (SRM) as described below. Laboratory quality control results will be provided in a laboratory report and EDDs (i.e., simple text format and SWAMP compatible format) with a batch identification number to correlate with the corresponding environmental sample data set. Table 14.2 describes the frequency and types of quality control samples for each constituent category.

1. **Laboratory Replicate/Split** – A sample is split by the laboratory into two portions and each portion is analyzed. Once analyzed, the results are evaluated by calculating the Relative Percent Difference between the two sets of results. This serves as a measure of the reproducibility, or precision, of the sample analysis. Typically, replicate results should fall within an accepted Relative Percent Difference range, depending upon the analysis.
2. **Method Blanks** – A method blank is an analysis of a known clean sample matrix that has been subjected to the same complete analytical procedure as the field sample to determine if potential contamination has been introduced during processing. Blank analysis results are evaluated by checking against RLs for that analyte. Results obtained should be less than the RL for each analyte. For toxicity, laboratory control water will be tested based on the manipulations performed on one or more of the ambient samples and will be consistent with the USEPA method guidance.
3. **Matrix Spike and Matrix Spike Duplicates (MS/MSDs)** – The purpose of matrix spikes and matrix spike duplicates are to determine how the matrix of the sample affects both the precision and bias associated with the results. Matrix spikes and matrix spike duplicates involve adding a known amount of the chemical(s) of interest to one of the actual samples being analyzed. One sample is split into three separate portions. One portion is analyzed to determine the concentration of the analyte in question in an un-spiked state. The other two portions are spiked with a known concentration of the analytes of interest. The recovery of the spike, after accounting for the

concentration of the analyte in the original sample, is a measure of the accuracy of the analysis. An additional precision measure is made by calculating the Relative Percent Difference of the duplicate spike recoveries. Both the Relative Percent Difference values and spike recoveries are compared against accepted and known method dependent acceptance limits. Results outside these limits are subject to corrective action.

4. **Standard Reference Material** – A SRM is a sample containing a known and certified amount of the analyte of interest and is typically analyzed with the analyst not knowing the analyte concentration. SRMs are typically purchased from independent suppliers who prepare them and certify the analyte concentrations. Results are evaluated by comparing results obtained against the known quantity and the acceptable range of results supplied by the manufacturer. For toxicity, accuracy will be measured with the use of a reference toxicant test that must be conducted per batch for species from commercial supplier settings or monthly for species raised within a laboratory.
5. **Laboratory Control Sample** – The laboratory control sample procedure involves spiking known amounts of the analyte of interest into a known, clean, sample matrix to assess the possible matrix effects on spike recoveries. High or low recoveries of the analytes in the matrix spikes may be caused by interferences in the sample. Laboratory control samples assess these possible matrix effects since the laboratory control sample is known to be free from interferences.
6. **Surrogate compounds** – Surrogate compounds accompany organic measurements in order to estimate losses of the target analyte during sample extraction and analysis. If there is any loss of the surrogate compound during preparation and analysis then it is presumed that the target analyte experienced a similar loss. Surrogate results will be reported with the corresponding organic results for each sample analyzed.
7. **Dilution Samples** – For dilutions carried out to facilitate analysis, all reported results must be corrected for the dilution and flagged to identify that a sample was diluted. Corresponding batch QA samples must be analyzed at the same dilution factor as the analytical batch.
8. **Benthic Macroinvertebrates** – Accuracy will be determined annually by having 20 percent of the samples re-analyzed and validated to SAFIT STE Level 2 (genus/species identifications with chironomid midges identified to genus/species group) by a professional taxonomist.

Table 14-2: Analytical Quality Control

Analyte	Laboratory Replicate	Method Blank	MS/MSD	SRM	LCS[a]
General Chemistry[b]	✓	✓	✓	✓	✓
Total and Dissolved Trace Metals	✓	✓	✓	–	–
Microbiology	✓	–	–	✓[c]	–
Organics					
Polynuclear Aromatic Hydrocarbons (PAHs)	–	✓	✓	✓	–
Pesticides	–	✓	✓	✓	–
Aroclor PCBs	–	✓	–	–	–
Synthetic Pyrethroid Pesticides by NCI-GCMS	–	✓	✓	✓	–
Volatiles	–	✓	✓	✓	–
Toxicity	–	✓	–	✓[d]	–
Other Toxicants	–	✓	–	✓	–

Frequency: Laboratory quality control samples will be analyzed once per analytical batch. An analytical batch is defined as 20 samples or less and may include samples from multiple projects.

(a) According the SWAMP requirements, the laboratory's control sample is an alternate method of assessing accuracy when a Standard Reference Material (SRM) is not available.
(b) Most general chemistry constituents are addressed by SWAMP requirements, however, some are not and quality control analyses will be conducted based on the USEPA Standard Methods.
(c) For microbiology, the SRM is the analysis of positive and negative controls.
(d) For toxicity, the SRM is a reference toxicant test that must be conducted per batch for species from commercial supplier settings or monthly for species raised within a laboratory.

15. INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE

All field equipment will be tested, inspected and maintained according to manufacturer specifications. Sample equipment testing, inspection and maintenance shall be performed on a general schedule of semi-annually or on an event basis as-needed, no more than seven days before a monitoring event (Table 15-1). Replacement parts will be installed as necessary and may be stored onsite in the monitoring shed or brought to the site with field crews. General descriptions of field equipment to be used for the monitoring programs covered under this QAPP are as follows:

Data Logging Flow Meter

Data logging flow meters measure, calculate and log flow data based on a set of continuous measurements and programmed information. Water stage is measured using a bubbler level meter or a pressure transducer. A bubbler level meter translates the proportional relationship of the hydrostatic pressure associated with releasing air bubbles from the bubbler orifice into the height of water above the bubbler orifice. Pressure transducers work in a similar manner except the pressure of the water acts directly on the pressure transducer installed in the water column. The flow meters may incorporate a velocity sensor to measure water velocity using Doppler technology, which rates the velocity of particles in the water. The flow meter allows for programming of the geometry of the conveyance and based on input from the water level sensor and velocity, if applicable, the flow meter calculates instantaneous flow rates. The flow meters also have inputs for a rain gauge, sampler communication and telemetry devices.

Automated Sampler

Automated samplers are programmable to collect time-weighted or flow-weighted composite samples. Samples are collected using Teflon® or Teflon®-lined intake tubing and silicone peristaltic pump tubing. When collecting time-weighted composites, the sampler can be programmed to collect sample aliquots based on desired time intervals. When collecting flow-weighted composites the sampler is programmed to collect samples based on data received from the flow meter. Samplers can be volume calibrated to collect aliquots of a desired volume. Samplers can be equipped with a distributor arm to deliver samples to multiple bottles, if desired. Other settings can be made to the samplers, including start/stop triggers such as high or low water level, which is transmitted via a flow meter. The samplers can also be set to deliver a notification to the data logging flow meter every time an aliquot is collected along with the sample status of "success" or "failure" to provide a record of sample history.

Tipping Bucket Rain Gauge

A tipping bucket rain gauge has a bucket inside that is calibrated to tip once a set volume of water associated with 0.01 inch of rainfall has accumulated. Each time the bucket tips a switch is momentarily closed, sending a signal to the data logging flow meter and it is recorded as 0.01 inch of rainfall with a date/time stamp.

Data Telemetry Unit

Data telemetry units (if available) can be used in areas where cellular data service is available to communicate remotely with the data logging flow meter. This allows for remote control of flow meter setting, sample pacings, data downloading and program initiation or completion.

Field Water Quality Probes

Field water quality probes are used to collect *in-situ* water quality measurements in the field by placing directly in the water column or in a secondary container if the water depth does not allow the probe to be completely submerged. Probes should be exposed to flow in a representative portion of the stream or discharge. If there is no flow (i.e., ponded) or a secondary container is required to make measurements, the probe should be gently agitated, or stir bar turned on (if applicable), particularly when making DO measurements using polarographic (Clark Cell) probes. Probes can either be individual or part of a multi-

parameter meter (sonde). Probes should be calibrated per manufacturer specification prior to use in the field.

Power

The automated sampling equipment and flow meters will be powered by 12-VDC power sources. The power sources will be either 12-VDC deep-cycle marine batteries or 12-VDC gel cell batteries. At each monitoring station, one battery will be used to power the automated samplers and another will power the flow meters and modems. A 30-watt solar panel may be installed at long-term stations, if desired, to keep the batteries charged. If a solar panel is installed a solar panel voltage regulator will be installed to regulate the voltage from the panel to the battery to allow for safe charging.

Equipment Security Housing

Fiberglass or metal equipment enclosures may be used at monitoring stations where access allows. The enclosures will house all monitoring equipment. The enclosures will be bolted to the concrete monitoring pads and locked to secure the monitoring equipment.

Permanent Station Installation

Monitoring stations installed as "permanent" stations are intended to remain in the same location for multiple years or indefinite periods of time. This type of installation typically includes installing a security housing to contain a flow meter, automated sampler, battery, solar panel and regulator, and rain gauge. Sample tubing, bubbler tubing and/or AVB sensors are routed to the discharge through conduit and mounted to stationary features or buried to provide long-term protection. If desired, the station electronics may be removed during the summer months to avoid potential overheating and damage. Sample tubing should be replaced with clean tubing at the beginning of each monitoring season as dictated by each monitoring program.

Temporary Station Installation

Monitoring stations installed as "temporary" stations are intended to remain onsite for short periods of time such as a single monitoring event or a single season with a few events. This type of installation typically involves mounting sampling tubing, bubbler tubing and/or AVB probes in the discharge using expansion rings or similar light-duty methods of installation. The tubing and probe cables are not typically shrouded in conduit and can either be removed between sampling events or coiled and stored onsite, depending on site characteristics and channel access. Monitoring electronics are placed onsite during pre-monitoring activities and may be locked together or to stationary features if available. Monitoring electronics are removed at the completion of sampling activities.

Handheld Flow Meter

Handheld flow meters are used to measure instantaneous water velocity. These meters can be used to take a single measurement or to conduct stream gauging in accordance with United States Geological Survey (USGS) stream gauging protocols (Rantz, 1982). Some handheld flow meters have the capability to store data points during stream gauging and output a final discharge value.

Handheld Global Positioning System (GPS) Unit

Handheld GPS units are used to locate the position of sites based on latitude and longitude. Units should be equipped with differential capabilities to provide higher accuracy. Users should allow time for the unit to communicate with satellites prior to use to obtain accurate position data.

Table 15-1: Testing, Inspection, and Maintenance of Field Equipment and Monitoring Instruments

Equipment	Maintenance/ Testing/Inspection Activity	Responsible Person	Frequency	SOP Reference
Data Logging Flow Meter	Maintenance and Inspection	Deploying agency or Consultant	Semi-annually or as needed	Manufacturer O&M Manual
Automated Sampler	Maintenance and Inspection	Deploying agency or Consultant	Semi-annually or as needed	Manufacturer O&M Manual
Tipping Bucket Rain Gauge	Maintenance and Inspection	Deploying agency or Consultant	Semi-annually or as needed	NA
Data Telemetry Unit	Maintenance and Inspection	Deploying agency or Consultant	Semi-annually or as needed	Manufacturer O&M Manual
Field Water Quality Meter(s)	Maintenance and Inspection	Deploying agency or Consultant	Semi-annually or as needed	Manufacturer(s) O&M Manual(s)

All laboratory equipment is tested, inspected and maintained based on manufacturer recommendations and accepted laboratory protocols. The laboratories maintain testing, inspection and maintenance practices as part of their method SOPs maintained in their laboratories by their Laboratory Director/QA Officer and can be provided upon request.

All field instrument testing, inspection, and maintenance frequencies are consistent with the SWAMP QAPrP. Monitoring consultants will maintain instrument testing, inspection and maintenance practices as part of the method SOPs and recorded in calibration logs at their respective offices. The District's Section Manager has reviewed these practices and finds them in conformity with SWAMP requirements.

16. INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Calibration of field meters will be performed no more than seven days prior to a sampling event, or as-needed. A calibration log will be maintained for all meters used in the field. All meters will be calibrated according to the manufacturer's operations manual. Any parameters that do not require frequent calibration per manufacturer recommendation will be checked in a known standard for verification and documentation purposes. Calibration logs will be kept on file at the District. For District-owned equipment, instructions for calibration and measurements are provided in Appendix H.

All laboratory equipment is calibrated based on manufacturer recommendations and accepted laboratory protocols. The laboratories maintain calibration practices as part of their method SOPs maintained in their laboratories by their Laboratory Director/QA officer and can be provided upon request.

Calibration for all flow meters and automated samplers will be conducted prior to installation and, thereafter, no more than seven days before a monitoring event. The data logging flow meter and automated sampler will be calibrated per the manufacturer's operation manual. For flow meter calibration, the recorded water level will be checked by comparing the level to actual levels while the water level sensor is submerged in water of a known level. Computational calibrations cannot be performed but deviations from known

values are documented and the equipment will be replaced or repaired as necessary. For automated sampler calibration, the aliquot volume will be calibrated using a graduated flask or beaker.

All field instrument calibration frequencies are consistent with the SWAMP QAPrP. Laboratory consultants maintain calibration practices as part of their method SOPs. The District's Section Manager has reviewed these practices and finds them in conformity with SWAMP requirements.

17. INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

All glassware, sample bottles and collection equipment, including tubing, will be inspected prior to use. All ordered supplies will be examined for damage as they are received. Bottles and caps will be inspected for damage prior to sampling, and only sound bottles with intact threads will be used. The container caps will be tested for tightness prior to transport of samples.

The monitoring agency's/consultant's Project Manager will ensure sufficient field supplies are on hand prior to the start of sampling for each period. Field supplies will be stored at each respective monitoring agency's/consultant's offices or onsite in a monitoring shed. Laboratory supplies will be stored at the laboratories conducting the work.

Table 17-1: Inspection/Acceptance Testing Requirements for Consumables and Supplies

Project-Related Supplies/Consumables	Inspection/Testing Specifications	Acceptance Criteria	Frequency	Responsible Individual
Pre-Cleaned Sample Containers	Open container	Lids screwed on bottles	100%	Sampling agency or Consultant
Laboratory Glassware	Dirty	Clean	100%	Laboratory Consultant
Lab Solvents and Acids	Leaks	No cracks or chips	Prior to use	Laboratory Consultant
19-Liter Glass or 1-Liter Glass	If not certified pre-cleaned then laboratory blanked	Pass blanking analysis	New bottles each monitoring year or if not blanked, then new bottles each event	Laboratory Consultant, Sampling agency or Consultant
Silicone Tubing	Laboratory cleaned and blanked	Pass blanking analysis	New tubing at start of fiscal year or if not blanked, then new tubing each event	Laboratory Consultant, Sampling agency or Consultant
Teflon Tubing	Laboratory cleaned and blanked	Pass blanking analysis	New tubing at start of fiscal year or if not blanked, then new tubing each event	Laboratory Consultant, Sampling agency or Consultant

18. NON-DIRECT MEASUREMENTS (EXISTING DATA)

Historical monitoring data and fire data collected by an outside agency will be used in the Monitoring Annual Report to identify trends and conduct comparisons.

19. DATA MANAGEMENT

Data will be submitted in a standardized SWAMP-compatible format consistent with the standard used by the Regional Data Center at SCCWRP in order to standardize the data provided by multiple entities, document data quality to ease the comparison of data sets and to facilitate timely submittals. The District will compile the monitoring and analytical data, and provide the data set(s) to San Diego, Santa Ana, and Colorado River Regional Boards in the respective Annual Monitoring Reports and deliverables. Data is submitted to the California Environmental Data Exchange Network (CEDEN) Regional Data Center at SCCWRP annually. Any intentional deviations from SWAMP protocols or requirements not specified in this QAPP (Volume II) or the Monitoring Plans (Volumes III, IV, or V) will be provided in the respective Monitoring Annual Report.

19.1 Hydrologic Data

The respective monitoring agency's or consultant's Project Manager is responsible for hydrologic data management of their respective monitoring project and will track the data logger results, which include rainfall, sampling history and discharge (velocity, stage and instantaneous flow) data, when applicable. The original electronic data logger files will be saved electronically as Insight files on the project file. Sampling teams will manually check the data logger results while at the site. The visual discharge and precipitation observed by field crews during the storm and the precipitation posted for nearby sites on the NWS website will be compared to the logged data. If a large discrepancy exists, all equipment will be checked for malfunction. Any other site problems, such as debris clogging the conduits, will be checked and eradicated during the monitoring event. After each storm event, the logged data will be screened for the following major items:

- A check of the meter and sampler settings associated with each data logger file, including Station ID and units, to verify that correct information matches the flow data set. Incorrect settings will be re-programmed for future events.
- A data gap check to identify time periods with no recorded data during the monitoring event. Any data gaps will be identified, logged, and investigated.
- A check of the discharge start time and precipitation start time.
- A check of rainfall intensity and discharge values throughout the monitoring event to verify that the discharge increased and decreased when the rainfall intensity increased and decreased.
- A check of the number of samples and discharge to verify that the frequency of sampling increased when discharge increased.

19.2 Field Observations and *In-situ* Measurements

The District's Monitoring Program Manager will review all Field Data Log Sheets for completeness, maintain the original hard copies and scan electronic copies (*.pdf) for storage in the project file. Photographs of the monitoring sites taken by field personnel will be uploaded into the project file within three business days of field visits. Field team members will name the photographs using the photograph naming convention developed specifically for a particular monitoring project. Calibration logs for handheld meters will be reviewed by the Project Manager and saved in the project file. Copies of field data sheets, photographs and calibration logs will be delivered to the District within fourteen (14) calendar days of each monitoring event in the form of a simple post-event technical memorandum (i.e., event summary). Refer to Section 19.5 for a description of the Event Summary deliverables.

19.3 Analytical Data

The laboratories will provide data in both *.pdf copies of lab reports and in a SWAMP-compatible electronic format. A SWAMP-compatible template will ensure that the data files can be uploaded to the SWAMP regional database as required by the permits. SWAMP Compatible Data Guidance Manuals are provided in Appendix I. The Laboratory Project Manager will review all lab reports and EDDs for accuracy, completeness and compatibility with SWAMP. Chemistry analytical results will be submitted to the District in *.pdf format and as EDDs (i.e., simple text format and SWAMP compatible format) within three (3) weeks (i.e., 21 calendar days) of receipt of samples.

Within seven (7) days from receipt, the District's Data Manager will screen preliminary data deliverables for the following major items:

- A 100% check between electronic data provided by the laboratory and the hard copy reports
- Conformity check between the Chain-of-Custody Forms and laboratory reports
- A check for laboratory data report completeness
- A check for typographical errors on the laboratory reports
- A check for use of appropriate analytical methods and reporting limits
- A check for suspect values, flagged data and review of laboratory QA data

After the District's Data Manager has made the necessary corrections or revisions and verified the data meets the quality requirements of the CMP and QAPP, the data will be uploaded into a database. The District maintains its rainfall in a proprietary integrated data management system known as Hydstra©[11]. The Hydstra© software system was installed early in FY 1999-2000. In 2017 the District upgraded their water quality database to Kisters Water Quality Module (KiWQM). It uses stringent quality control procedures and includes custom data analysis and reporting procedures. Water quality data collected by other Permittees may also be stored in the District's database. The KiWQM database will incorporate a number of quality control checks and queries to further verify and validate data. The District's Database Manager will control the access to the project's database. Kisters' data entry procedures are provided in Appendix M. The laboratory EDDs will be maintained in a file separate to the cumulative database so the original SWAMP compatible EDDs are maintained and can be used as a reference. If data is reissued, the file name will include the date and the word "revised". To manage the revision and prevent duplicate entries, the erroneous dataset will be removed from the database prior to uploading the revised dataset.

19.4 Bioassessment Data

The District's Data Manager and/or consultant Project Manager will review all lab reports and EDDs for accuracy, completeness, and compatibility with SWAMP. Lab reports and EDDs will be stored by the District and/or consultant in the project file. Bioassessment and toxicity analytical results will be provided to the District in hard copy format and as an EDD within six (6) weeks of receipt of samples.

[11] Although Hydstra© and KiWQM are Kisters proprietary data management systems, the program supports export of data in commonly used spreadsheet and database formats. The use of trademark or brand names does not connote a recommendation of a particular product.

19.5 Technical Memorandums

Technical Memorandums will be developed by the consultant for monitoring projects under their charge to provide the District's Monitoring Program Manager with a summary of the activities conducted. These summaries will follow the general guidelines below unless otherwise specified in a task order.

Post-Event Technical Memorandum: Consultants will develop and submit a Post-Event Technical Memorandum (i.e., event summary package) to the District following each event for monitoring projects under their charge (e.g., wet weather monitoring, Stream Assessment/Bioassessment monitoring, and/or dry weather monitoring) as applicable. The deliverable will contain the following:

- An event summary table summarizing the details of the monitoring event: event type, sample team, locations monitored, flow, rainfall (if applicable), and types of samples collected, etc.
- Bioassessment/ Stream Assessment data (if applicable), not including chemistry, in a SWAMP-compatible EDD
- Field data in a SWAMP-compatible EDD
- Field data sheets (including any composite sampling flow data and %)
- Photographs
- Calibration logs

For wet weather and dry weather monitoring events (excluding Stream Assessment/Bioassessment) the deliverables will be submitted in *.pdf format along with the associated SWAMP-compatible EDDs within fourteen (14) calendar days.

For Stream Assessment/ Bioassessment monitoring events, the deliverables will be submitted in *.pdf format within fourteen (14) calendar days. The associated SWAMP-compatible EDDs will be provided within ninety (90) calendar days or once available from the subcontracted laboratory.

GROUP C ELEMENTS: ASSESSMENTS AND RESPONSE ACTIONS

20. ASSESSMENTS AND RESPONSE ACTIONS

The Section Manager has the power to halt all sampling and analytical work by a consultant if the deviations noted are considered detrimental to data quality.

The District's Monitoring Program Manager will be responsible for the day-to-day oversight of consultant monitoring activities, laboratory analyses, and/or data reporting. Any failures (e.g., instrument failures) that occur during data collection and/or laboratory analyses will be the responsibility of the field crew or laboratory conducting the work, respectively. It is the responsibility of the consultant Project Mangers to report any assessments and proposed corrective actions to the District's Monitoring Program Manager and Data Manager.

Three types of assessments will be performed as part of this project to ensure that the sampling and analysis activities are in accordance with the approved QAPP. They are as follows:

1. **Surveillance of Sample Collection Activities:** The District's Monitoring Program Manager will be responsible for oversight of sampling activities and jointly the District's Monitoring Program Manager and Data Manager will review field datasheets to verify that the samples were collected in accordance with QAPP requirements. If the review identifies field activities to be in violation of QAPP requirements, the District's Monitoring Program Manager has the authority to stop these activities until corrective actions are successfully implemented. Corrective actions could include additional training to improve field team performance and QAPP compliance, or appropriate re-sampling of sites, as needed. The District's Monitoring Program Manager will report all such actions to the District's Watershed Monitoring Section Manager and document it in the project file. This information will be communicated regularly between the District's Monitoring Program Manager, the District's Data Manager, and the District's Watershed Monitoring Section Manager.
2. **Data Quality Assessment:** Each Laboratory Manager will be responsible for providing a summary of QA/QC data to the District's Monitoring Program Manager, who will consult with the District's Data Manager to verify that the performance criteria of the QAPP were met. This will occur following receipt of each report from the contract laboratory. If it is determined that the precision and accuracy objectives were not met the District's Data Manager will notify the Laboratory Manager and District's Monitoring Program Manager. The Laboratory Manager will review laboratory techniques to minimize errors, and samples will be re-analyzed, if possible.
3. **Assessment of Data Entry:** Once the performance criteria are met and the data has been submitted to the District, the District's Data Manager will review data files to ensure that errors are detected and corrected. If necessary, the District may request a revised dataset from the Consultant. The District will retain original data files and qualified data will be retained in the District's database. Data is qualified according to SWAMP protocols in the District's database.

21. REPORTS TO DISTRICT MANAGEMENT

This section describes internal processes for conducting interim progress reporting to District management. The District's Monitoring Program Manager periodically provides informal progress reports to the Section Manager describing Monitoring Program implementation, field concerns, and interpretation of the monitoring results. The purpose of these reports is to brief the Section Manager in order to facilitate Monitoring Program oversight and assessment activities. Informal progress reports may be completed through internal meetings (i.e. undocumented), verbal communication, and/or written summary of current monitoring activities. Final Monitoring Program QA assessment and reporting will be submitted to the Section Manager in the form of the Draft Monitoring Annual Report for each region. The Section Manager will review the Draft Monitoring Annual Report(s) for completeness and consistency with program requirements and will work with the Monitoring Program Manager to determine ways to improve program implementation as needed.

Table 21-1: Reports to Management

Type of Report	Frequency	Person(s) Responsible for Report Preparation	Report Recipients
Informal Progress Report	Quarterly or As needed	Monitoring Program Manager	Section Manager
Final Assessment Report	Annual (Based on Annual Reporting deadlines)	Monitoring Program Manager	Section Manager

GROUP D ELEMENTS: DATA VALIDATION AND USABILITY

22. DATA REVIEW, VERIFICATION AND VALIDATION REQUIREMENTS

All analytical data will be reviewed and compared to the Data Quality Objectives described in Section 7 of this QAPP, along with the applicable QA/QC practices. If results fail to meet any Data Quality Objective, the District Monitoring Project Manager and/or the District Section Manager will flag them for further review. Batch QA samples will be reviewed to determine the potential cause of failure to meet the Data Quality Objective. Data will be separated into three categories: data meeting all Data Quality Objectives (acceptable data), data failing precision or recovery criteria (further investigation warranted) and data failing to meet accuracy criteria (data is rejected).

If further investigation is warranted based on data failing precision or recovery criteria, all aspects of the data will be assessed for data quality by the District Monitoring Program Manager. At that point, the data will either be accepted or rejected. If accepted, the data will be flagged with a "J" per USEPA specifications. If data fails to meet accuracy criteria, or the cause of the failure cannot be identified and rectified, the data will be excluded from inclusion in the study results. All rejected data will be retained in the Monitoring Program database, and qualified as "rejected". The ultimate decision of whether to accept or reject a data point will be made by the District Monitoring Program Manager in consultation with the District Section Manager.

If the analysis for more than ten percent of any given analyte fails to meet the Data Quality Objective, the Project Manager and Section Manager will meet to discuss the appropriateness of the Data Quality Objective and any potential modifications. All proposed modifications of Data Quality Objectives shall require a reissuance of the QAPP.

23. VERIFICATION AND VALIDATION METHODS

Data verification is the process of evaluating the completeness, correctness and conformance of the dataset against the method, procedural or contractual requirements. The goal of data validation is to evaluate whether the data quality goals established during the planning phase have been achieved (USEPA 2002). Data quality indicators will be continuously monitored by the analyst producing the data (i.e., field and lab personnel), as well as the District Monitoring Program Manager, with assistance from the District Section Manager, throughout the project to ensure that corrective actions are taken in a timely manner. Data validation is an analyte- and sample-specific process that extends verification to determine the analytical quality of the dataset (USEPA 2002). Laboratory and field personnel responsible for conducting QA analysis will be responsible for documenting when data do not meet measurement quality objectives as determined by data quality indicators.

23.1 Data Verification and Validation Responsibilities

Data collected in the field will be validated and verified by the District's Monitoring Program Manager and the District's Data Manager, and/or the consultant Project Manager. The laboratories will maintain COCs and sample manifests.

Laboratory validation and verification of the data generated is the responsibility of the respective Project Manager. Laboratories will maintain analytical reports in a database format as well as all QA/QC documentation for the laboratory. The Laboratory QA Officer will perform checks of all of its records.

The District's Section Manager and Monitoring Program Manager are responsible for oversight of data collection and the initial analysis of the raw data obtained from the field and the contracted laboratory. All data records will be checked visually and recorded as checked by initials and dates.

Reconciliation and correction of any data that fails to meet the Data Quality Objectives will be done by the District's Monitoring Program Manager in consultation with the District's Data Manager, the District's Section Manager, and consultant/agency Project Managers as appropriate. Any corrections require a unanimous agreement that the correction is appropriate.

23.2 Process for Data Verification and Validation

Data verification and validation for sample collection and handling activities will consist of the following tasks:

- Verification that the sampling activities, sample locations, number of samples collected and type of analysis performed is in accordance with QAPP requirements;
- Documentation of any field changes or discrepancies;
- Verification that the field activities (including sample location, sample type, sample date and time, name of field personnel, etc.) were properly documented;
- Verification of proper completion of sample labels and COC forms, and secure storage of samples; and
- Verification that all samples recorded on COC forms were received by the laboratory.

Data verification and validation for the sample analysis activities will include all of the following:

- Verification that appropriate methodology has been followed;
- Verification that instrument calibrations have been adequately conducted;
- Verification that QC samples meet performance criteria;
- Verification that analytical results are complete; and
- Verification that documentation is complete.

Verification and validation of data entry includes:

- Sorting data to identify missing or mistyped (too large or too small) values;
- Double-checking all typed values; and
- Verification that correct data types correspond to database fields (i.e., text for text, integers for integers, number for numbers, dates for dates, times for times, etc.).

24. RECONCILIATION WITH USER REQUIREMENTS

The wet weather, dry weather, and extended flow monitoring data produced by this Monitoring Program will be used by the District to complete assessment and annual reporting. The Draft and Final Reports produced by the District will evaluate potential sources of the Pollutants-of-Concern throughout the MS4 and receiving water conditions using dry weather and wet weather monitoring data associated with this Program. Data will be evaluated to identify and prioritize locations that may need management actions and the sources of contaminants. The limitations and assumption of the data will be provided to allow the District to determine the data's usefulness. Data will be qualified in the Monitoring Program database to identify any data considered suspect, rejected or estimated.

APPENDIX A:

BABCOCK CHAIN-OF-CUSTODY, DRIVING DIRECTIONS, AND LABORATORY PROCEDURES (Procedures provided electronically by request only)

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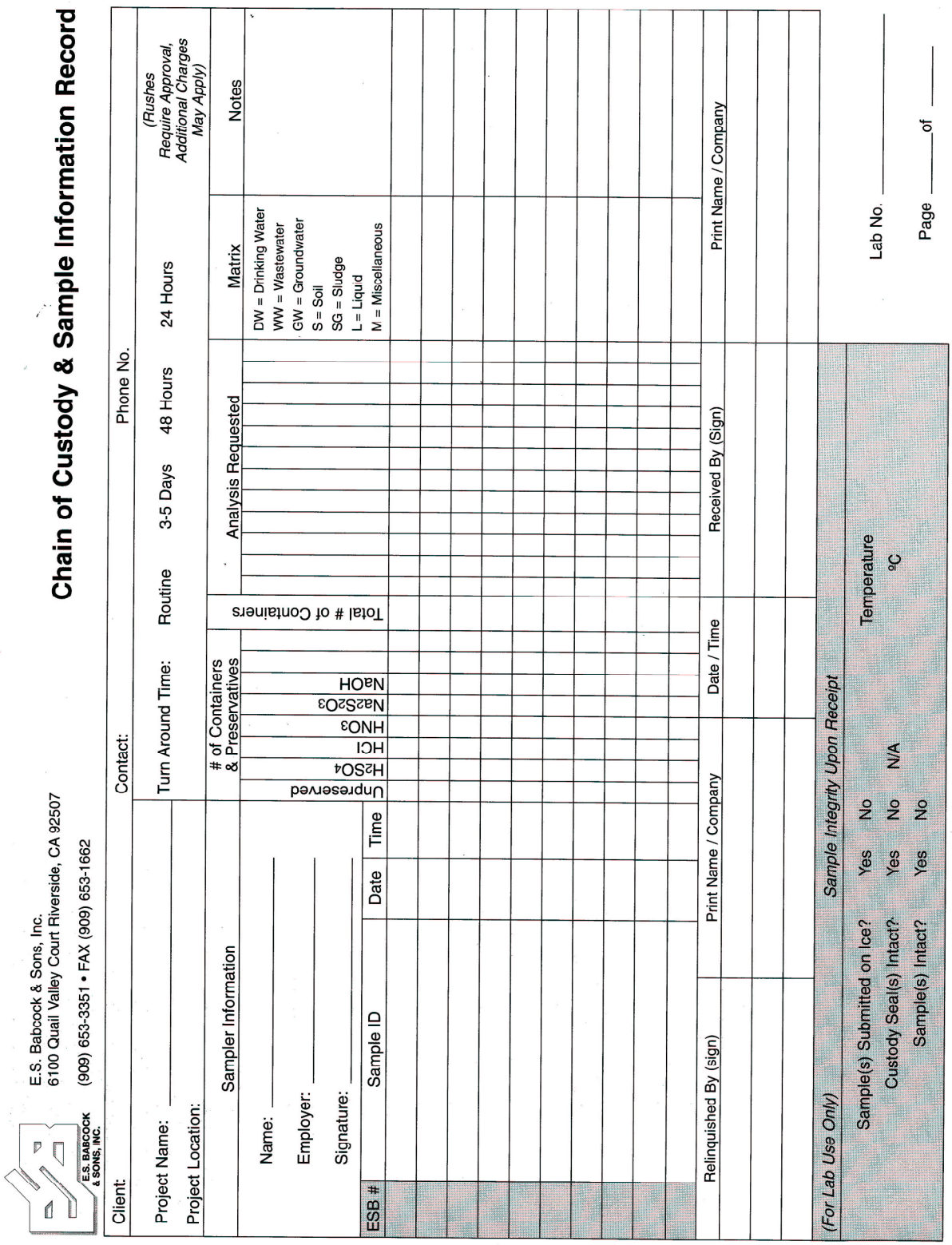
Babcock Chain of Custody Form



E.S. Babcock & Sons, Inc.
6100 Quail Valley Court Riverside, CA 92507
(909) 653-3351 • FAX (909) 653-1662

E.S. BABCOCK & SONS, INC.

Chain of Custody & Sample Information Record

Client: Contact: Phone No.

Project Name: Turn Around Time: Routine 3-5 Days 48 Hours 24 Hours *(Rushes Require Approval, Additional Charges May Apply)*

Project Location:

Sampler Information

Name:

Employer:

Signature:

ESB #	Sample ID	Date	Time	# of Containers & Preservatives: Unpreserved	H_2SO_4	HCl	HNO_3	$Na_2S_2O_3$	NaOH	Total # of Containers	Analysis Requested	Matrix	Notes

DW = Drinking Water
WW = Wastewater
GW = Groundwater
S = Soil
SG = Sludge
L = Liquid
M = Miscellaneous

Relinquished By (sign)	Print Name / Company	Date / Time	Received By (Sign)	Print Name / Company

(For Lab Use Only) *Sample Integrity Upon Receipt*

Sample(s) Submitted on Ice? Yes No Temperature

Custody Seal(s) Intact? Yes No N/A °C

Sample(s) Intact? Yes No

Lab No. _____

Page _____ of _____

Chain of Custody Form Instructions

Example filled-out Chain of Custody Forms are available in the monitoring location-specific binders at David Ortega's (951-955-4390) office. Additional, site specific instructions are provided for most CMP stations.

1. **Client**: **RCFC&WCD**

2. **Contact**: [name of monitoring program manager] **Rebekah Guill**

3. **Phone number**: The Contact's phone number **951-955-2901**

4. **Project Name**: SAR/SMR/WWR (note which one) or Complaint Response

5. **Project Location**: Brief description

6. **Turn Around Time**: Usually Routine.

7. **Sampler Name**: [name of lead sampler]

8. **Employer**: RCFC&WCD or the company name if other than a District employee collected the sample.

9. **Signature**: Signature of the lead sampler.

10. **Sample ID**: If at an existing MS4 monitoring station, note the station number here. If at a different location, use station number 823 for WWR complaints, 809 for SAR complaints, and 825 for SMR complaints. This number is used to enter the analysis into the database; **do not use other than the station number and a sequence number, if needed**. For example, the first of a sequence for a complaint sample collected in the Santa Ana Region would be labeled as "809-01".

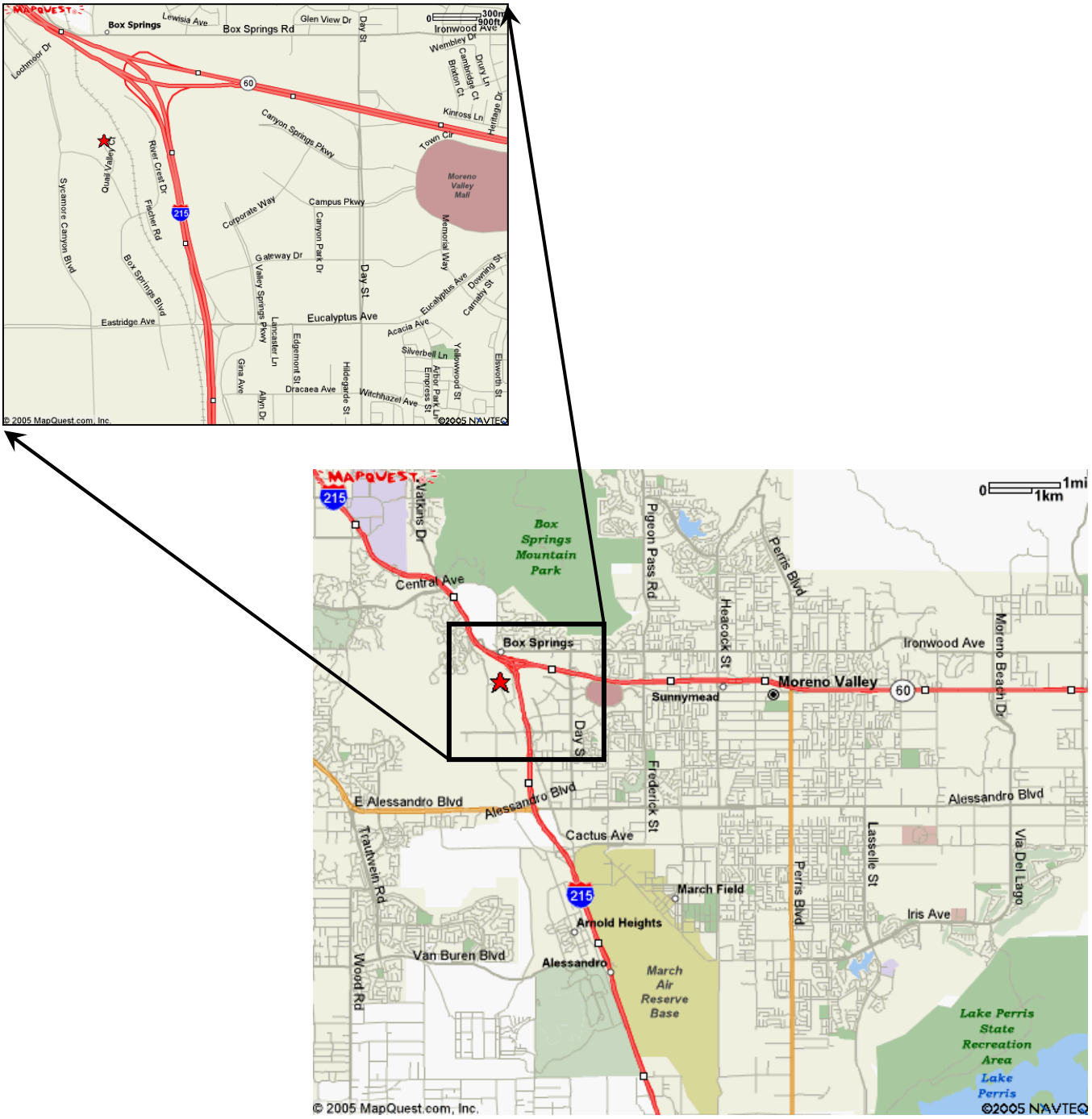
11. **# of Containers & Preservatives**: Write the number of bottles with a specific preservative under the preservative's column. Write the number of unpreserved bottles under the "Unpreserved" column. Write the total number of containers under the appropriate column as a check.

12. **Analysis Requested**: Indicate the pre-determined analyses for the samples or attach the specific watershed analyses sheet.

13. **Matrix**: Usually wastewater (WW) or soil (S)

14. **Relinquished By**: This area is important and must be filled out. When a person hands the sample to another person, the date and time the transfer took place and the signature of both parties involved in the transfer must be included. For example, when the samples are delivered to the lab, the District and lab staff people will sign and date the *Chain of Custody*. If someone outside of the District collects the sample, that person and you will be the first signatories.

Map to Babcock Laboratories



Driving directions to Babcock (taken from Mapquest)

From the South (e.g., Temecula):

Merge onto I-15 N	
Take I-215 N toward Riverside/San Bernardino	28.8 miles
Take the EUCALYPTUS AVE / EASTRIDGE AVE exit.	0.2 miles
Turn SLIGHT LEFT to take the EASTRIDGE AVE ramp.	<0.1 miles
Turn LEFT onto EUCALYPTUS AVE / EASTRIDGE AVE. Continue to follow EASTRIDGE AVE.	0.1 miles
Turn RIGHT onto BOX SPRINGS BLVD.	0.4 miles
Turn LEFT to stay on BOX SPRINGS BLVD.	0.1 miles
Turn RIGHT onto QUAIL VALLEY CT.	0.1 miles
End at **6100 Quail Valley Ct**	

From the West (e.g., Corona)

Take the CA-91 E toward SAN BERNARDINO	
Merge onto I-215 S / CA-60 E	4.2 miles
Take the BOX SPRINGS exit toward FAIR ISLE DR.	0.2 miles
Turn RIGHT onto BOX SPRINGS RD.	<0.1 miles
Turn LEFT onto SYCAMORE CANYON BLVD	0.5 miles
Turn LEFT onto BOX SPRINGS BLVD	0.2 miles
Turn LEFT onto QUAIL VALLEY CT.	0.1 miles
End at **6100 Quail Valley Ct**	

From the North (e.g., Norco)

Merge onto I-15 S toward SAN DIEGO	
Merge onto CA-60 E toward RIVERSIDE	16.5 miles
Take the BOX SPRINGS exit toward FAIR ISLE DR	0.2 miles
Turn RIGHT onto BOX SPRINGS RD	<0.1 miles
Turn LEFT onto SYCAMORE CANYON BLVD	0.5 miles
Turn LEFT onto BOX SPRINGS BLVD	0.2 miles
Turn LEFT onto QUAIL VALLEY CT.	0.1 miles
End at **6100 Quail Valley Ct**	

From the East (e.g., Banning)

Merge onto I-10 W toward LOS ANGELES	
Merge onto CA-60 W via the exit on the LEFT toward RIVERSIDE	18.4 miles
Take the BOX SPRINGS exit toward FAIR ISLE DR	0.1 miles
Turn LEFT onto BOX SPRINGS RD.	0.1 miles
Turn LEFT onto SYCAMORE CANYON BLVD.	0.5 miles
Turn LEFT onto BOX SPRINGS BLVD	0.2 miles
Turn LEFT onto QUAIL VALLEY CT	0.1 miles
End at **6100 Quail Valley Ct**	

APPENDIX B:

FIELD DATASHEET AND EXAMPLE ELECTRONIC GUIDANCE

FIELD DATA SHEET

RIVERSIDE COUNTY
WATERSHED PROTECTION

STATION ID: _____ **SAMPLE DATE** (MM/DD/YYYY): _____

STATION NAME: _____ WATERSHED: ☐SAR ☐SMR ☐WWR

PROJECT NAME: _____ Within: ☐Unincorp. or

CONVEYANCE TYPE: _____ ☐City of _____

GPS INFO: Lat _____ Long _____ GPS Unit: _____ ☐Receiving Water ☐Within IAH

PRINTED NAMES of Sampling Team: _____ ☐ Outfall, Owner:_____

SIGNATURE of lead sampler: _____ Sampling AGENCY: _____

SAMPLE INFORMATION ☐ **VISITED, NOT SAMPLED (TIME:_____)**

EVENT CATEGORY: ☐ Wet Weather (Storm) OR ☐ Dry Weather ☐ Recon, IC/ID, or Complaint
☐1st ☐2nd ☐3rd ☐4th ☐ Other _____

SAMPLE ID(s) [# of Bottles**]: 1617-D1-782-01 [___], 1617-XX-XXXX-01-C [___], 1617-XX-XXXX-XX [___]**

STREAM FLOW:

Dry: ☐Yes ☐No Ponded: ☐Yes ☐No
Rising Groundwater: ☐Yes ☐No
Connects to Surface Receiving Water ☐Yes ☐No
Dry weather event u/s influence: ☐Yes ☐No

TYPE (check all that apply):

☐ **Grab** (-01) [SAMPLE TIME: _____]
☐ **Composite**(-01-C) _____ (COC last aliquot)
☐ **Field DUP**(-02) _____ ☐ **Field Blank**(-03) _____
☐ **Travel Blank**(-04) _____ ☐ Other:_____

FIELD PARAMETERS Time Measured: _____

	Result (primary/dup)	Units	Meter	Calibration Date
☐ **Water Temp**				
☐ **pH**				
☐ **EC**				
☐ **Turbidity**				
☐ **DO**				
☐				
☐				

FLOW ESTIMATION:

☐ USGS Gauge height/stage _____ ft Q (cfs) = _____
[Gauge Name/No.: _____]
☐ Calculation by visual measurement: Q (cfs) = _____
= [Coef(1,$^2/_3$,_____)]*[depth_____ft]*[width_____ft]*[vel_____fps]

Circular pipe: [vel_____fps][depth_____ft][width_____ft][R=_____ft]

COMPOSITE Samples: Auto/Grab, Flow/Time Weighted, ____Hrs

	Time	H(in.)	Flow(cfs)	%		Time	H(in.)	Flow(cfs)	%
1					13				
2					14				
3					15				
4					16				
5					17				
6					18				
7					19				
8					20				
9					21				
10					22				
11					23				
12					24				

SITE CONDITIONS

PRECIPITATION:
NOW: ☐ None ☐ Drizzle/Sprinkle ☐ Rain ☐ Hail/Snow
Is there >72 hrs since previous rainfall event? ☐Yes ☐ No
(A measurable rainfall event is an event with >0.1 inch of rain)
[~ Storm Start Time: _____]
[~ Storm End Time: _____]
Total Rainfall Estimate: _____

ODOR: ☐ None ☐ Sulfides ☐ Sewage ☐ Smoke ☐ Petroleum ☐ Other: _____
☐ Floatables_____ ☐ Settleables _____
☐ Vegetation_____ ☐ Staining _____

COLOR: ☐ Colorless ☐ Green ☐ Yellow ☐ Brown ☐ Other

CLARITY: ☐ Clear (see bottom) ☐ Cloudy ☐ Murky
Sheen Present: ☐ Yes ☐ No

TRASH: ☐ Yes ☐ No
From: ☐ Flows ☐ Litter ☐ Dumping ☐ Other_____

Observations/Notes ☐ **Photograph(s)**

☐ **Associated monitoring u/s, d/s** *(circle one or both and complete required FDS(s))* **at:**

- Field Data Sheet (FDS) Instructions -

Station ID – Enter station number and sampling date. **NOTE: These Station ID numbers must match bottle labels & COCs.** Remaining fields self-explanatory. Major land uses can be estimated in the field or back in the office.

Sample Information –Self-explanatory.

- Bottles must be stored on ice from when the sample is collected to when they reach the laboratory.
- Make sure the bottles are properly sealed (caps on snug).
- **Note all Sample IDs taken at this station, and specify the number of containers in each sample set after the ID in [__].** ***EXAMPLE, In the case where a primary sample, a duplicate, and a trip blank sample are collected for the same event:***
  1415-W1-746-01 [36], 1415-W1-746-02 [36], 1415-W1-746-04 [2]. (Note: -02 and -03 Require a Separate COC)
- A grab sample is a single sample collected at one time. **This must match bottle labels and chain of custody.**
- A composite sample is a series of grab samples collected over a period of time. The separate samples are combined into a single flow-proportioned sample prior to analysis, usually at the laboratory. Ensure that the sample times, flow heights and flow estimation columns are filled out at the bottom of the page.

Field Parameters – Note the time at which field parameters were measured for both primary and DUPLICATE samples. Field parameters must be measured, **bolded items** are the minimum. **Always include units!** Enter name (not type) of field meter used and its last calibration date in corresponding field. If field **DUPLICATES** are taken, a 2nd set of field parameters must be recorded in the results column, but not for field blanks. ***EXAMPLE: pH 6.77 / 6.91, where 6.77 is the -01 sample and 6.91 is the -02 sample.***

Flow Estimation

- If there is a USGS gauge, enter the gauge height. Discharge can be retrieved when back at the office. Note the name or gauge number in space provided.
- If needed, note the channel shape parameters so flow can be calculated. Flow speed can be measured with a leaf or stick and a stopwatch. Do not use trash as a floatable in estimating velocity!
  - Coef = 1 (straight wall/rectangular channel), $^2/_3$ (trapezoidal channel), ½ (triangular channel), 0.8 (rough bottom), 0.9 (smooth bottom).
  - Width: Use top width of flow
- ***Flow in circular pipes.*** Record velocity (vel, fps), depth of flow @ center of pipe (ft), top width of flow (ft), and Radius of pipe (R, ft). Flow will be calculated at the office using Table .

Site Conditions – Self-explanatory.

The date(s) of last rain/storm may be filled out at the office.

Use the categories below to assist in describing the flow and the surroundings and stream flow:

Odor: None, Musty, Sewage, Rotten Egg, Sour Milk, Fishy, Petroleum, Ammonia, Chlorine, Decaying Organisms, Other (describe)

Floatables: None, Oil, Foam, Animal Waste, Green Waste, Algae, Food, Paper, Plastic, Other (describe). Include estimated percentage and character of the floatables in observations field at bottom of sheet. (e.g., foam with approx. 1" high bubbles, trash is approx. 75% paper, light sheen oil, etc.)

Settleables: describe- sediment, biofilm, etc.

Vegetation: describe vegetation present- reeds, bushes, tree canopy

Staining: None, Salt, Clay, Oil, Rust, Microbes, Other (describe)

Color: None, Yellow, Brown, Grey, Red, Green, Amber, Blue, Olive Brown, Other (describe)

Sheen: Gasoline, Oil or other fuel

SMR (Only) Action Levels:
Notify Monitoring Manager if the following are exceeded.

Parameter	NAL (Dry)	SAL (Wet)
Turbidity	20 NTU	126 NTU
pH	6.5 - 8.5	--
DO	<5.0 mg/L (Warm Waters)	--

Composite Samples (cross out if not used)

Circle method(s): Auto or Grab, Flow or Time and provide duration (#hrs). Note the time and the flow for each sample collected. If available at the sampling site, note the height reading (H, feet) at the staff gauge. The composited sample will be flow-proportioned in the laboratory.

Notes/Observations – Check box if photographs were taken

Note any observations regarding the sampling location, *including any procedural variances* that occurred (i.e., sampling upstream, instrument malfunction, wildlife in area, safety, etc.). Make note of other conditions: *Sediments* [None, Normal, Excessive, Other (describe)], *Structural* [Normal, Cracking, Spauling, Other (describe)], *Biological* [Algal Bloom, Larvae, Crawfish, Frogs, Fish, Water Fowl, Other (describe)].

If associated monitoring (or additional sampling) is to be performed at another location, check the box and circle one or both (u/s, d/s), provide the Station ID(s) for the other station(s) and complete a separate FDS for each station (e.g., SMR MS4 Outfalls IAH sampling requires sampling at the Outfall site and at both the upstream and downstream proximate Receiving Water sites.

EXAMPLE: If sampling at Outfall 902MS4021, then note: ☒ **Associated monitoring u/s, d/s at: 902RW4020, 902RW4022.**

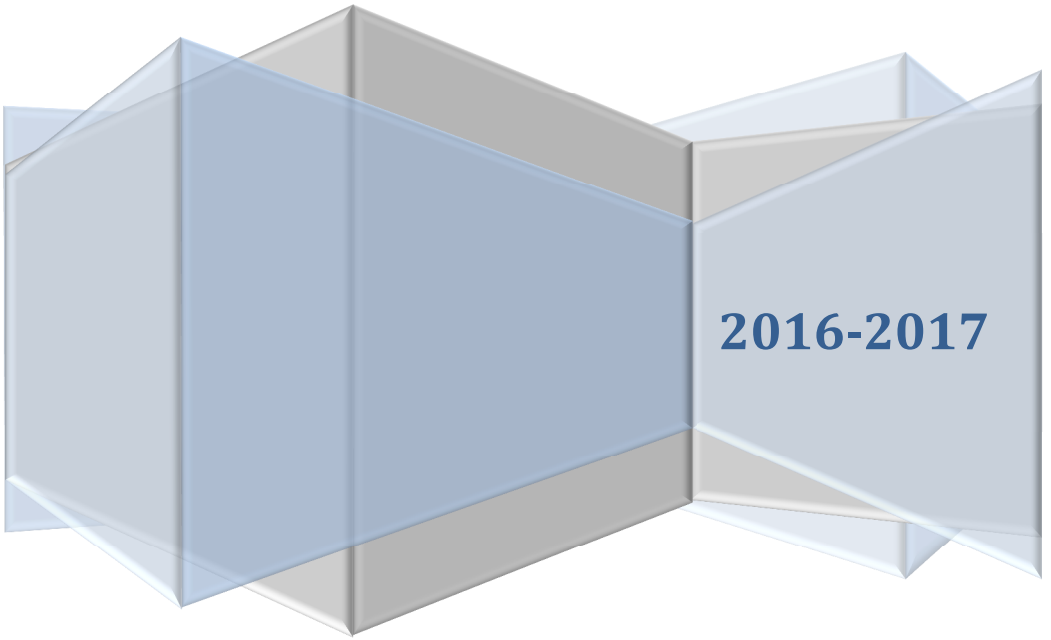
Riverside County Flood Control & Water Conservation District

WATERSHED PROTECTION DIVISION

EXAMPLE

Field Data Sheet Guide

Survey123 and Paper Form



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Field Parameters
Flow Estimation

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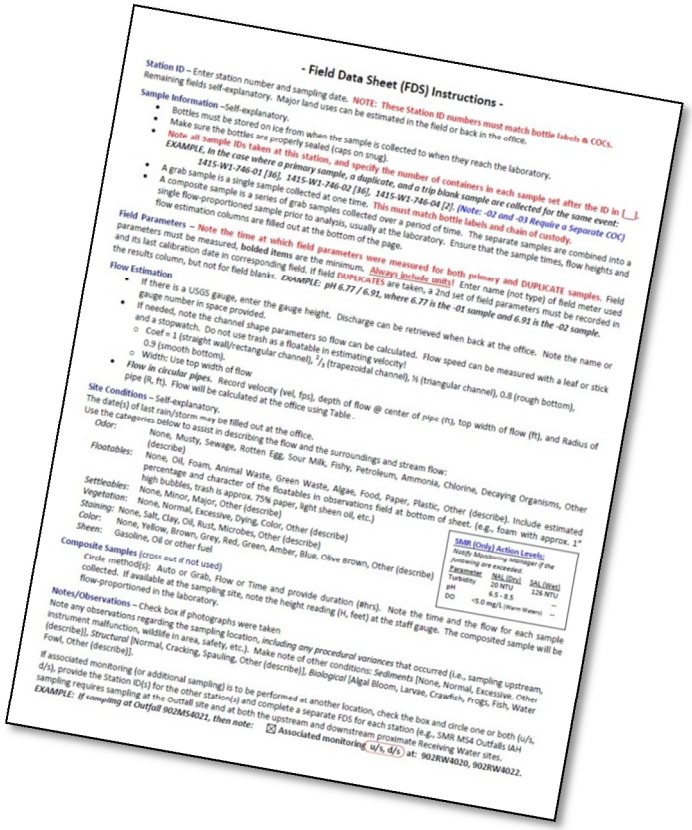
Field Data Sheet

Survey123 & Paper Form



Field Data Sheet (paper form)

Instructions on back



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  1415-W1-746-01 [36], 1415-W1-746-02 [36], 1415-W1-746-04 [2]. (Note: -02 and -03 Require a Separate COC)
  This must match bottle labels and chain of custody.
- A grab sample is a single sample collected at one time.
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Use the categories below to assist in describing the flow and the surroundings and stream flow:
Odor: None, Musty, Sewage, Rotten Egg, Sour Milk, Fishy, Petroleum, Ammonia, Chlorine, Decaying Organisms, Other (describe)
Floatables: None, Oil, Foam, Animal Waste, Green Waste, Algae, Food, Paper, Plastic, Other (describe). Include estimated percentage and character of the floatables in observations field at bottom of sheet. (e.g., foam with approx. 1" high bubbles, trash is approx. 75% paper, light sheen oil, etc.)
Settleables: None, Minor, Major, Other (describe)
Vegetation: None, Normal, Excessive, Dying, Color, Other (describe)
Staining: None, Salt, Clay, Oil, Rust, Microbes, Other (describe)
Color: None, Yellow, Brown, Grey, Red, Green, Amber, Blue. Olive brown, Other (describe)
Sheen: Gasoline, Oil or other fuel

SMR (Only) Action Levels:
Notify Monitoring Supervisor if the following are exceeded

Parameter	MAL (Dry)	SAL (Wet)
Turbidity	20 NTU	126 NTU
pH	6.5 - 8.5	--
DO	<5.0 mg/L (Warm Water)	--

Composite Samples (cross out if not used)
Circle method(s): Auto or Grab, Flow or Time and provide duration (#hrs). Note the time and the flow for each sample collected. If available at the sampling site, note the height reading (H, feet) at the staff gauge. The composited sample will be flow-proportioned in the laboratory.

Notes/Observations – Check box if photographs were taken
Note any observations regarding the sampling location, *including any procedural variances* that occurred (i.e., sampling upstream, instrument malfunction, wildlife in area, safety, etc.). Make note of other conditions: *Sediments* [None, Normal, Excessive. Other (describe)]. *Structural* [Normal, Cracking, Spauling, Other (describe)]. *Biological* [Algal Bloom, Larvae, Crawfish, Frogs, Fish, Water Fowl, Other (describe)].
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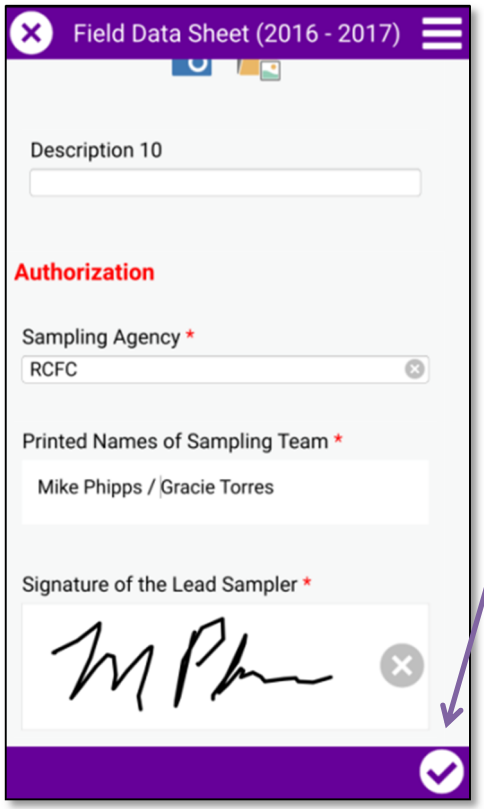
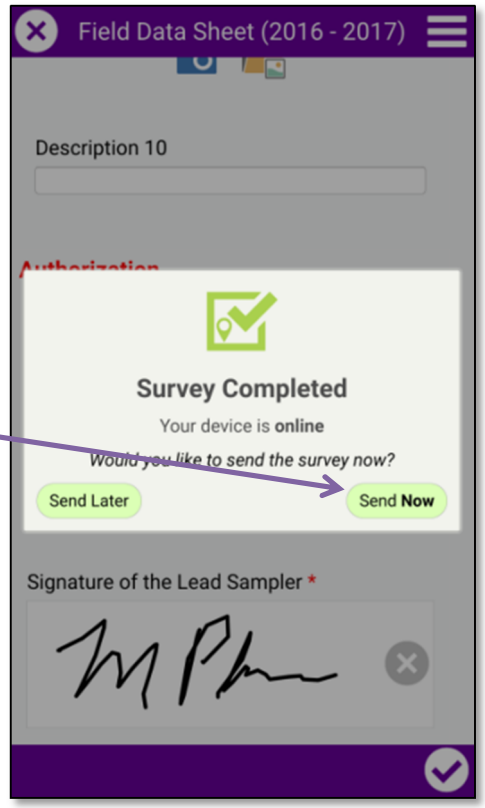
EXAMPLE: If sampling at Outfall 902MS4021, then note: ☒ **Associated monitoring (u/s, d/s) at: 902RW4020, 902RW4022.**

If you have any questions, please ask!



Submittal
Once all required data is filled in, select the check mark to complete entry.



To confirm, select "**Send Now**".
Note: In the case that there is no internet service, "**Send Later**" stores your submission until internet becomes available.

General Information

Paper Form

Station ID

Station Name

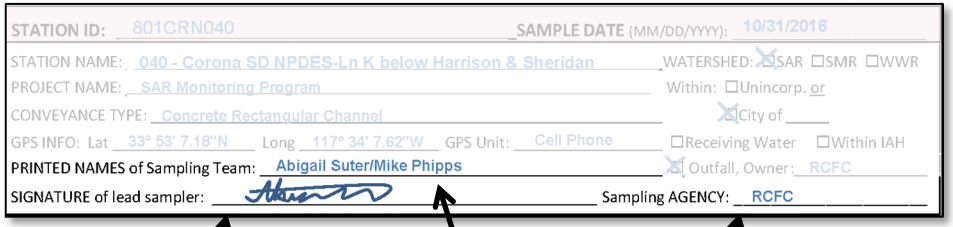
Sample Date
Date sampling took place

STATION ID: 801CRN040 SAMPLE DATE (MM/DD/YYYY): 10/31/2016
STATION NAME: 040 - Corona SD NPDES-Ln K below Harrison & Sheridan WATERSHED: ☒SAR ☐SMR ☐WWR
PROJECT NAME: SAR Monitoring Program Within: ☐Unincorp. or
CONVEYANCE TYPE: Concrete Rectangular Channel ☒City of
GPS INFO: Lat 33° 53' 7.18"N Long 117° 34' 7.62"W GPS Unit: Cell Phone ☐Receiving Water ☐Within IAH
PRINTED NAMES of Sampling Team: Abigail Suter/Mike Phipps ☒Outfall, Owner: RCFC
SIGNATURE of lead sampler: Sampling AGENCY: RCFC

Project Name
Indicate Project Name
Examples:
- SAR Monitoring Program
- SMR Monitoring Program
- WWR Monitoring Program
- MSAR TMDL Program
- LE/CL TMDL Program
- etc.

Watershed
Mark an '**X**' on appropriate box

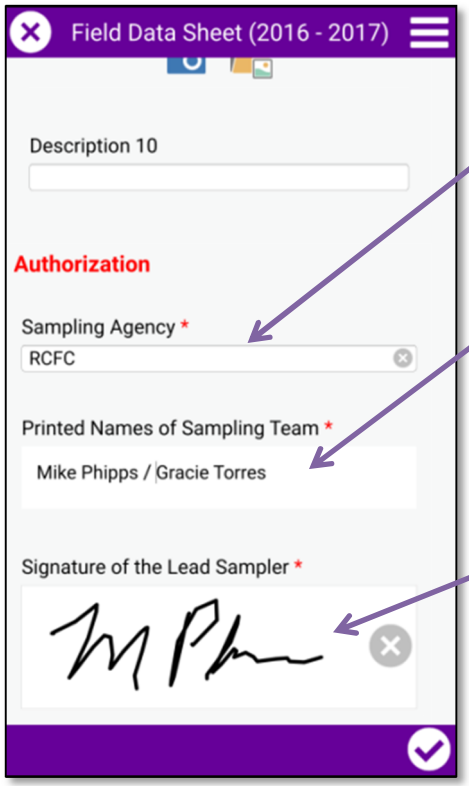
Mark an '**X**' on appropriate box and if applicable, indicate city



Signature
Lead sampler must sign

Sampling Team
Write in samplers' full names

Sampling Agency
Will usually be RCFC



Sampling Agency
Will usually be RCFC

Sampling Team
Write in samplers' full names

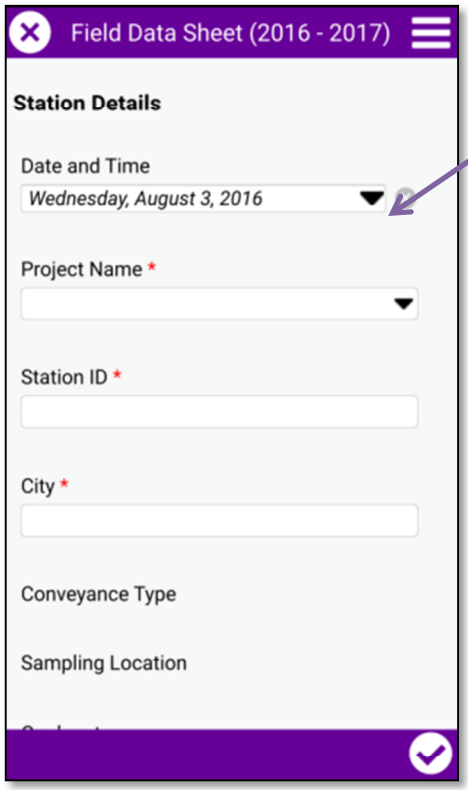
Signature
Lead sampler must sign
Note: The writing area is always active. In case of error, you can clear the space by selecting the

Authorization & Submission

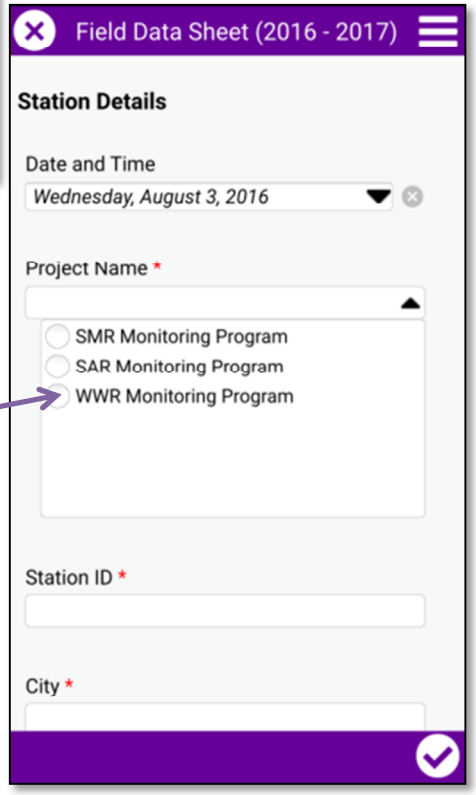
Survey 123

To begin a New Form
Click on **Collect**

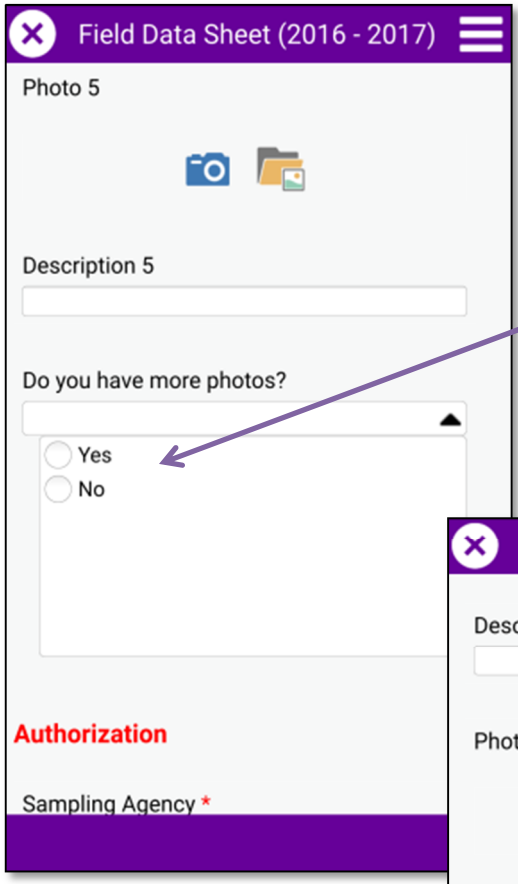




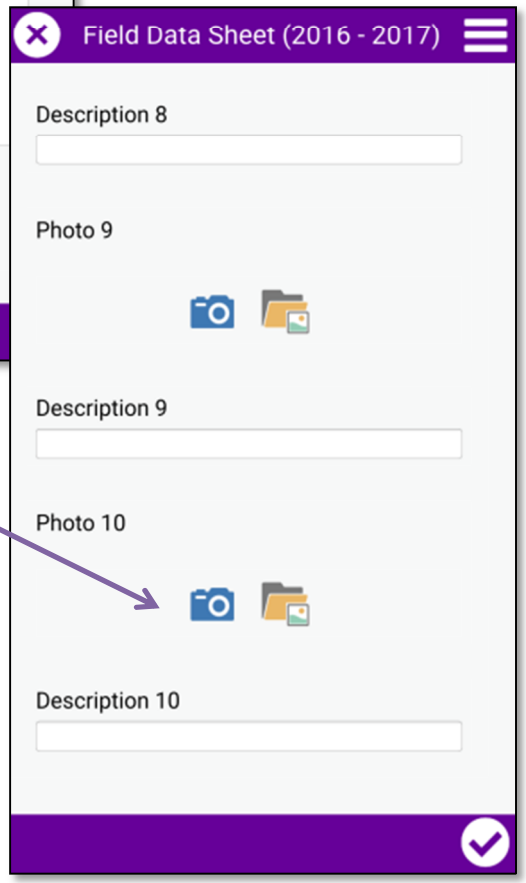
Sample Date
Date sampling took place
Note: will automatically fill



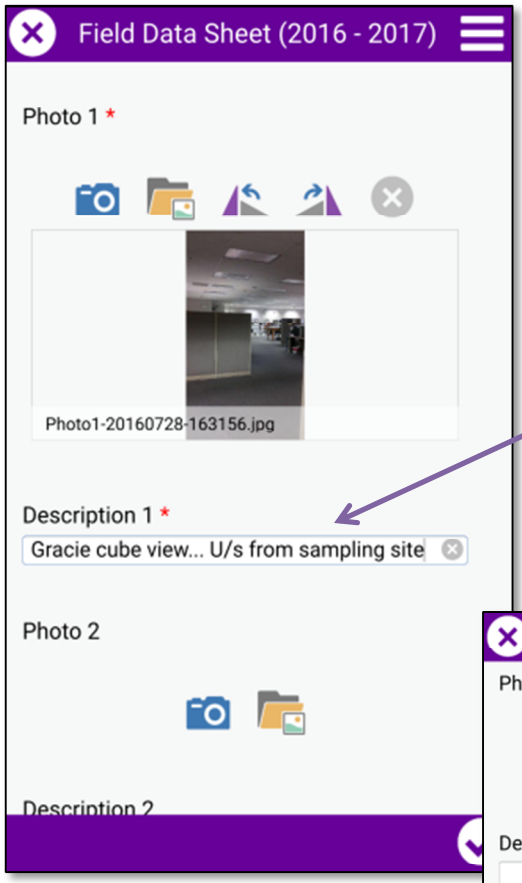
Watershed
Click on appropriate Program
Note: This selection fulfills both the watershed and project name



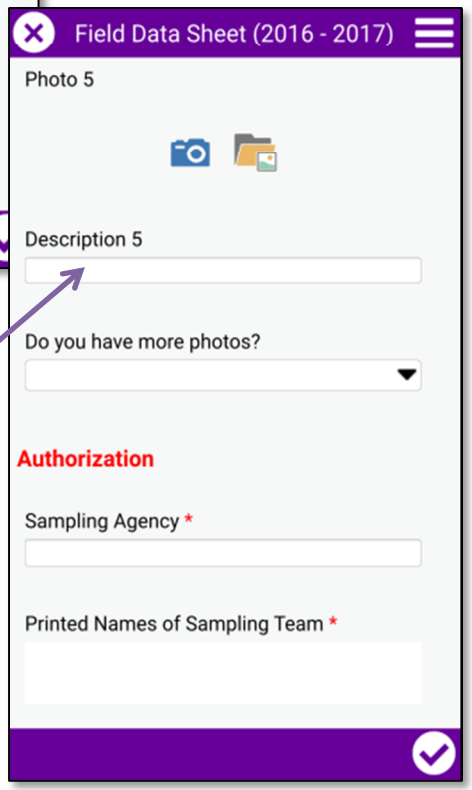
If you require more than 5 photos, select '**Yes**'.



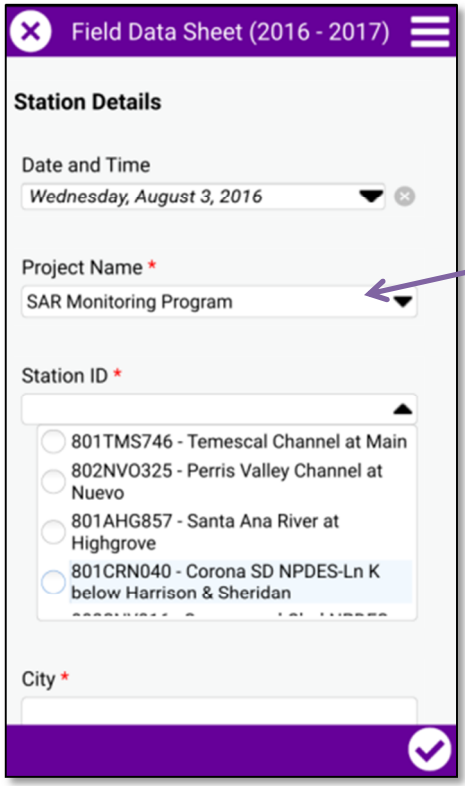
Note: Selecting '**Yes**' will add 5 more photo slots.
Only **10** photos can be taken on the app. If you need more, use the camera on your District cellphone and note this under **Notes and Observations**.



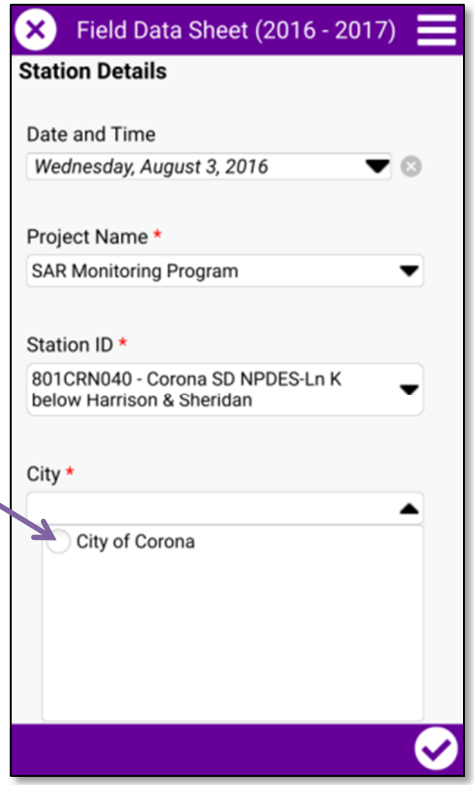
Description
Describe photo taken



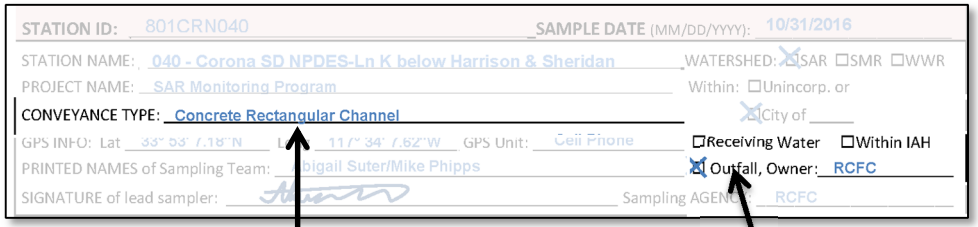
Note: You initially can take **up to 5** photos.



Station ID
Select from drop down menu.
Note: The station Name & ID have been combined



City Name
Select appropriate city
Note: should only provide one option based on previously filled sections



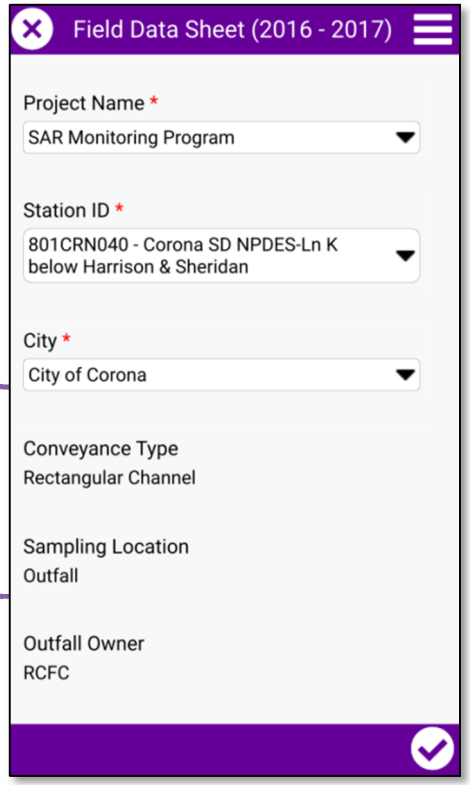
Conveyance Type

Indicate nature of facility

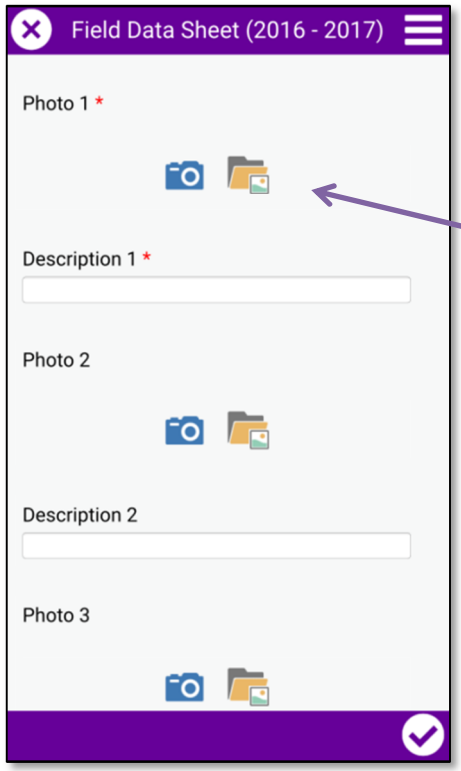
Examples:

- Concrete Rectangular Channel
- Natural Channel
- Trapezoidal

Mark an '**X**' on appropriate box



Note: Conveyance, Sampling Location, and Owner are automatically filled-in with information from the database



Photographs

To take a photo inside the app, select the camera.

To upload a photo taken outside the app, select the folder and locate the correct file.

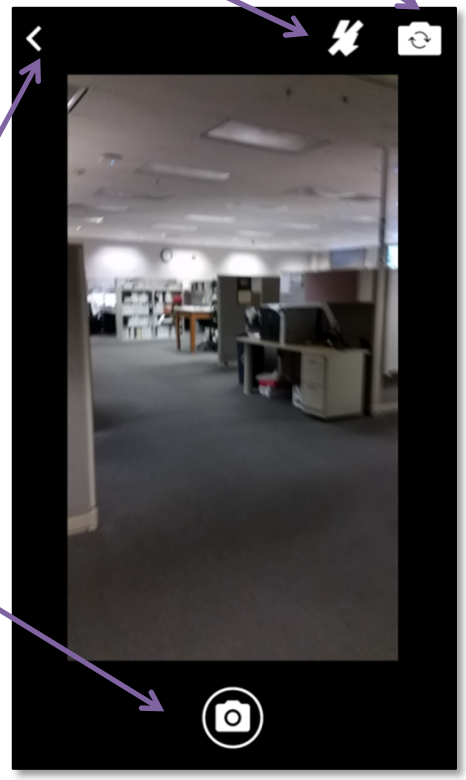
Note: At least one photo is required

The lightning bolt turns the flash feature on/off if available.

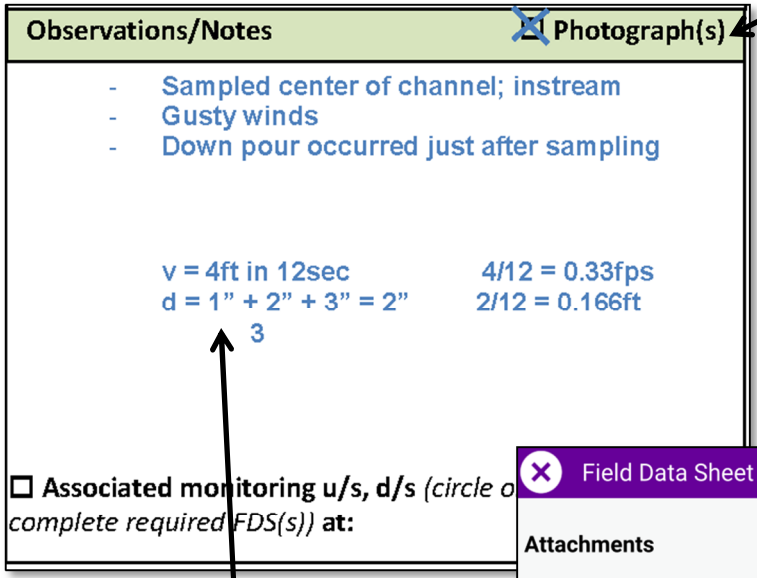
Upper camera icon switches between front and rear camera if available

Arrow returns you to previous page in case you no longer wish to take the current photo

Lower Camera icon takes the picture. You will be automatically redirected once the picture is taken.

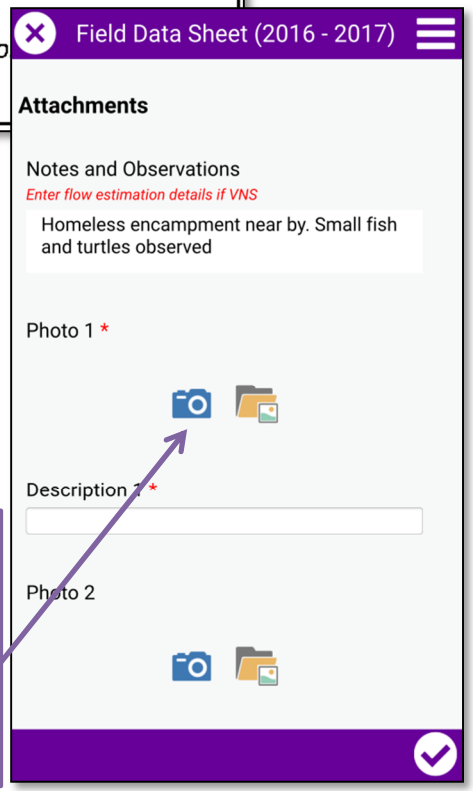


Photographs
Should be taken upstream and downstream of sampling site; mark as appropriate



Observation/Notes
Note all observations made while sampling.

Examples:
- Weather, wind patterns
- Human or animal activity/influence
- Conditions that interfere with sampling
- Major changes in condition



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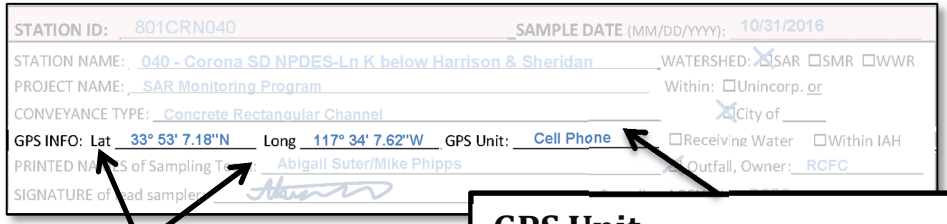
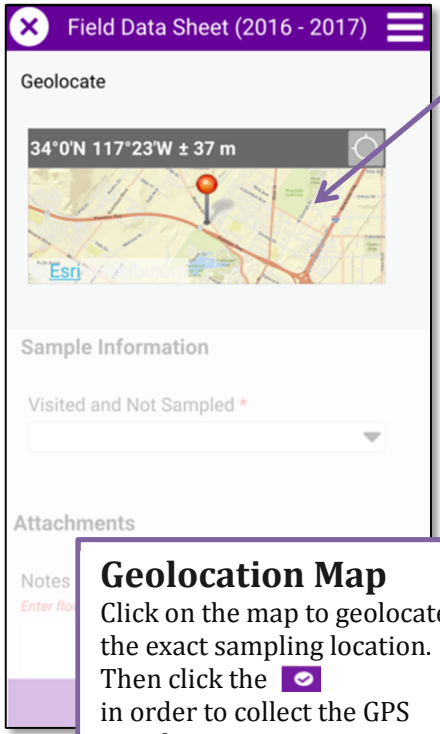


GPS Info
Latitude
Longitude

GPS Unit
Indicate how GPS info was obtained

Examples:
- Cell Phone
- TomTom
- Garmin



Geolocation
The app is capable of finding the device's GPS location.

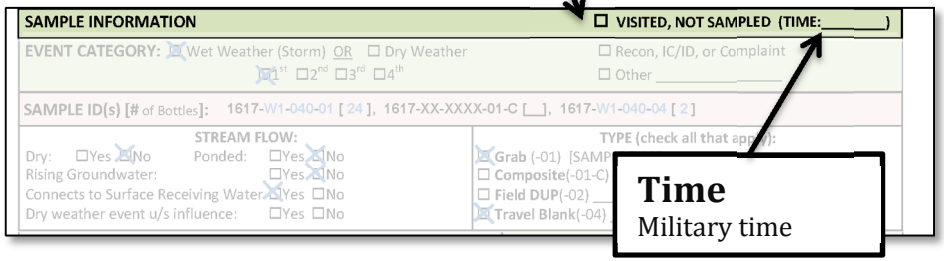
Note: Geolocation functions offline.

Geolocation Map
Click on the map to geolocate the exact sampling location. Then click the in order to collect the GPS coordinates.

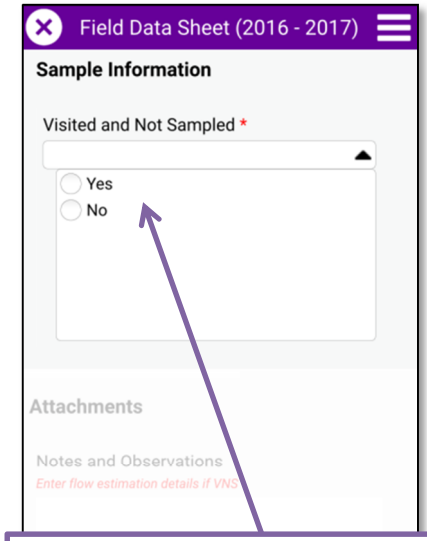
Note: The pin will not move from the middle



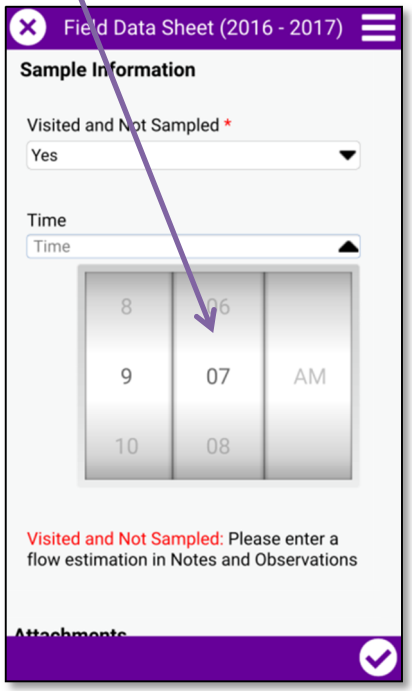
VNS (Visited, Not Sampled)



Time
Military time



VNS Time
Note: The wheel must be moved at least once for a time to be input.



VNS (Visited, Not Sampled)
If '**YES**' is selected, indicate a time (shown below) all other collection fields will be hidden.
Note: You will be prompted to estimate a flow in the Notes and Observation section.

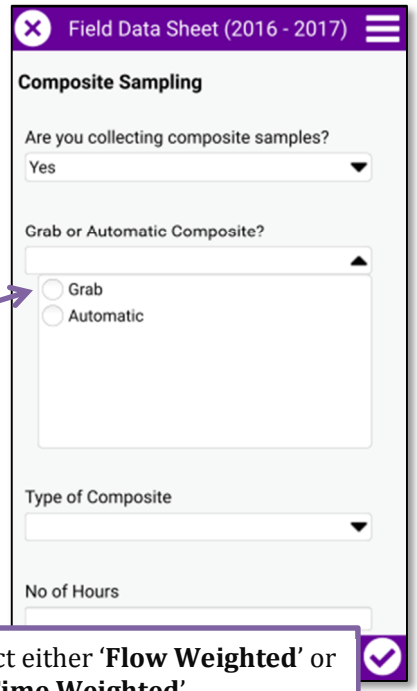
Visited and Not Sampled: Please enter a flow estimation in Notes and Observations

If '**NO**' is selected, continue filling out the form

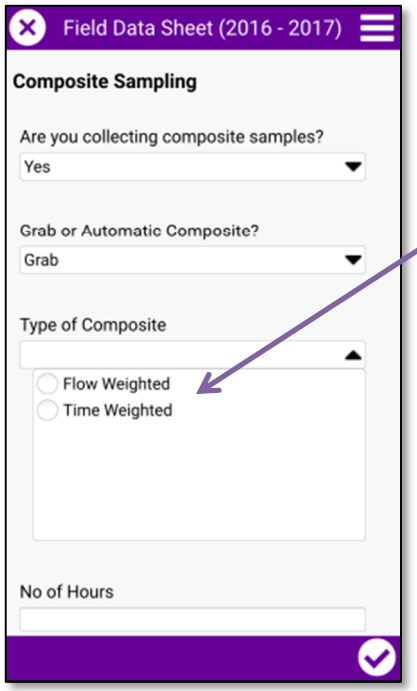
Notes & Observations

Photographs

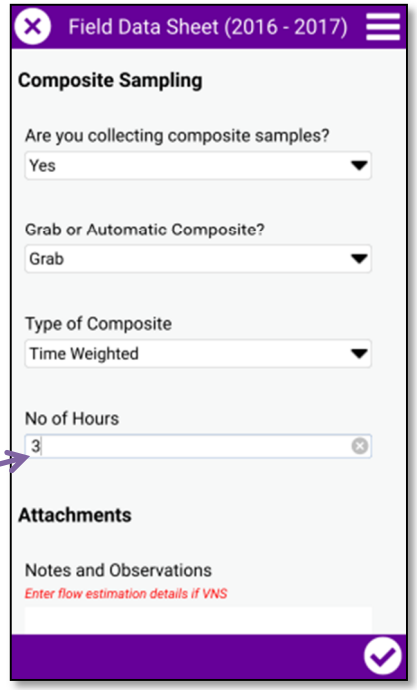
Composite Samples
If you are collecting composite samples, select '**Yes**' and continue.



Select either '**Grab**' or '**Automatic**'.

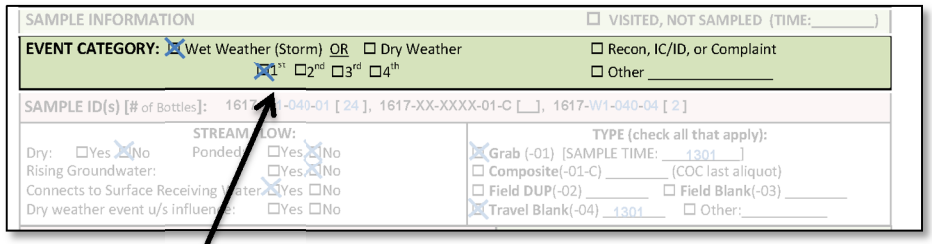


Select either '**Flow Weighted**' or or '**Time Weighted**'



No of Hours
3 or 24

Sampling Information

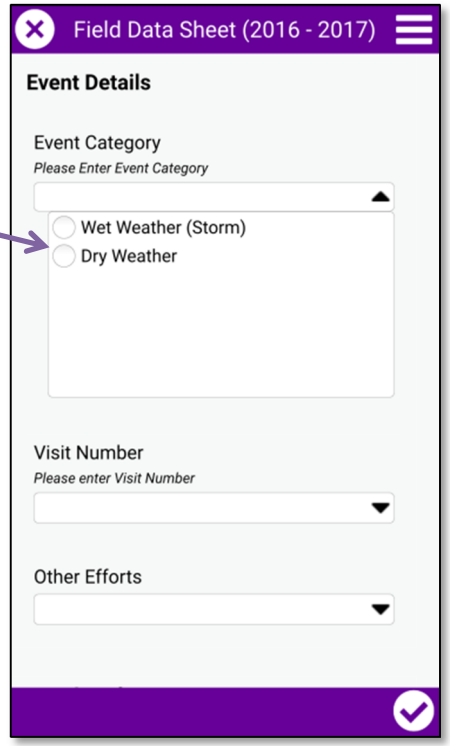


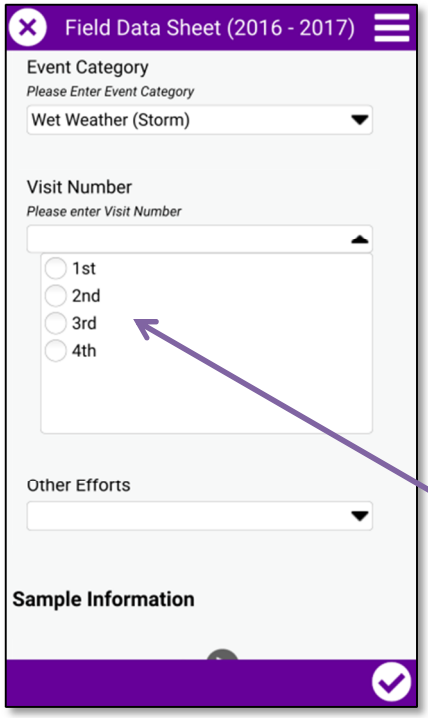
Mark an '**X**' on appropriate box

Event Category

Select whether '**Wet**' of '**Dry**' event

Note: These options are only available when 'No' is selected for **VNS**





Visit Number

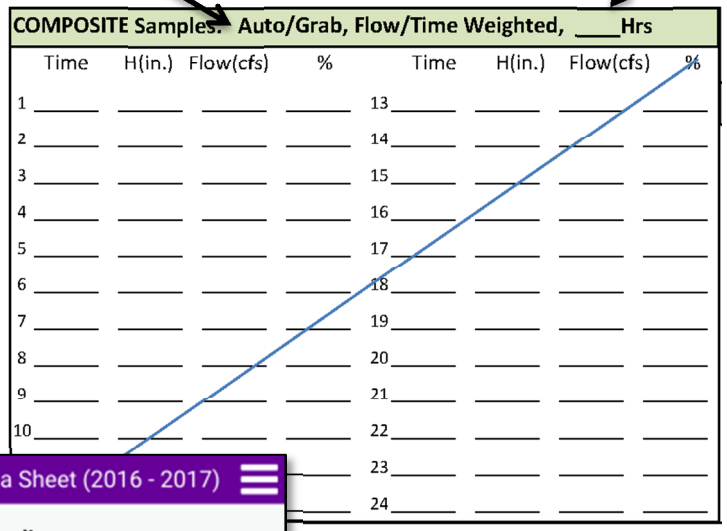
Select event number

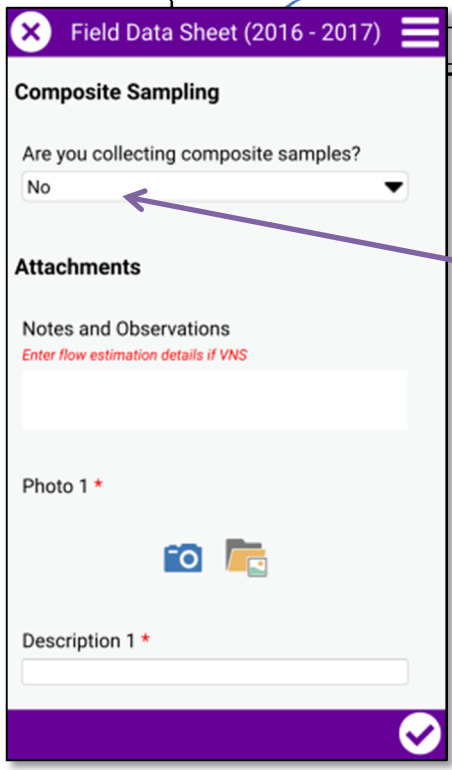
Composite Samples

If you are collecting composite samples, circle the corresponding composite types

Hours

3 or 24





Composite Samples

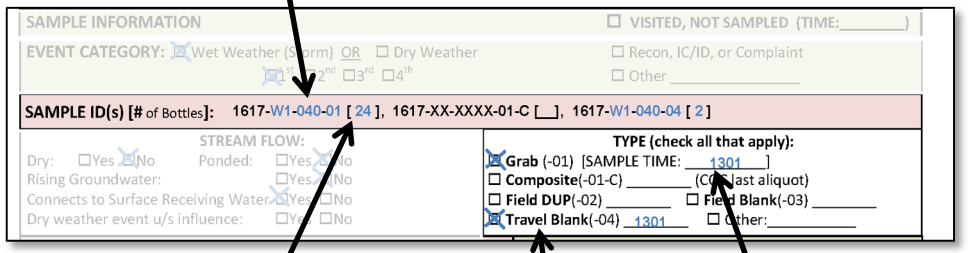
If you are not collecting composite samples, select '**No**'.

Note: If "No" is selected, no further composite information is required

Composite Sampling

Sample ID (s)
Fiscal Year – Event Type and Number – Type of Sample

01 = Primary Sample (grab)
01-C = Primary Sample (composite)
02 = Field Duplicate
03 = Field Blank
04 = Travel Blank

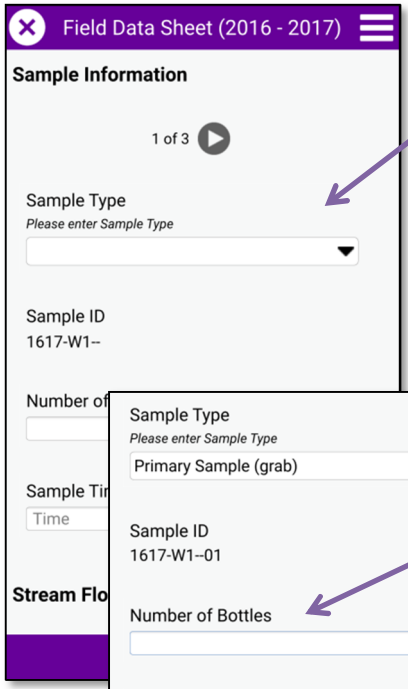


Use the provided Bottle List to fill in the number of bottles

Sample Time
Military Form

Mark an '**X**' on appropriate box

If Duplicate/Field Blank samples are taken, note the time (also in Military Form)

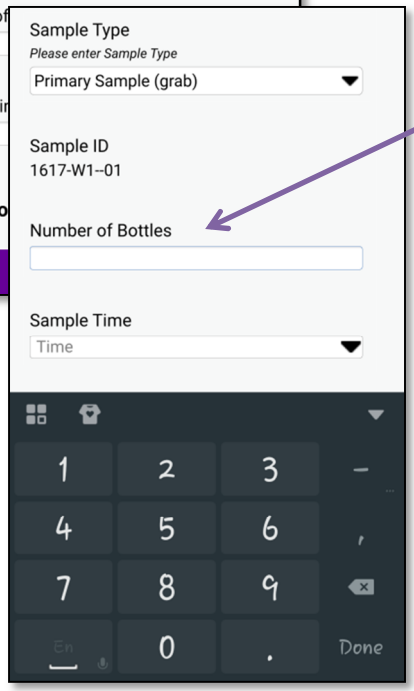


Sample Type

Select the appropriate type from the drop down menu

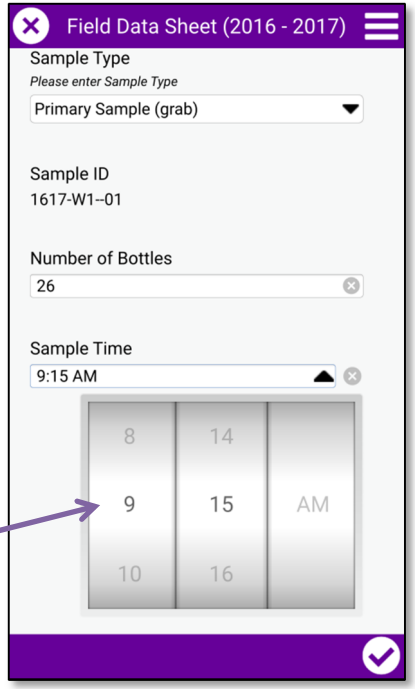
Example:

- Primary Sample (grab)
- Primary Sample (composite)
- Field Duplicate
- Field Blank
- Travel Blank



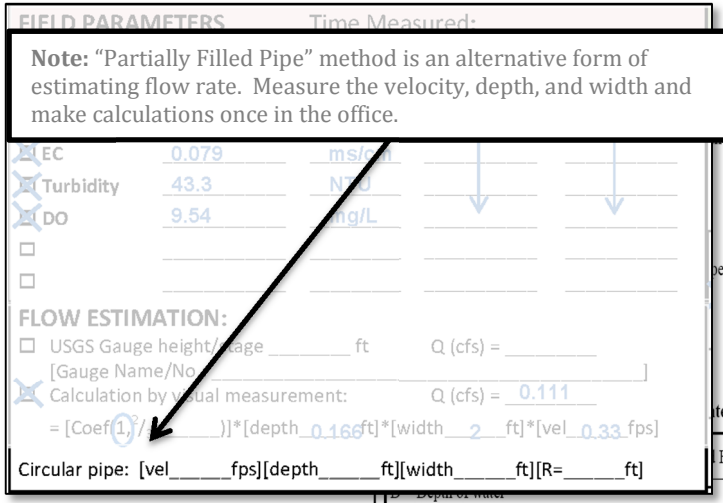
Bottle Count

Use the provided Bottle List to fill in the number of bottles



Sample Time

Note: The wheel must be moved at least once for a time to be input.



Note: "Partially Filled Pipe" method is an alternative form of estimating flow rate. Measure the velocity, depth, and width and make calculations once in the office.

ough a pipe or out of an outfall.
the following formula using the

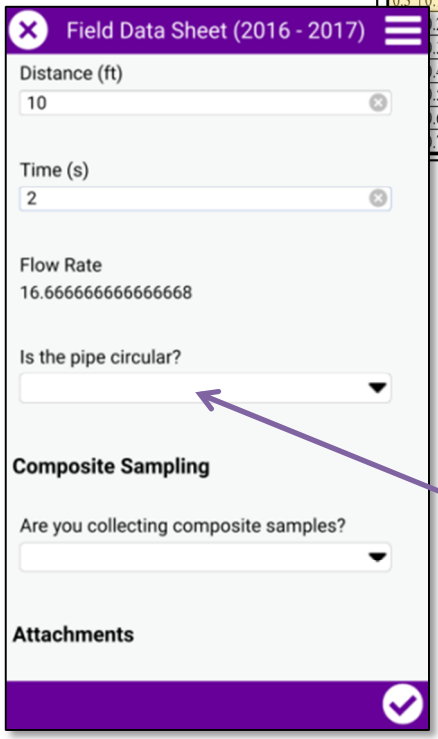
e formula chart below using the D/d value

ted Value (Ta) Chart

Hundredths of the Quotient of D/d

d = diameter of the pipe
Ta = Tabulated Value (i.e. if D/d = 0.263 then Ta = 0.1623)

D/d	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0013	0.0037	0.0069	0.0105	0.0147	0.0192	0.0242	0.0294	0.0350
0.1	0.0409	0.0470	0.0534	0.0600	0.0668	0.0739	0.0817	0.0885	0.0951	0.1039
0.2	0.1118	0.1199	0.1281	0.1365	0.1440	0.1535	0.1623	0.1711	0.1800	0.1890
0.3	0.1982	0.2074	0.2187	0.2280	0.2355	0.2450	0.2540	0.2642	0.2780	0.2836
0.4	0.2934	0.3032	0.3130	0.3220	0.3328	0.3428	0.3527	0.3627	0.3727	0.3827
0.5	0.3980	0.4030	0.4130	0.4230	0.4330	0.4430	0.4520	0.4620	0.4720	0.4820
0.6	0.4920	0.5020	0.5120	0.5210	0.5310	0.5400	0.5500	0.5590	0.5690	0.5780
0.7	0.5870	0.5960	0.6050	0.6140	0.6230	0.6320	0.6400	0.6490	0.6570	0.6660
0.8	0.6740	0.6810	0.6890	0.6970	0.7040	0.7120	0.7190	0.7250	0.7320	0.7360
0.9	0.7450	0.7500	0.7560	0.7610	0.7660	0.7710	0.7750	0.7790	0.7820	0.7840

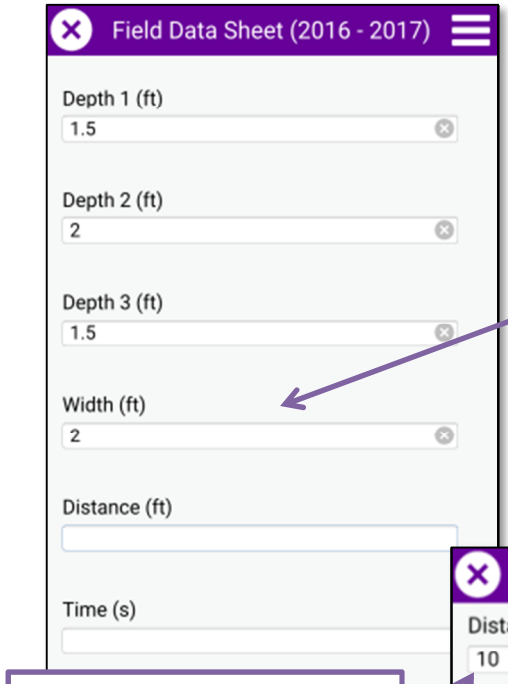


Circular Pipe

If there is a circular pipe present, answer '**Yes**'.

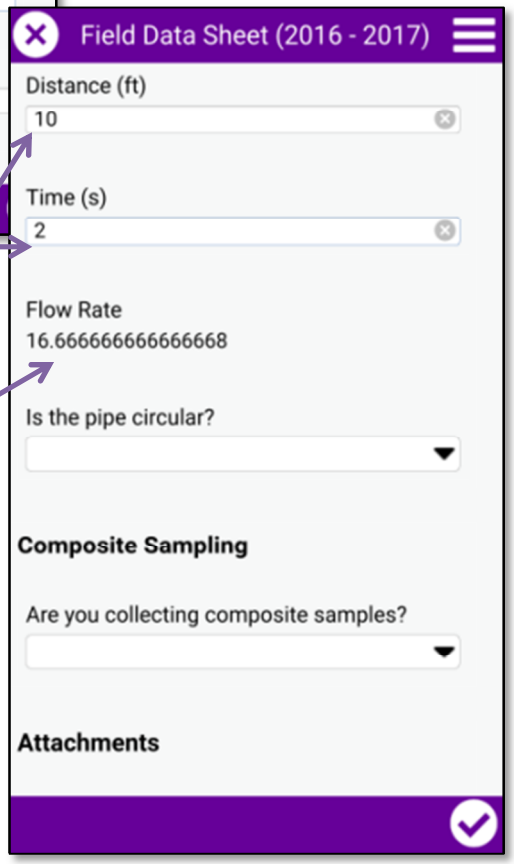
Note: If 'Yes' is selected, no further flow estimation inputs are necessary.

If there is not a circular pipe present, answer 'No'

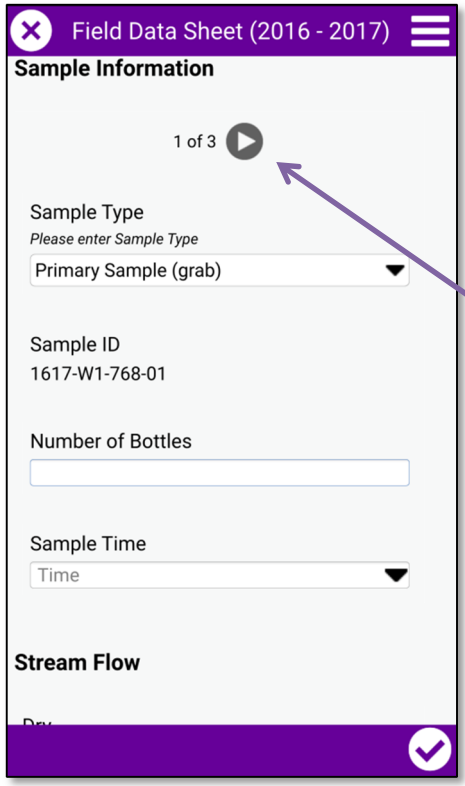


Width
Measure and record width of channel

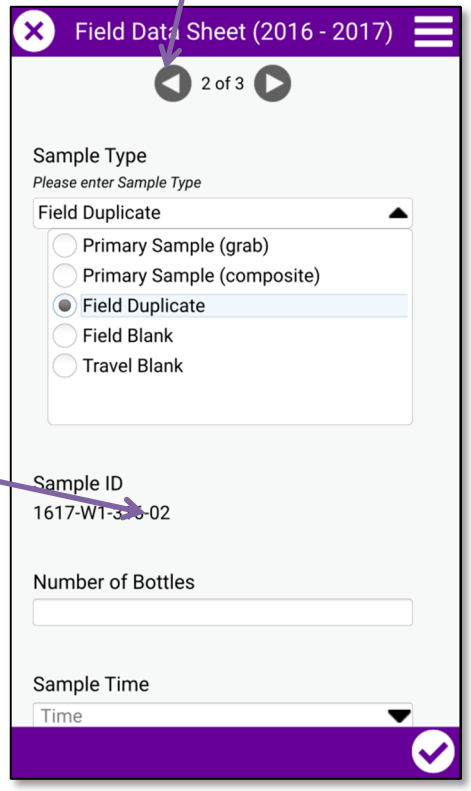
Distance and Time (for Velocity)
Use "Orange Peel" method. The required measurements are **distance** and **time**.



Flow
Note: This is calculated **automatically** once coefficient, depth, width, distance and time (for velocity) have been entered.



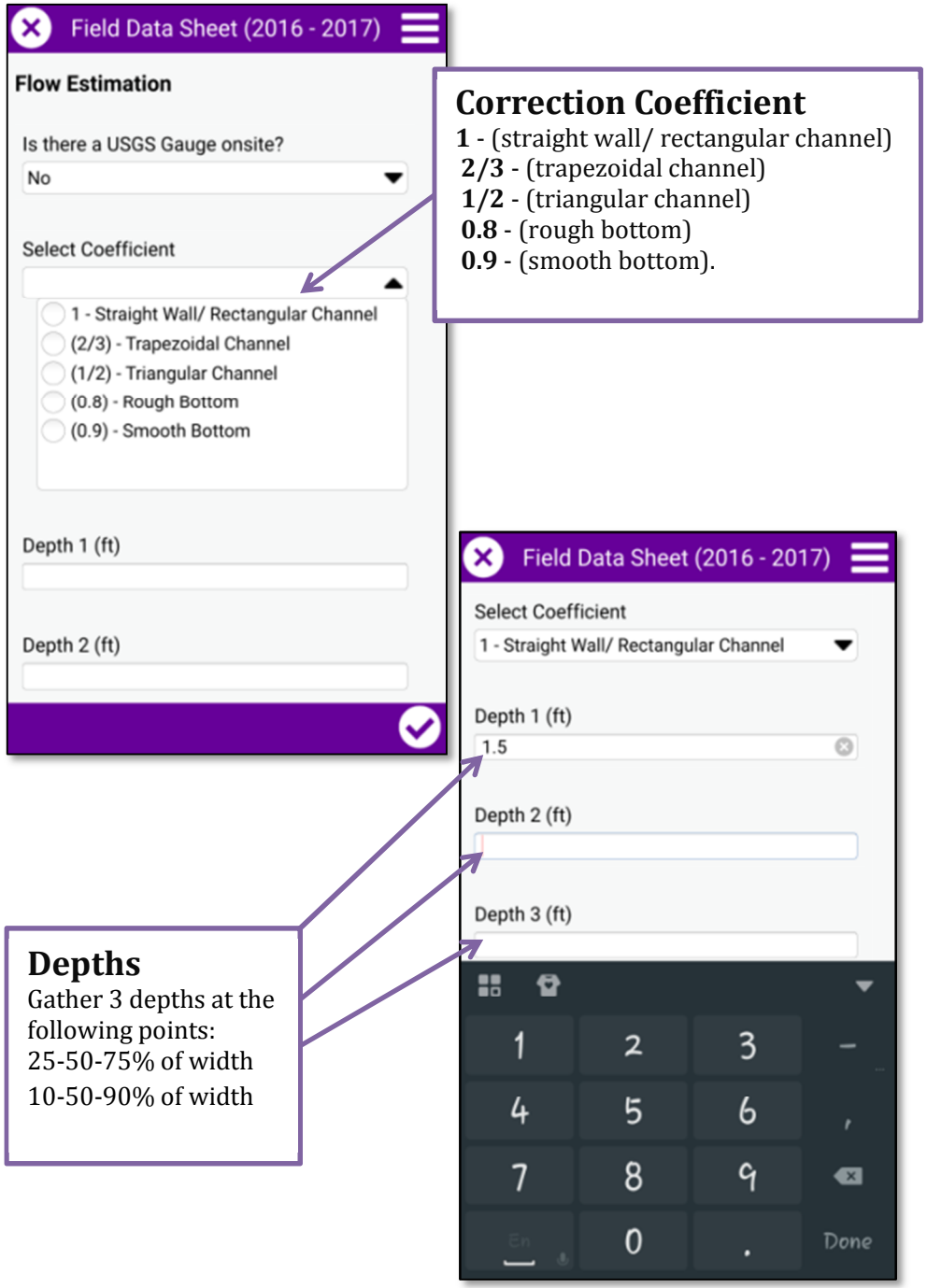
When taking multiple types of samples, use the arrows above to switch between sample type pages.

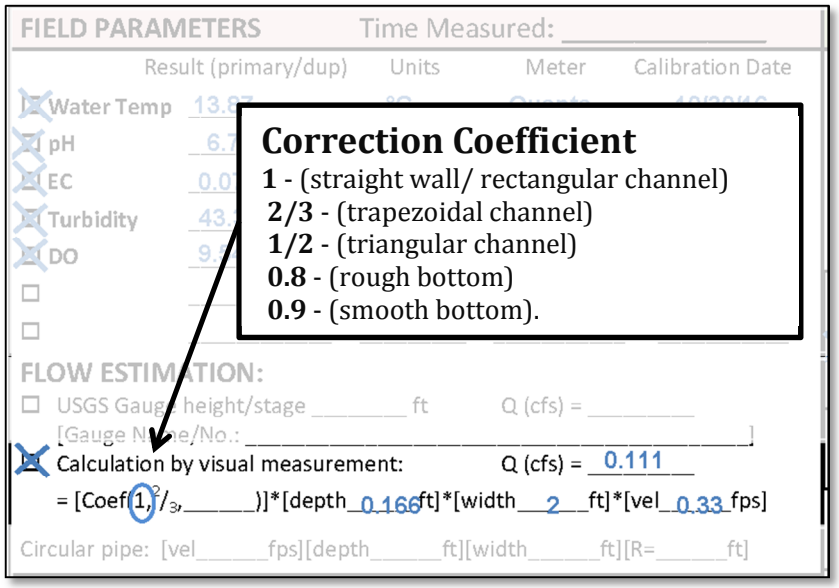


Note: If the sample numbering does not match the selected type, then you must switch pages with the arrows to update to current page.
Ensure that you return to the correct page before continuing.

Site Descriptions

FIELD DATA SHEET GUIDE 2016-2017





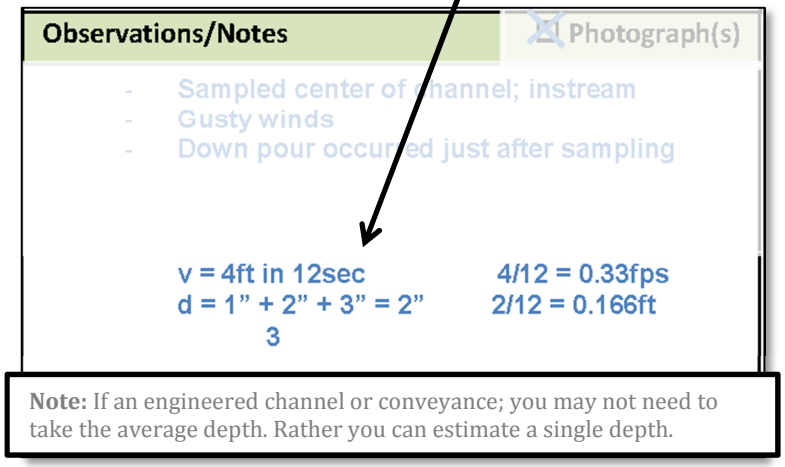
Correction Coefficient

1 - (straight wall/ rectangular channel)
2/3 - (trapezoidal channel)
1/2 - (triangular channel)
0.8 - (rough bottom)
0.9 - (smooth bottom).

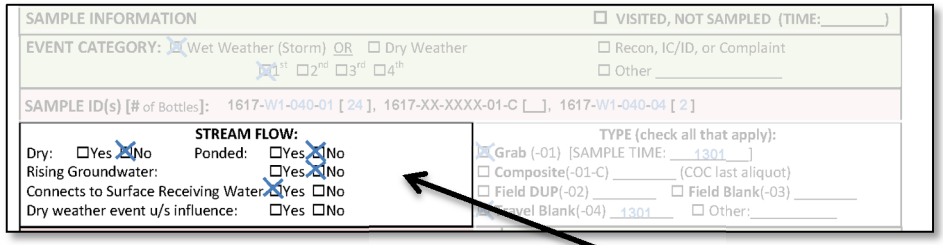
Observation/Notes

Use this section for calculations
Velocity found by "Orange Peel" method
Depth is an average of 3 or more representative point along the width
Example:

- 25-50-75% of width
- 10-50-90% of width

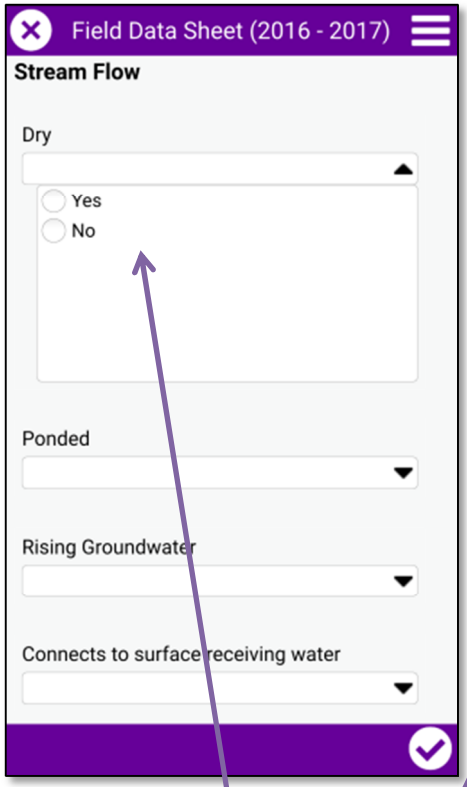


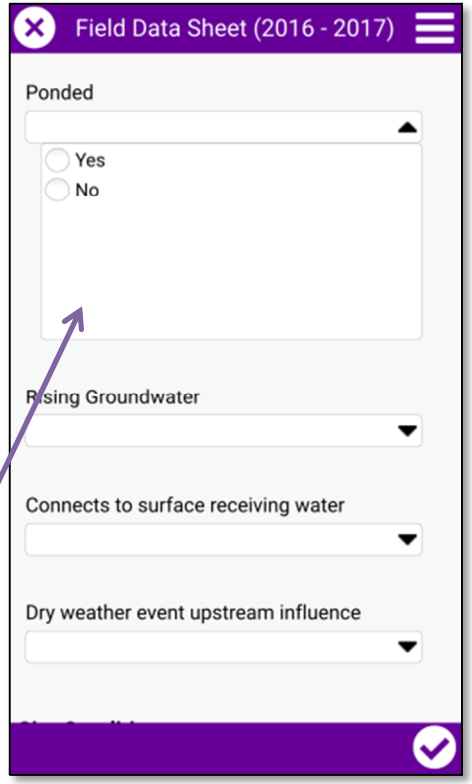
Note: If an engineered channel or conveyance; you may not need to take the average depth. Rather you can estimate a single depth.



Stream Flow

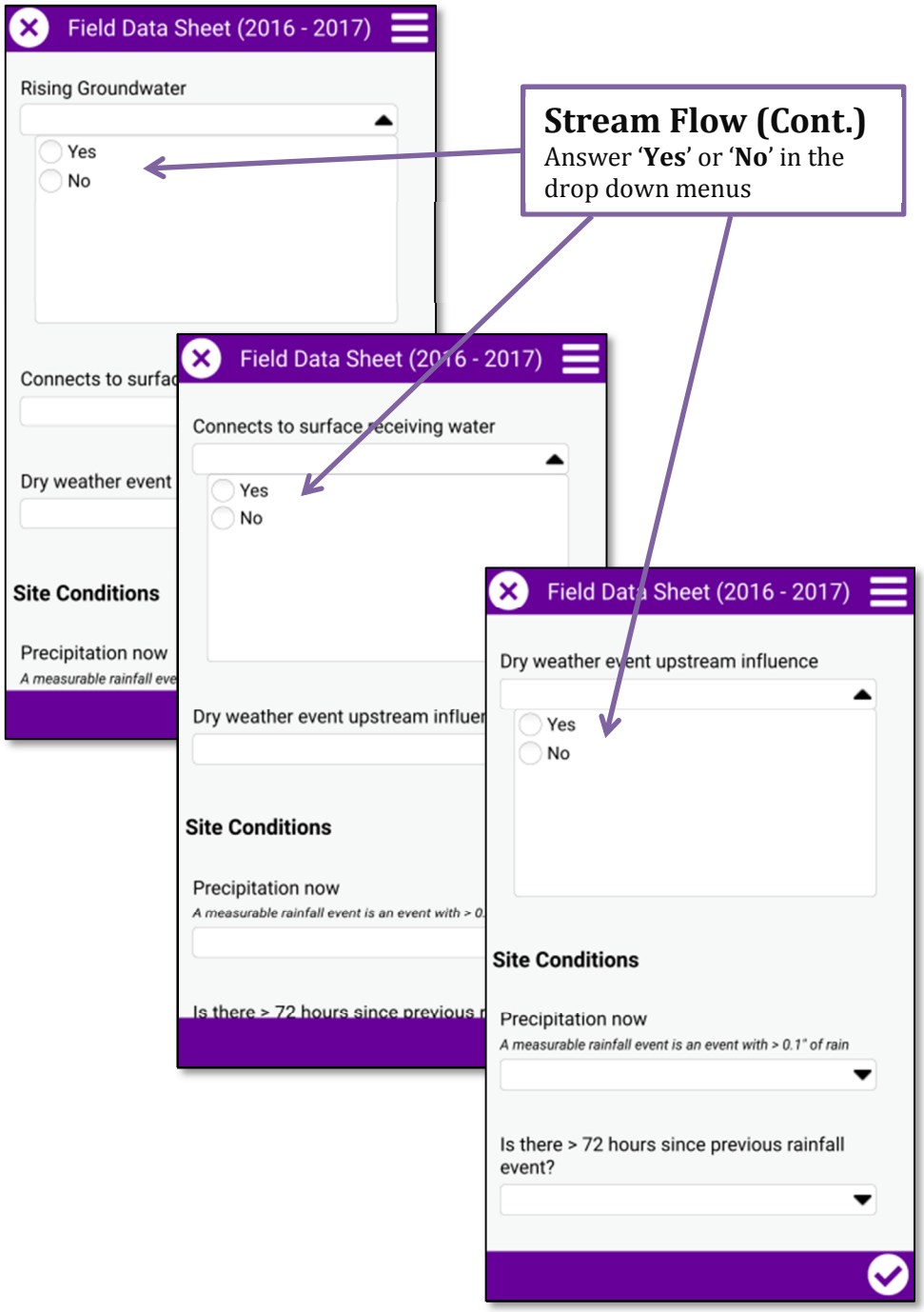
Mark an '**X**' on appropriate box





Stream Flow

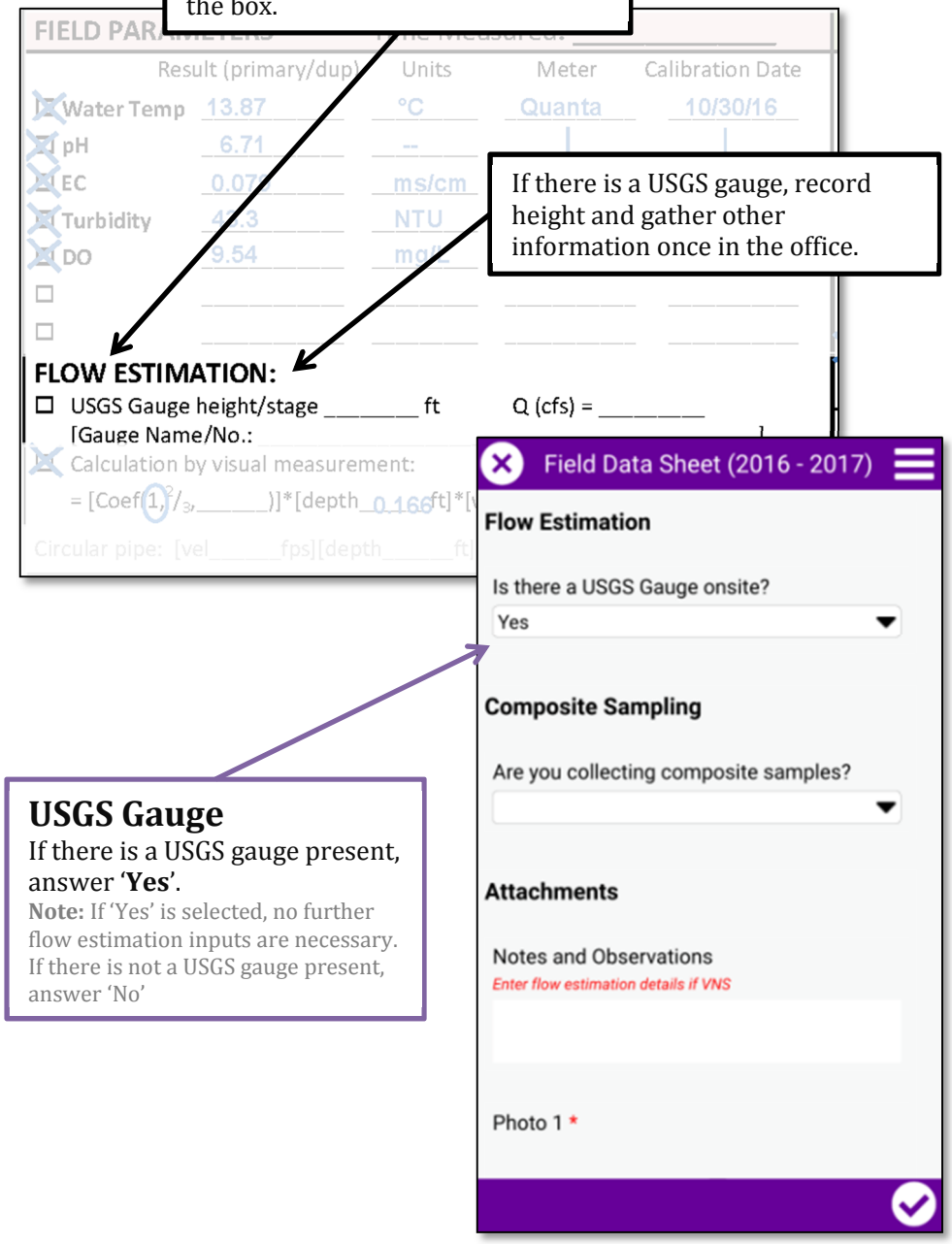
Answer '**Yes**' or '**No**' in the drop down menus



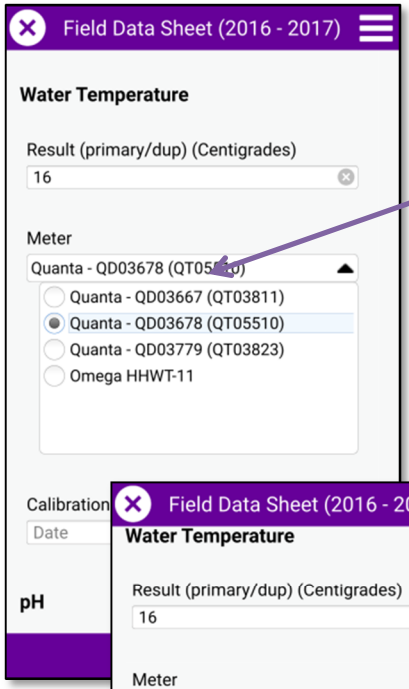
Stream Flow (Cont.)
Answer '**Yes**' or '**No**' in the drop down menus

Flow Estimation Type
If there is a USGS at the site, check the box.

If there is a USGS gauge, record height and gather other information once in the office.



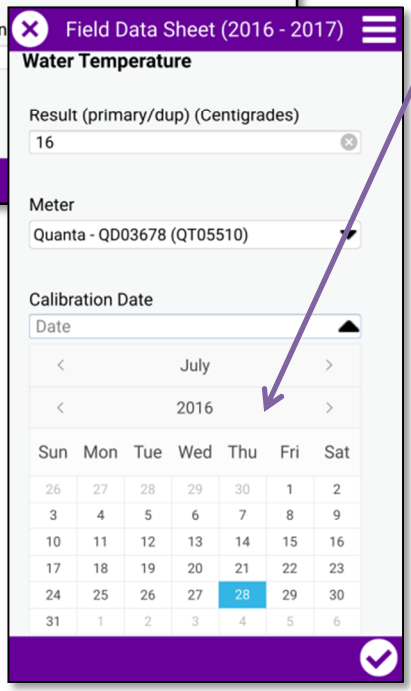
USGS Gauge
If there is a USGS gauge present, answer '**Yes**'.
Note: If 'Yes' is selected, no further flow estimation inputs are necessary. If there is not a USGS gauge present, answer 'No'



Meter

Select the meter used for measurements

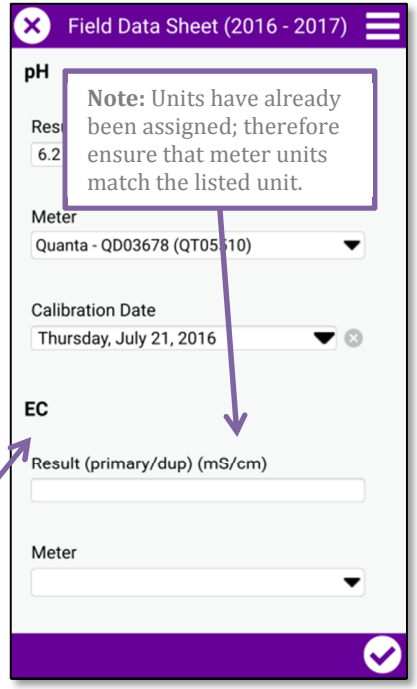
Note: Serial number can be found on back of display case



Calibration Date

Using the drop down calendar to select the date the meter used was calibrated

Note: Should be within 7 days of use. Date will be provided on meter case.



Note: Units have already been assigned; therefore ensure that meter units match the listed unit.

All field parameters follow the same template. Continue to enter the required data.

Note: The meter and calibration date should match across all field parameters.

Site Conditions

Mark an '**X**' on appropriate box

- If there has not been a storm in the past 72 hours before sampling, mark '**YES**'
- Stormwater Monitoring Program Manager will advise samplers if answer is '**NO**'

A storm event is qualified if greater than 0.1 inches of rainfall

Precipitation

Mark an '**X**' on appropriate box

Time of Storm

Military form

SITE CONDITIONS

PRECIPITATION:
NOW: ☐ None ☒ Drizzle/Sprinkle ☐ Rain ☐ Hail/Snow
Is there >72 hrs since previous rainfall event? ☒ Yes ☐ No
(A measurable rainfall event is an event with >0.1 inch of rain)
[~ Storm Start Time: 0607]
[~ Storm End Time:]
Total Rainfall Estimate: ____

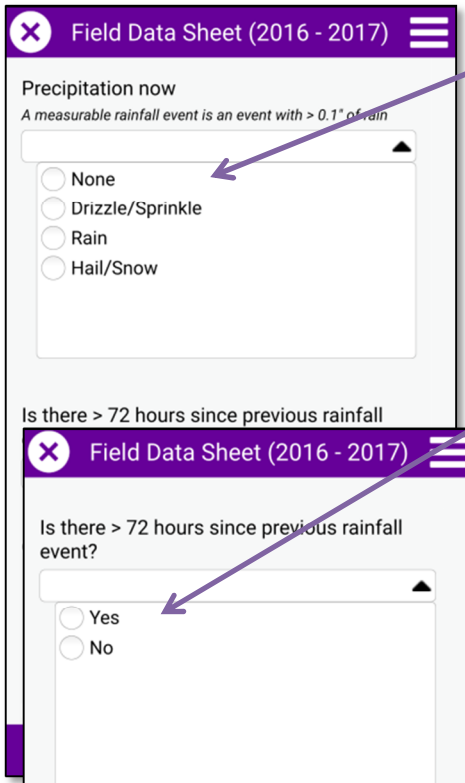
ODOR: ☒ None ☐ Sulfides ☐ Sewage ☐ Smoke ☐ Petroleum ☐ Other: ____
☒ Floatables leaves ☒ Settleables sediment
☐ Vegetation ☐ Staining

COLOR: ☒ Colorless ☐ Green ☐ Yellow ☐ Brown ☐ Other

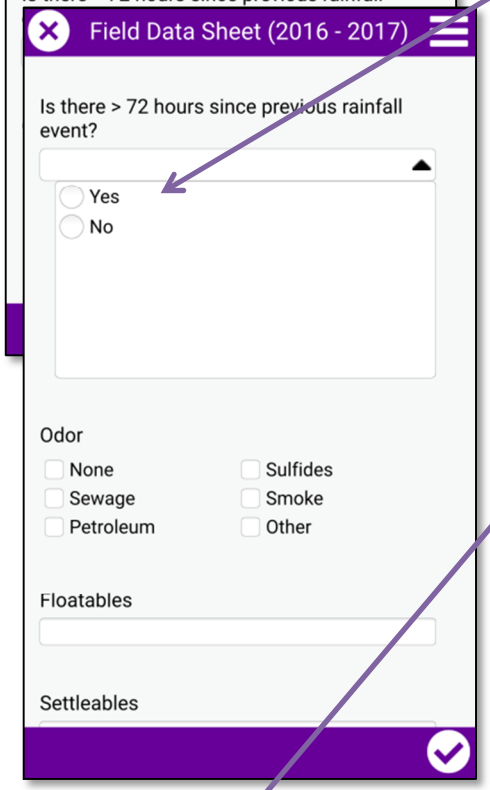
CLARITY: ☒ Clear (see bottom) ☐ Cloudy ☐ Murky
Sheen Present: ☒ Yes ☐ No

TRASH: ☒ Yes ☐ No
From: ☐ Flows ☐ Litter ☒ Dumping ☐ Other____

Mark an '**X**' on appropriate box and record an accurate description for **Odor, Color, Clarity, and Trash**



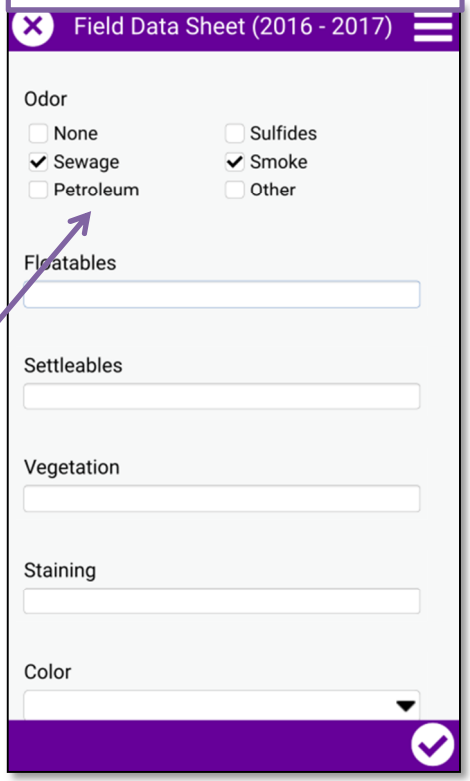
Precipitation
Select current weather condition



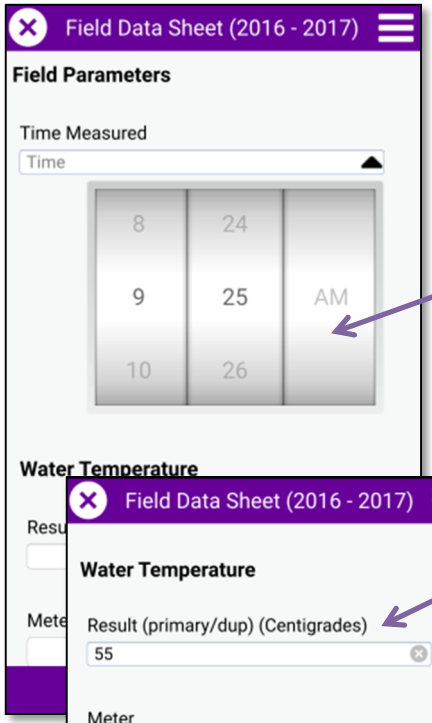
Per requirements there must be 72 hours of dry weather before sampling so generally always mark **'YES'**

Stormwater Monitoring Program Manager will advise samplers if answer is **'NO'**

- A storm event is qualified if greater than 0.1 inches of rainfall

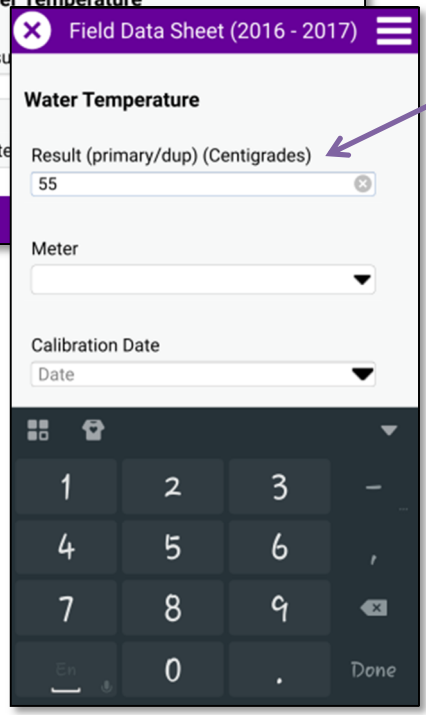


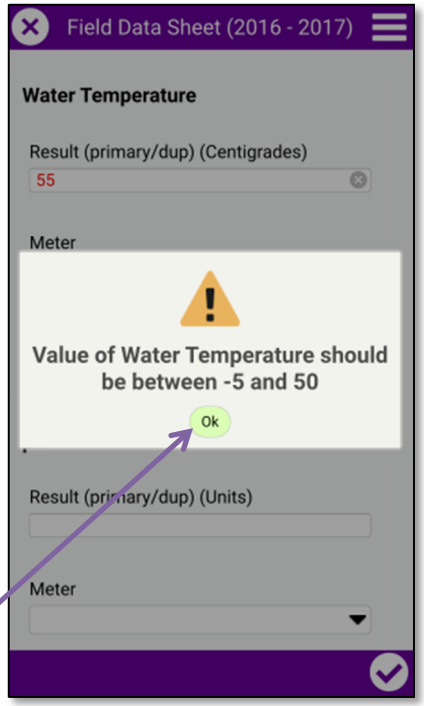
Odor
Select all odors that may apply



Field Measurement Time
Note: The wheel must be moved at least once for a time to be input.

Parameter
Using the keypad, enter the parameter reading





Note: If the parameter reading is outside the acceptable range, you will be prompted to fix it.

Meter Readings

Use correct significant figures

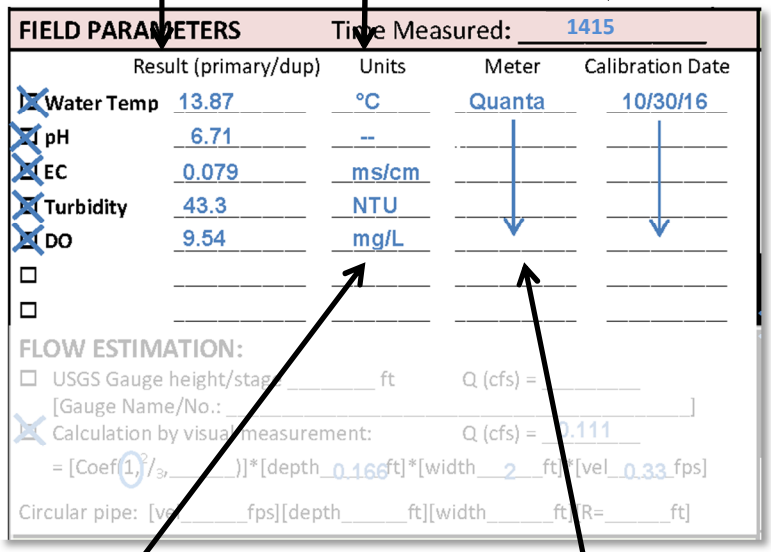
- 2-3 decimal places

Note: Use the "Acceptable Ranges" page in your binder to confirm the readings are within meter capabilities.

Field Measurement Time

Military form

Note: Record Units as shown on meter



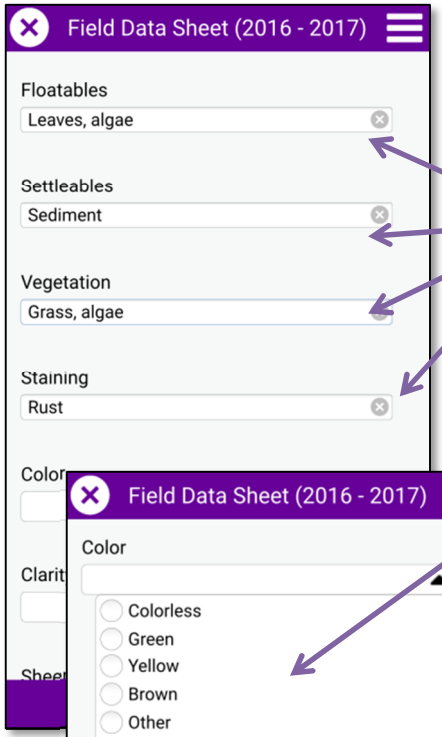
Meter

Record instrument used for field measurements

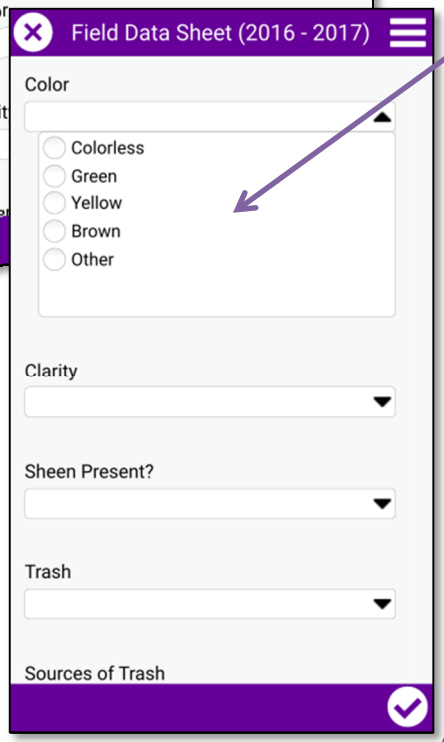
Calibration Date

Date the meter used was calibrated

Note: Should be within 7 days of use. Date will be provided on meter case.

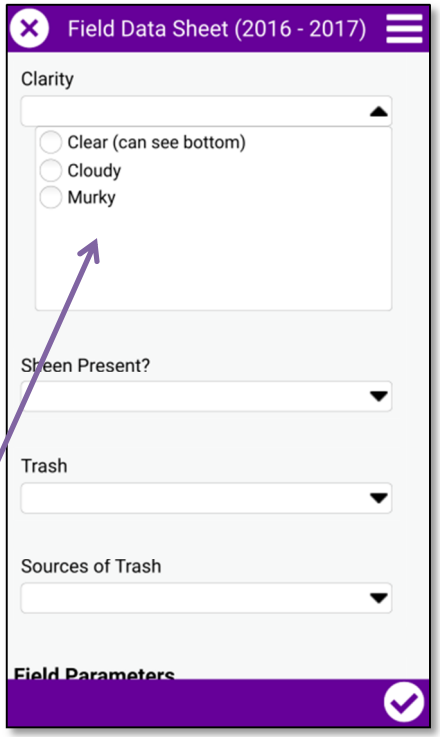


Describe observations for **Floatables, Settleables, Vegetation, and Staining**



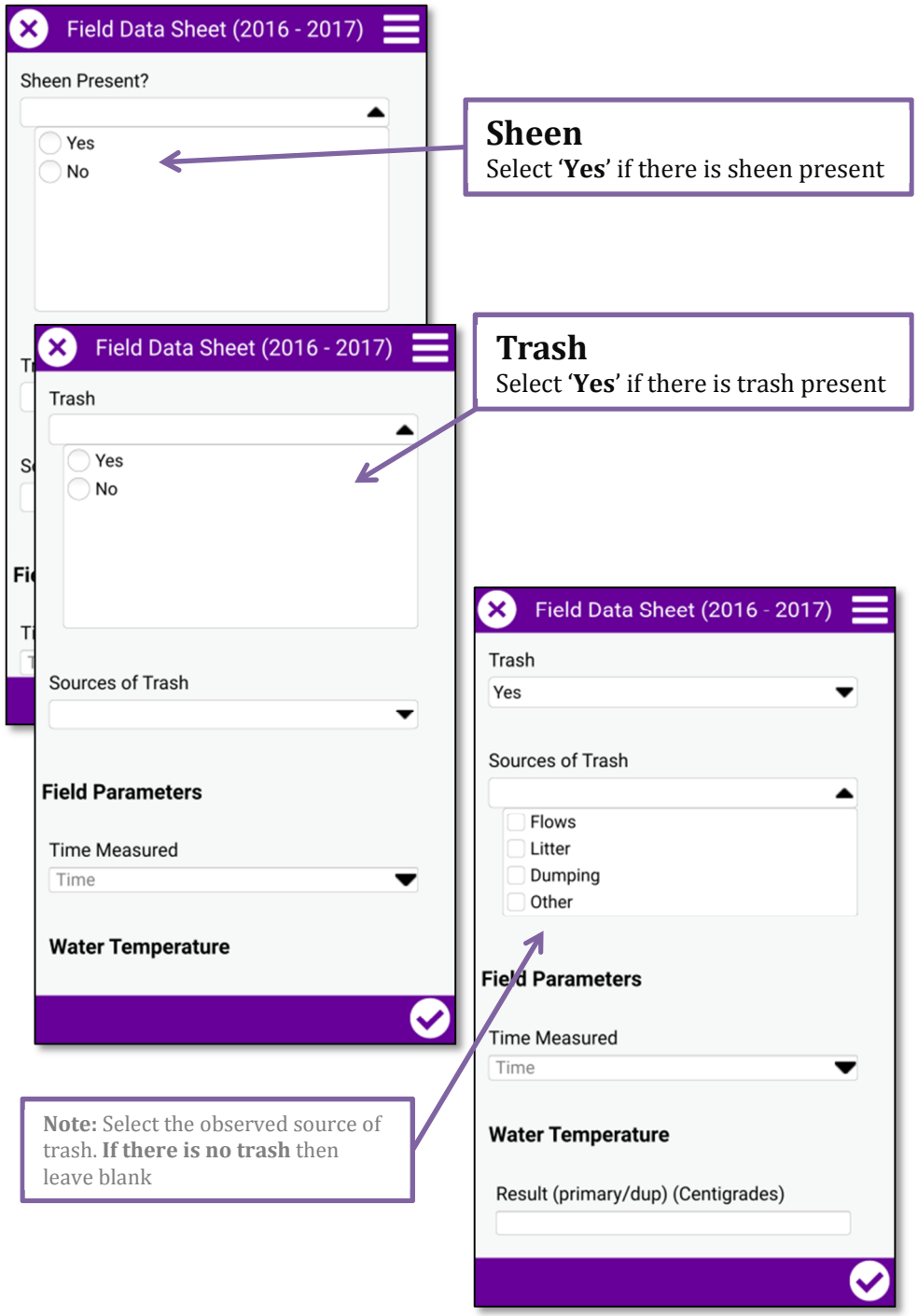
Color

Select the observed color



Clarity

Select the observed clarity



Field/Flow Parameters

APPENDIX C:

MONITORING LOCATIONS BY PERMIT

Table C-1 Monitoring Locations by Permit*

Watershed	Station Name	Station Number	Station Type	Latitude	Longitude
Santa Ana	Corona Storm Drain	801CRN040	Outfall	33° 53' 07.18"	-117° 34' 07.62"
Santa Ana	Sunnymead Channel	802SNY316	Outfall	33° 55' 03.47"	-117°14' 36.43"
Santa Ana	Hemet Channel	802HMT318	Outfall	33° 44' 04.71"	-117° 00' 22.23"
Santa Ana	Magnolia Center Storm Drain	801MAG364	Outfall	33° 57' 56.60"	-117° 24' 56.08"
Santa Ana	University Wash	801UNV702	Outfall	33° 59' 49.94"	-117° 22' 22.07"
Santa Ana	North Norco Channel	801NNR707	Outfall	33° 54' 26.93"	-117° 34' 59.80"
Santa Ana	Perris Line J	802PLJ752	Outfall	33° 48' 16.45"	-117° 12' 31.54"
Santa Ana	Temescal Channel at Main	801TMS746	Receiving Water (Wet)	33° 53' 22.27"	-117° 33' 09.74"
Santa Ana	Perris Valley Channel at Nuevo	802NVO325	Receiving Water (Wet / Dry)	33° 48' 04.29"	-117° 12' 02.14"
Santa Ana	Santa Ana River at Highgrove	801AHG857	Receiving Water (Dry)	34° 01' 03.06"	-117° 22' 07.37"
Santa Margarita	Upper Santa Margarita River	902USM828[1,2]	Long-term Receiving Water	33° 28' 19.20"	-117° 08' 42.60"
Santa Margarita	Wilson Creek	902WLC650[1, 4]	NEW Long-term Receiving Water	33° 29' 14.51"	-116° 54' 59.74"
~~Santa Margarita~~	~~Adobe Creek~~	~~902ADB848[2]~~	~~Receiving Water (Reference) MLS[3] & Stream Assessment~~	~~33° 30' 48.10"~~	~~-117° 16' 04.40"~~
~~Santa Margarita~~	~~Lower Temecula Creek~~	~~902LTC777[2]~~	~~Receiving Water MLS[3] & Stream Assessment~~	~~33° 28' 26.40"~~	~~-117° 07' 46.10"~~
~~Santa Margarita~~	~~Lower Murrieta Creek~~	~~902LMC778[2]~~	~~Receiving Water MLS[3] & Stream Assessment~~	~~33° 28' 47.00"~~	~~-117° 08' 34.80"~~
~~Santa Margarita~~	~~Redhawk Channel~~	~~902RDH768[2]~~	~~Receiving Water Stream Assessment~~	~~33° 28' 34.60"~~	~~-117° 05' 40.80"~~
~~Santa Margarita~~	~~Sandia Creek at Deluz Rd~~	~~902SND100[2]~~	~~Receiving Water (Reference) Stream Assessment~~	~~33° 29' 31.9"~~	~~-117° 14' 47.04"~~

[1] Selected as the Long-term Receiving Water station as part of the WQIP.

[2] Historical receiving water station for stream assessment monitoring under the prior permit and during the Transitional monitoring requirement of the 2015 Regional Permit.

~~[3] MSL – Historical Mass Loading Station, to be monitoring under Transitional requirements.~~

[3] A back-up station may be selected in the event that property is not accessible. See SMR WQIP.

Watershed	Station Name	Station Number	Station Type	Latitude	Longitude
Santa Margarita	Outlet to W side of Tucalota Creek south of Murrieta Hot Springs Road	902MS41033	Outfall (Wet Weather)	33°33'7.78"	-117° 8'11.11"
Santa Margarita	Outlet to Temecula Creek @ South of Breeze Way Pl and Summit View Pl	902MS42240	Outfall (Wet Weather)	33°29'11.59"	-117° 3'49.15"
Santa Margarita	Outlet to Warm Springs Creek d/s of M.H.S. Rd.	902MS44034	Outfall (Wet Weather)	33° 32' 51.10"	-117° 10' 18.79"
Santa Margarita	Outlet to Murrieta Creek @ Diaz Rd behind RCWD pump station	902MS43015	Outfall (Wet Weather)	33°30'59.36"	-117°10'20.39"
Santa Margarita	Outlet to NW side of Wildomar Channel @ Gruwell Street	902MS45031	Outfall (Wet Weather)	33°36'13.13"	-117°16'43.17"
Santa Margarita	Outlet to Redhawk Channel South of Vail Ranch Pkwy	902MS41010	Outfall (Dry Weather)	33.47279	-117.09199
Santa Margarita	Outlet to Santa Gertrudis Creek Channel West of I15 (Right Outlet)	902MS41025	Outfall (Dry Weather)	33.52413	-117.16518
Santa Margarita	Outlet to East side of Tucolata Creek South of Murrieta Hot Springs Road	902MS41032	Outfall (Dry Weather)	33.55210	-117.13610
Santa Margarita	Outlet to Tucolata Creek North West of Encanto Rd b/t Pereza Ct Castillo Rd	902MS41037	Outfall (Dry Weather)	33.56805	-117.110321
Santa Margarita	Outlet to Tributary of Murrieta Creek - Nutmeg SD North of Lafayette Dr	902MS41061	Outfall (Dry Weather)	33.59424	-117.206618

Watershed	Station Name	Station Number	Station Type	Latitude	Longitude
Santa Margarita	Outlet to North side of Tucalota Creek East of Westridge Dr	902MS42207	Outfall (Dry Weather)	33 34.568	-117 6.308
Santa Margarita	Outlet to Benton Creek Channel East of Pourroy Rd	902MS42211	Outfall (Dry Weather)	33 35.635	-117 6.029
Santa Margarita	Outlet to French Valley Channel West @Skyview Rd (Right Outlet)	902MS42235	Outfall (Dry Weather)	33 36.396	-117 6.408
Santa Margarita	Outlet to French Valley Channel West @Skyview Rd (Left Outlet)	902MS42236	Outfall (Dry Weather)	33 36.398	-117 6.407
Santa Margarita	Outlet to North side of Morgan Valley Wash @ Chimisal Rd and Verde Rd	902MS42245	Outfall (Dry Weather)	33 27.986	-117 4.183
Santa Margarita	Outlet to Warm Springs Channel North West of Jefferson Ave	902MS44030	Outfall (Dry Weather)	33.53306	-117.176411
Santa Margarita	Outlet to Warm Springs Creek @ Sugarberry Lane	902MS44033	Outfall (Dry Weather)	33.54282	-117.17023
Santa Margarita	Outlet to East side of Warm Springs Creek South of Murrieta Hot Springs Road	902MS44039	Outfall (Dry Weather)	33.55669	-117.159967
Santa Margarita	Outlet d/s Murrieta Creek MDP Line D @ Murrieta Hot Springs Rd (Left Box)	902MS44062	Outfall (Dry Weather)	33.58216	-117.256209
Santa Margarita	Outlet d/s Murrieta Creek MDP Line D @ Murrieta Hot Springs Rd (Right Pipe)	902MS44063	Outfall (Dry Weather)	33.58121	-117.256591

Watershed	Station Name	Station Number	Station Type	Latitude	Longitude
Santa Margarita	Outlet North of Rancho Crystalaire Dr and East of Honors Dr	902MS43038	Outfall (Dry Weather)	33.50957	-117.115947
Santa Margarita	Outlet to West side of Murrieta Creek East of Felix Valdez Ave	902MS43062	Outfall (Dry Weather)	33.49623	-117.153531
Santa Margarita	Outlet North of Pachanga Pkwy East of Trotsdale Dr	902MS43082	Outfall (Dry Weather)	33.47177	-117.122115
Santa Margarita	Outlet to Temecula Creek South of Bike Path East of Redhawk Pkwy	902MS43099	Outfall (Dry Weather)	33.47853	-117.09665
Santa Margarita	Outlet to Santa Gertrudis Creek @ Santa Gertrudis Creek Trail and Margarita Rd	902MS43123	Outfall (Dry Weather)	33.53346	-117.152525
Santa Margarita	Outlet East side of Elizabeth Lane South of Clinton Keith	902MS45012	Outfall (Dry Weather)	33.59669	-117.22815
Santa Margarita	Outlet South side of Country Park Dr East of Smith Ranch Rd	902MS45015	Outfall (Dry Weather)	33.60056	-117.22509
Santa Margarita	Outlet u/s Oak Creek Rd SD North of Clinton Keith @ Loring Rd	902MS45019	Outfall (Dry Weather)	33.60141	-117.22081
Santa Margarita	Outlet South side of La Estrella St b/t Trig Rd and Salida del Sol	902MS45024	Outfall (Dry Weather)	33.60506	-117.2337631
Santa Margarita	Outlet u/s Oak Creek Rd SD South of Clinton Keith @ Hitching Post Ln	902MS45026	Outfall (Dry Weather)	33.59711	-117.2228056

Watershed	Station Name	Station Number	Station Type	Latitude	Longitude
White Water	Ramsey Street	719RMS782	Storm Drain	33° 48' 35.00"	-116° 51' 31.50"
White Water	Portola Avenue	719POR817	Outfall	33° 44' 16.80"	-116° 22' 24.60"
White Water	CVSC at Avenue 52 Bridge	719CVS884	Receiving Water	33° 40' 20.90"	-116° 08' 57.80"

***Note: Monitoring locations for other efforts, such as Special Projects or Regional Programs are not included herein. Refer to the respective Workplans.**

APPENDIX D:

CLEAN HANDS/ DIRTY HANDS SOP

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▶ Recommendation: Clean-sampling techniques are recommended when collecting samples for analysis of trace-organic compounds and major inorganic elements, particularly when the target analyte could be subject to contamination from field or laboratory procedures at a level that could exceed data-quality requirements.

Table 4-2. Clean Hands/Dirty Hands techniques for water-quality sampling

- Clean Hands/Dirty Hands techniques require two or more people working together.
- At the field site, one person is designated as Clean Hands (*CH*) and a second person as Dirty Hands (*DH*). Although specific tasks are assigned at the start to *CH* or *DH*, some tasks overlap and can be handled by either, as long as the prescribed care is taken to prevent contaminating the sample.
- Both *CH* and *DH* wear appropriate disposable, powderless gloves during the entire sampling operation and change gloves frequently, usually with each change in task. (Wearing multiple layers of gloves allows rapid glove changes.) Gloves must be appropriate to withstand any acid, solvent, or other chemical substance that will be used or contacted.
- *CH* takes care of all operations involving equipment that contacts the sample; for example, *CH*
  - Handles the surface-water sampler bottle.
  - Handles the discharge end of the surface-water or ground-water sample tubing.
  - Transfers sample to churn or cone splitter.
  - Prepares a clean work space (inside vehicle).
  - Sets up processing and preservation chambers.
  - Places equipment inside chambers (for example, sample bottles, filtration and preservation equipment).
  - Works exclusively inside chambers during collection/processing and preservation.
  - Changes chamber covers, as needed.
  - Sets up field-cleaning equipment and cleans equipment.
- *DH* takes care of all operations involving contact with potential sources of contamination; for example, *DH*
  - Works exclusively exterior to processing and preservation chambers.
  - Prepares and operates sampling equipment, including pumps and discrete samplers, peristaltic pump switch, pump controller, manifold system.
  - Operates cranes, tripods, drill rigs, vehicles, or other support equipment.
  - Handles the compressor or other power supply for samplers.
  - Handles tools such as hammers, wrenches, keys, locks, and sample-flow manifolds.
  - Handles single or multiparameter instruments for field measurements.
  - Handles the churn carrier, including outer protective bags.
  - Handles stream-gaging or water-level equipment.
  - Sets up and calibrates field-measurement instruments.
  - Measures and records water levels and field measurements.

APPENDIX E:

SOPS FOR CONDUCTING FIELD MEASUREMENTS AND FIELD COLLECTION OF WATER AND BED SEDIMENT SAMPLES IN SWAMP

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Collections of Water and Bed Sediment Samples with Associated Field Measurements and Physical Habitat in California.Version 1.1 updated March-2014

The SOPs below are for reference and information purposes only, the documents are recommended, not required by the Surface Water Ambient Monitoring Program (SWAMP). Please see the SWAMP Quality Assurance Program Plan at: http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for more information regarding SWAMP QA/QC requirements.

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For the purpose of implementing the requirements of the Riverside County Flood Control and Water Conservation District's (District) Monitoring Programs, as described in the Consolidated Monitoring Program (CMP), the following SOP includes additional redlines and notes (for clarity) and highlights (for emphasis) describing adaptations to the procedures herein as specific to the District's monitoring staff. Otherwise all guidance provided herein should be considered as relevant to compliance monitoring activities as conducted by others.

Acknowledgements:

This procedure has been modified from the Texas Natural Resources Conservation Commission's Procedure Manual for Surface Water Quality Monitoring, with major input from the United State's Geological Survey's (USGS's) National Water Quality Assessment (NAWQA) Protocol for Collection of Stream Water Samples, for which due credit is here with given.

The current version of these protocols was written by Sean Mundell (Moss Landing Marine Labs MPSL Field Sampling Team) with most of the credit to Max Puckett(CDFW) for originally writing this document for part of the original SWAMP QAMP, 2001. Significant contributions also came from Eric von der Geest and the (SWAMP) Quality Assurance (QA) Team, The SWAMP Data Management Team(DMT), Billy Jakl(MPSL), Mary Hamilton (RWQCB 3), and Bettina Sohst(former MPSL employee),

Field Measurements

Field Data Sheets (Refer to the District's CMP Vol. II - Appendix B for equivalent Field Data Sheet)

Field data sheets are used to record field observations, probe measurements, and water and sediment chemistry sampling. Field data sheets are provided through the Marine Pollution Studies Laboratory website at http://swamp.mpsl.mlml.calstate.edu/resources-and-downloads/database-management-systems/swamp-25-database/templates-25/field-data-sheets#WQFieldData

Click on the correct field data sheet for the most recent version. There are guidelines provided below to standardize what is recorded on all data sheets and that should be helpful in completing each form. The entries discussed below and on the field data sheets are recorded at each sampling site.

Notes to Standardize SWAMP Field Data Sheets (For in the field use)

General details commonly relevant to the District's Monitoring Programs are highlighted in yellow for emphasis.

KEY REMINDERS to IDENTIFY SAMPLES:

1. **SAMPLE TIME** is the SAME for all samples (Water, Sediment, & Probe) taken at the sampling event. Use time of FIRST sample; important for COC (is used for identification of sample).
2. **LEFT BANK/RIGHT BANK**
   Left bank is defined as the bank to the left of the observer when facing downstream, and the *right bank* is to the right of the observer when facing downstream
3. **GROUP;** many different ways to do a group, one suggestion is to create groups which assign trips to assess frequency of field QA

SAMPLE TIME: The District's current practice is to record sample time as real time for field measurements via probe, grab sample, and/or last aliquot collected for the composite. These types of samples may be with 5-10 minutes of each other.

COLLECTION DETAILS:

1. **PERSONELL**: S. Mundell, G Ichikawa (first person listed is crew leader)
2. **LOCATION:** Bank, Thalweg, Mid-Channel, Open Water**.** Use "open water" in bay/estuary/harbor only if no distinguishable channel exists
3. **GRAB vs. INTEGRATED**: GRAB samples are when bottles are filled from a single depth; INTEGRATED sample are taken from MULTIPLE depths/grabs and combined.
   A. GRAB: use 0.1 for subsurface samples; if too shallow to submerge bottle; depth = 0
   B. INTEGRATED: -88 in depth sampled, record depths combined in sample comments
4. **TARGET LAT/LONG**: Refers to the existing station location that the sampling crew is trying to achieve; can be filled out prior to sampling
5. **ACTUAL LAT/ LONG**: is the location of the current sample event.
6. **HYDROMODIFICATION:** Describe existing hydro modifications such as a grade control, drainage pipes, bridge, culvert
7. **HYDROMOD LOC**: if there is an IMMEDIATE (with in range potentially effecting sample) hydro modification; Is the hydro modification upstream/downstream/within area of sample; if there is no hydro modification, NA is appropriate
8. **STREAM WIDTH and DEPTH**: describe in meters at point of sample.

FIELD OBSERVATIONS: (each one of these observations has a comment field in the database so use comment space on data sheet to add information about an observation if necessary)

1. **PICTURES:** use space to record picture numbers given by camera; be sure to rename accordingly back in the office. (StationCode_yyyy_mm_dd_unique code)
2. **WADEABILITY**: in general, is water body being sampled wadeable to the average person AT the POINT of SAMPLE **BEWARE OF VELOCITY!**
3. **DOMINANT SUBSTRATE**: if possible; describe DOMINANT substrate type; use UNK if you cannot see the dominant substrate type
4. **BEAUFORT SCALE**: use scale 0-12; refer to scales listed on page 28
5. **WIND DIRECTION**: records the direction from which the wind is blowing
6. **OTHER PRESENCE**: VASCULAR refers to terrestrial plants or submerged aquatic vegetation

ORDER OF ACTIVITIES:
(a) Sample
(b) Measurements
(c) Photo
(modify as necessary based on site conditions)

(SAV) and NONVASCULAR refers to plankton, periphyton etc. These definitions apply to vegetation IN the water at the immediate sampling area.

7. **OBSERVED FLOW**: Visual estimates of flow range in cubic feet/second. Flow severity should be noted for each SWAMP visit to non-tidally influenced flowing streams and submitted on the SWAMP Field Data Sheet. It should be recorded even if flow is visible but not measurable on that sampling visit. This is an observational measurement that is highly dependent on the knowledge of monitoring personnel.
8. **WATER COLOR**: This is the color of the water from standing creek side
9. **WATER CLARITY**: this describes the clarity of the water while standing creek side; clear represents water that is clear to the bottom, cloudy may not be clear to bottom but greater than 4 inches can be seen through the water column.
10. **PRECIPITATION LAST24hrs:** refers to field crew's best categorization of rainfall in the last 24 hrs; may or may not effect Overland Runoff Last 24 hrs
11. **OVERLAND RUNOFF LAST 24 hrs**: Significant precipitation is defined as any amount that visibly influences water quality. Light Precipitation = fog, drizzle, and/or light rain with no overland runoff; Mod to Heavy Precipitation = rain such that site probably or definitely received at least some overland runoff.
12. **SEDIMENT COMP**: generally described sediments used for chemistry sample Note: these reminders do not give all details needed to maintain equivalent SWAMP sampling protocols, they are strictly for "infield" use to help insure comparability of field observations.
13. **WATER APPEARANCE:** Note general appearance (e.g., color, unusual amount of suspended matter, debris or foam)
14. **SEDIMENT APPEARANCE** Color, Odor and sediment composition should be noted.
15. **WEATHER:** Note recent meteorological events that may have impacted water quality; (e.g., heavy rains, cold front, very dry, very wet)
16. **BIOLOGICAL ACTIVITY:** Note excessive macrophyte, phytoplankton or periphyton growth. The observation of water color and excessive algal growth is very important in explaining high chlorophyll a values. Other observations such as presence of fish, birds and spawning fish are noted.
17. **WATERSHED or INSTREAM ACTIVITIES:** Note in stream or drainage basin activities or events that is impacting water quality (e.g., bridge construction, shoreline mowing, livestock watering upstream).
18. **RECORD of PERTINENT OBSERVATIONS RELATED to WATER QUALITY and STREAM USES:** If the water quality conditions are exceptionally poor, note that standards are not met in the observations, (e.g., dissolved oxygen is below minimum criteria). Note uses (e.g., swimming, wading, boating, fishing, irrigation pumps, navigation). Eventually, for setting water quality standards, the level of use will be based on comments related to the level of fishing and swimming activities observed at a station.
19. **SPECIFIC SAMPLE INFORMATION:** Note specific comments about the sample itself that may be useful in interpreting the results of the analysis (e.g., number of sediment grabs, or type and number of fish in a tissue sample). If the sample was collected for a complaint or fish kill, make a note of this in the observation section.
20. **MISSING PARAMETERS:** If a scheduled parameter or group of parameters is not collected, make some note of this in the comments. If possible, request for lab to analyze any missed parameters and note on the COC.
21. **RECORD of DATA SUBMISSION:** Initials and date are recorded on the field data sheet showing a record that the data has been transcribed onto data forms and submitted to the ~~SWAMP~~ *Typical.* District's Data Manager data management staff.

Record of Samples Collected for Purposes of Chemical Analysis

The general types of chemical samples to be collected are listed for each site, since this may vary from site-to-site (e.g., metals-in-water, pesticides-in-sediments, conventional water quality). Analyses authorization forms are recommended since different authorized laboratories perform different chemical analyses. The method of preservation for each chemical sample is recorded, as appropriate on the Chain of Custody Form (COC).

Field Data Measurements

While collecting water samples (see Field Collection Procedures for Water Samples page 29), record appropriate field measurements. When field measurements are made with a multi-parameter instrument, it is preferable to place the sonde in the body of water to be sampled and allow the dissolved oxygen (D.O.) to equilibrate. D.O. usually takes the longest to equilibrate out of the probe measurements (pH, Temperature, Conductivity and Turbidity) Field measurements are made at the centroid of flow, if the stream visually appears to be completely mixed from shore to shore. *Centroid* is defined as the midpoint of that portion of the stream width which contains 50% of the total flow. Probe measurements and water sampling are best to collect in the stream location that best represents the entire stream. For routine field measurements, the date, time and depth are reported as a grab. Quality control requirements for field measurements are listed in Quality Control and Sample Handling Tables for Field Measurements in Fresh and Marine Water. ***WARNING** Due to potential safety concerns, (e.g., high velocity flows, hazardous debris, etc.) to avoid injury District staff shall NOT face backwards in streams, rivers, or channels. Probes will be faced upstream.***

Recommended Depths for Conducting Field Data Measurements

Water Depth Less than 5 ft (<1.5 m)

If the water depth is less than 5 ft (1.5 m), grab samples for water are taken at approximately 0.1 m (4 in.), and multi-probe measurements are taken at approximately 0.2 m (8 in.). This is because all sensors have to be submerged, so 0.1 m would not be deep enough. But taking a grab sample at 0.2 m is not always feasible, as it is difficult to submerge bottles to that depth, and in many cases the bottle will hit the stream bottom.

Water Depth Greater than 5 ft (>1.5 m)

If the water depth at the sampling point exceeds 5 ft (1.5 m) in depth, a vertical profile of dissolved oxygen, temperature, pH and specific conductance are made using the multi-parameter probe equipment. The depth of the sonde at the time of measurement is most accurately determined from the depth sensor on the multi-parameter sonde rather than depth labels on the cable.

~~**Vertical Depth Profiles and Depth-Integrated Sample Collection**~~

Vertical profile measurements are not part of the monitoring conducted by District staff.

~~If depth integration sampling is being conducted, or if vertical profile measurements are requested, multi-probe measurements are made starting at a depth of 0.2 m, and are then conducted at 1.0, 2.0, 3.0, 4.0, and 5.0 m depths after that until 5.0 m depth is reached. Beginning at 5.0 m, measurements are made every 5.0 m through depth profile.~~

Field data for multi-parameter vertical depth profiles are recorded in final form on the SWAMP Field Data Sheets and submitted to the SWAMP data management staff. Go to http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting.

Water Temperature (^{O}C)

Water temperature data are recorded for each site visit in final form on a Field Data Sheet and submitted to the ~~SWAMP~~ data management staff.

Temperature Sampling Procedures

Temperature is measured in-stream at the depth(s) specified above. Measuring temperature directly from the stream by immersing a multi-probe instrument or thermometer is preferred.

Hand Held Centigrade Thermometer

If an electronic meter is not available, the temperature is measured with a hand-held, centigrade thermometer (Rawson, 1982).

- < In wadeable streams, stand so that a shadow is cast upon the site for temperature measurement.
- < Hold the thermometer by its top and immerse it in the water. Position the thermometer so that the scale can be read.
- < Allow the thermometer to stabilize for at least one minute, then without removing the thermometer from the water, read the temperature to the nearest 0.1^{o} C and record.
- < Do not read temperature with the thermometer out of the water. Temperature readings made with modern digital instruments are accurate to within $\pm$ 0.1^{o} C.

Temperature Measurement from a Bucket

When temperature cannot be measured in-stream, it can be measured in a bucket-Nalgene or plastic container. Care must be taken to insure a measurement representative of in-stream conditions.

The following conditions must be met when measuring temperature from a bucket:

- ≤ The bucket must be large enough to allow full immersion of the probe or thermometer.
- ≤ The bucket must be brought to the same temperature as the water before it is filled.
- ≤ The probe must be placed in the bucket immediately, before the temperature changes.
- ≤ The bucket must be shaded from direct sunlight and strong breezes prior to and during temperature measurement.
- ≤ The probe is allowed to equilibrate for at least one minute before temperature is recorded.
- ≤ After these measurements are made, this water is discarded and another sample is drawn for water samples which are sent to the laboratory.

pH (standard units)

pH data is recorded for each SWAMP visit in final form on the Field Data Sheets and submitted to the SWAMP data management staff. Go to http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting.

pH Sampling Equipment

The pH meter should be calibrated according to the recommended procedures for calibration and maintenance of SWAMP field equipment. Calibration directions are listed in the manufactures field equipment operations manual. The pH function is pre and post calibrated every 24 h of use for multi-parameter instruments.

Typical - Follow the manufacturer's recommendations. Calibrate pH meter within 7 days of use. No post calibration unless an issue is identified in the field with a meter reading.

pH Sampling Procedures

In-stream Method

Preferably, pH is measured directly in-stream at the depth(s) specified earlier in this document. Allow the pH probe to equilibrate for at least one minute before pH is recorded to the nearest 0.1 pH unit.

pH Measurement from a Bucket

When pH cannot be measured in-stream, it can be measured in a bucket-Nalgene or plastic container. The following precautions are outlined above; “Temperature Measurement from a Bucket”.

Potential Problems

- If the pH meter value does not stabilize in several minutes, out gassing of carbon dioxide or hydrogen sulfide, or the settling of charged clay particles may be occurring (Rawson, 1982).
- If out gassing is suspected as the cause of meter drift, collect a fresh sample, immerse the pH probe and read pH at one minute.
- If suspended clay particles are the suspected cause of meter drift, allow the sample to settle for 10 min, then read the pH in the upper layer of sample without agitating the sample.
- With care, pH measurements can be accurately measured to the nearest 0.1 pH unit.

Dissolved Oxygen (mg/L)

Dissolved oxygen (D.O.) data is recorded for each SWAMP visit in final form on a Field Data Sheet and submitted to the SWAMP data management staff.
See http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting.

Dissolved Oxygen Sampling Equipment

The dissolved oxygen meter should be calibrated according to the recommended procedures for calibration and maintenance of SWAMP field equipment. Calibration directions are listed in the manufactures field equipment operations manual.

Multi-probe Instrument

Pre and post calibrate the D.O. sensor every 24 h and for elevations greater than 500 ft on the multi-probe instrument. Preferably, D.O. is measured directly in-stream at the depth(s) specified in the Field Measurements section above. The D.O. probe must equilibrate for at least 90 s before D.O. is recorded to the nearest 0.1 % saturation or mg/L. Care must be taken at profile stations to insure that the reading is stable for each depth. Since dissolved oxygen takes the longest to stabilize, record this parameter after temperature, conductivity and pH. If the D.O. probe has an operable, automatic stirrer attached, the D.O. probe does not have to be manually stirred. However, if the probe is not equipped with an automatic stirrer, manual stirring must be provided by raising and lowering the probe at a rate of 1 ft/s (0.3m/s) without agitating the water surface. If the stream velocity at the sampling point exceeds 1 ft/s, the probe membrane can be pointed upstream into the flow and manual stirring can be avoided (Rawson, 1982).

Typical - Follow the manufacturer's recommendations. Calibrate DO meter within 7 days of use. No post calibration unless an issue is identified with meter reading.

D.O. Measurement from a Bucket

When D.O. cannot be measured in-stream, it can be measured in a bucket-Nalgene or plastic container, following precautions outlined in the Temperature Measurement from a Bucket listed above. During equilibration and reading, water should be moved past the membrane surface at a velocity of 1 ft/s (0.3 m/sec), either by automatic stirrer or manual stirring. If stirred manually in a bucket, the water surface is not agitated (Rawson, 1982).

Meters are equipped with an automatic stirrer. Use the stirrer if measurements are NOT taken *in situ*.

24-Hour Average D.O. Continuous Monitoring (if requested in special study)

NOT APPLICABLE: This is not a current practice under the District's Monitoring Program.

Unattended 24-Hour D.O. Data Collection

Why Collect 24-Hour Data

Dissolved oxygen sampling for standards compliance is targeted to water bodies where low instantaneous D.O. levels indicate partial or nonsupport of designated aquatic life uses. Intensive monitoring is conducted with automated equipment that is preset to record and store field measurements hourly over one 24-h period. Four or more dissolved oxygen measurements may also be made manually at 4-6-h intervals over one 24-h period, as long as one is made near sunrise (0500-0900 h) to approximate the daily minimum. However, data collected with automated equipment is preferred.

When to Take Measurements

All 24-h D.O. monitoring events must be spaced over an index period representing warm-weather seasons of the year (approx March 15-October 15), with between one-half to two-thirds of the measurements occurring during the critical period (July 1-September 30). The ***critical period*** of the year is when minimum stream flows, maximum temperatures, and minimum dissolved oxygen concentrations typically occur in area streams. **A flow measurement must be taken at the time of deployment.** In a perennial stream, a 24-h data for standards compliance can not be used if the flow is less than the 7Q2. In perennial streams, the D.O. criterion to do not apply for flows under the 7Q2. A period of about one month must separate each 24-h sampling event. Additional samples may be collected outside the index period to further characterize a water body, but that information is generally not used for assessing standards compliance.

Frequency of Measurements

The measurement interval should be no more than once per 15 min and no less than once per hour.

NOT APPLICABLE: This is not a current practice under the District's Monitoring Program.

Where to Take Measurements

For purposes of determining standards compliance with the 24-h average criteria, samples collected near the surface will be considered representative of the mixed surface layer. In deep streams, reservoirs, and tidally influenced water bodies, automated equipment is positioned between 1 foot (from the surface) to one-half the depth of the mixed surface layer. At least 10 24-h monitoring events (using the 24-h criteria and/or absolute minimum criteria) at each site within a 5-year period are recommended to provide adequate data for assessment.

When to Collect Other Routine Samples, if doing 24-hour D.O. measurements

Other routine field measurements and water samples should be collect at either the time of deployment, at the reference check, or when the multi-probe recording 24-h data is retrieved. When ever possible, flow must be measured at the 24-h site.

Priority for Scheduling 24-Hour Sampling Events

- < 303d listed waterbodies
- < Waterbodies with Concerns for DO problems (too few samples available for full use assessment).
- < Occurrence of low D.O. concentrations observed during the day
- < Waterbodies with trends indicating declining D.O. concentrations
- < Waterbodies which would contribute to an Eco-region data set

Data Reporting for 24-hour D.O. measurements

Dissolved oxygen values recorded over the 24-h period are summed and divided by the number of measurements to determine the average concentration, which is compared to the 24-h criterion. The lowest D.O. value from each 24-h set is compared to the minimum criterion. There will be occasions when a complete 24-h data set won't be possible. For example, if there are 18 measurements instead of 24, a time weighted diurnal average needs to be calculated. This can be easily done using GW Basic.

Support of assigned aquatic life use is based on 24-h D.O. average and minimum criteria for each monitoring event. Report the 24-h average D.O. value, number of measurements over a 24-h period, and the minimum, and maximum values. Report data as a time composite sample with a beginning and ending date and time, covering the 24-h period measured.

Specific Conductance (µS/cm)

Specific conductance should be recorded for each SWAMP visit in final form on a Field Data Sheet and submitted to the ~~SWAMP~~ data management staff.
See http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting.

Specific Conductance Sampling Equipment

The conductivity meter should be calibrated according to the recommended procedures for calibration and maintenance of SWAMP field equipment. Calibration directions are listed in the manufactures field equipment operations manual.

Specific Conductance Sampling Procedure

Preferably, conductivity is measured directly in-stream at the depth(s) specified earlier in this document. Allow the conductivity probe to equilibrate for at least one minute before specific conductance is recorded to three significant figures (if the value exceeds 100). The primary physical problem in using a specific conductance meter is entrapment of air in the conductivity probe chambers. The presence of air in the probe is indicated by unstable specific conductance values fluctuating up to +/-100 µS/cm. The entrainment of air can be minimized by slowly, carefully placing the probe into the water; and when the probe is completely submerged, quickly move it through the water to release any air bubbles.

If specific conductance cannot be measured in-stream, it should be measured in the container it can be measured in a bucket-Nalgene or plastic container. The following precautions are outlined above; "Temperature Measurement from a Bucket".

Salinity (parts per thousand--ppt, or ‰) This only applies to SMC Bioassessment - conducted by others

The value for salinity is computed from chloride concentration or specific conductance. The calculation assumes a nearly constant ratio for major ions in an estuary when seawater is diluted by river water. This assumption does not hold for cases where salinity is less than about three parts per thousand. Salinity determinations at such low values are only approximate. In estuarine waters, salinity is a relevant and meaningful parameter. Often the salinity may be low, approaching that of freshwater. Nevertheless, this is useful information. Determine if a station is estuarine from historical records (i.e., experiences cases where salinity is >2.0 ppt) and always report salinity at this station, regardless of the salinity during periods of high flow.

Salinity is measured directly in-stream at the depth(s) specified earlier in this document. Salinity data should be recorded for each SWAMP visit in final form on a Field Data Sheet and submitted to the SWAMP data management staff. See http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting.

Values between 2.0 ppt and 1.0 ppt should be reported as <2.0 ppt rather than the actual value and values <1.0 ppt should be reported as <1.0 ppt. The field instruments compute salinity from specific conductance and temperature, and display the value in parts per thousand. Report salinity values above 2.0 ppt to the nearest 0.1 ppt.

NOT APPLICABLE: This is not a current practice conducted by District field staff.
However, it may used for TMDL monitoring - conducted by others.

Secchi Disc Transparency (meters)--if requested in special study

NOT APPLICABLE: This is not a current practice conducted by District field staff.
However, it may used for TMDL monitoring - conducted by others.

Secchi disk transparency should be recorded for each SWAMP visit in final form on a Field Data Sheet and submitted to the SWAMP data management staff. See http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting.

Secchi Disk Sampling Equipment

- Secchi disk, 20 cm in diameter
- Measuring tape

Secchi Disk Transparency Sampling Procedures

Preferably, Secchi disk transparency is measured directly in-stream wherever conditions allow. The Secchi disk should be clean, weighted and suspended with chain, wire, or Dacron line (the line used to suspend the Secchi disk should not be nylon or cotton; stretching may cause erroneous readings). Another option is to attach the Secchi disk to a metal rod calibrated in metric units.

Average Turbidity

The Secchi disk should be lowered vertically in a location shielded from direct sunlight. Glare from the water's surface will affect the accuracy of the measurement. Don't wear sunglasses.

Slowly lower the disk until it disappears from view. The person viewing the disk should maintain an eye level of less than two meters above the water's surface. Note the depth at which the disk disappears from view.

Slowly raise the disk until it becomes visible. Note the depth at which the disk reappears.

Compute the mathematical average of the two depths noted and record the average value to two significant figures on the field data sheet. The recorded average value is the Secchi disk transparency.

High Turbidity (Muddy Water)

In streams with very high turbidity, high velocity, and/or poor access, it may be necessary to measure Secchi disk transparency in a bucket. Fill the bucket from the centroid of flow being careful not to disturb the substrate.

Follow steps above for measuring the Secchi disk depth within 30 s after raising the filled bucket from the water's surface. Or, re-suspend the solids by stirring, then quickly make the measurement.

Record Secchi disk transparency to two significant figures.

Low Turbidity (Clear Water)

Some bodies of water will be so clear and shallow that it will not be possible to lower the Secchi disk until it disappears from view.

Measure and record the depth at the deepest point accessible. Report Secchi disk transparency as greater than the deepest depth measured.

Example (Low Turbidity): South Fork Rocky Creek is a small (<1 ft^3/s) clear stream. The stream in the vicinity of the sampling site was less than 1 m deep and the bottom was clearly visible everywhere. However, a pool was located in the stream next to a bridge. The maximum depth of the pool was 2.6 m at which depth the Secchi disk was still visible. Therefore, Secchi disk transparency for South Fork Rocky Creek was recorded as > 2.6 m.

Importance of Secchi Disk Data

Eutrophication, the natural aging process in reservoirs and lakes is accelerated by human activities which add nutrients to lakes, reservoirs, and the surrounding watersheds. Section 314 of the Clean Water Act (CWA) of 1987 requires all states to classify lakes and reservoirs according to trophic state. Although chlorophyll a is the most direct measure of algal biomass, other indices and programs utilize Secchi disk depth as the primary factor.

Turbidity Measurement with Turbidity Meter

Nephelometric Turbidity (turbidity standard unit is called Nephelometric Turbidity Units (NTU)) can be determined by measuring the amount of scatter when light is passed through a sample using a turbidity meter. The LaMotte 2020 Turbidity meter is a suitable instrument for example. There are also turbid-ometers attached to multi-probe instruments like YSI or Hydro-Lab.

Turbidity meters should be calibrated using a standard close to the expected sample value. Calibration standards should be used that are relative to the suspended sediment particles in the sampleable water column. Typical calibration standard values are 1, 10, 100, and 1000 NTU's.

For instructions on how to operate the instruments refer to the manufacturer's manual. Turbidity measurements can be executed together with water sampling. The turbidity sample has to be representative for the sampled water mass. Make sure that no gas bubbles are trapped in the vial for the reading and that the outside of the vial is wiped completely clean (i.e., meaning free of moisture, lint and fingerprints). Take several measurements to assure an accurate reading. Do not record values that vary greatly. If variations are small, record an average. If settling particles are present, record a reading before and one after settling. The meter might have to be recalibrated with a different standard, if the sample water readings are outside of the calibration standard limits.

Flow

Sampling crews should be notified on reconnaissance forms if it is known that there is an operational United States Geological Survey (USGS) gage located at or nearby a sampling site. If there is a USGS gage nearby, a gage height in feet is recorded and later converted to an instantaneous flow value and recorded on the field data sheet. The gage height is always to be reported to the USGS for conversion to flow. If a USGS gage is not available, a flow measurement should be taken, if requested. See Instantaneous Flow Measurement information starting on page 13 in this document. In addition, it is recommended that a flow severity value is recorded at each stream or river station that is not tidally influenced. See the Flow Severity section starting on page 13 of this document. Centroid velocity measurements may also be taken as a minimum acceptable rough characterization of the stream flow as requested, although this measurement is not to be recorded as a flow, since it is only a velocity measurement
Flow information for over 200 USGS sites is available on the Internet. The address is **http://water.usgs.gov/index.html**. This is useful information in determining flow conditions prior to sampling. This information may be included in general observations.

Flow Measurement Method (Reporting)

This section contains several options for flow measurement approaches; however, per the District's Consolidated Monitoring program, taking in situ flow measurements via 'orange peel method is standard.

The method used to measure flow is noted by reporting which instrument or gage is used. Examples are, Flow Gage Station (USGS/IBWC), Electric Marsh-McBirney flo mate 4000, Mechanical (ex. Pigmy meter), Weir/Flume, Other (orange peel, etc.) Flow data transformers are used to enter flow data into the SWAMP database. Please contact the SWAMP data management team to obtain the flow data transformer.

Flow (ft^3/s)

If requested, flow data should be recorded for each monitoring visit to non-tidal, flowing streams. Flow data should be recorded in final form on a Field Data Sheet and submitted to the ~~SWAMP~~ data management staff. See http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa for detailed information on data reporting. The following are two exceptions to the flow reporting requirement:

No Flow/ Pools — If there is no flow at a stream site and accessible, isolated pools remain in the stream bed, collect and report the required field data and laboratory samples from the pools and report instantaneous flow. Under these conditions, flow (ft^3/s) should be reported as zero. The reported flow severity value should be one. Pools may represent natural low-flow conditions in some streams and the chemistry of these pools will reveal natural background conditions.

Dry — If the stream bed holds no water, the sampling visit is finished. Report that the stream was "dry" in the observations and record a value of six (meaning "dry") for flow severity. No value is reported for flow since there is no water.

Flow Measurement

See Page 20 & 21 - Flow Estimate Procedure
(District standard practice)

If a flow measurement is required at a site, measure and record flow after recording visual observations. The intent of measuring flow first is to delay collection of chemical and biological water samples with limited holding times. Care must be taken not to collect water samples in the area disturbed during flow measurement. There are several acceptable flow measurement methods that can be used.

This is an option for some sites for data confirmation; however, per the District's Consolidated Monitoring program, taking in situ flow measurements via 'orange peel method is a standard practice.

U.S. Geological Survey (USGS) Gaging Station

Some SWAMP Stations are sampled at sites where the USGS maintains flow gaging equipment. On any type of sampling visit to a site that has a USGS flow gage, observe and record the gage height to the nearest hundredth of a foot in the field logbook. Upon return to the office, contact the USGS office responsible for maintaining the gage. USGS personnel can provide the flow value in cubic feet per second (ft^3/s) that corresponds to the gage height. Although SWAMP personnel may have a rating curve available to them, shifts associated with changes in the stream bed may occur over time. Always call the USGS to determine the shift. At some sites the shift changes frequently. At others, the relation between stream flow and gage height is almost unchanging. If a gage is no longer maintained by USGS, cross out the recorded gage height and be prepared to measure flow by another method on the return visit to that site.

Several factors may influence the accuracy of the USGS rating curves that are used to convert gage height to flow. If there is any doubt about the accuracy of a USGS gage height reading or flow rating curve, sampling personnel should measure the flow if possible.

Gage height may be indicated at a USGS gage by one of three methods:

Staff Gage

Staff gages are enameled steel plates (with the appearance of large measuring tapes) bolted to some stable structure. For example, staff gages may be bolted to concrete bridge abutments, pillars, or docks. The staff gage face is white with black lettering and gradations. The gradations shown are feet, tenths of a foot, and 0.02 of a foot. The point at which the water level crosses the staff gage should be recorded to the nearest hundredth of a foot.

Wire Weight Gage

Wire weight gages are locked, metal boxes with approximate dimensions of 15 in. long x 12 in. tall x 12 in. deep. Wire weight gages are usually affixed to bridge rails near mid-stream. They must be unlocked with a USGS key. The wire weight gages house a weight attached by wire cable to a graduated reel (gradations are tenths and hundredths of feet) with a counter at one end.

When the reel is released the weight can be gradually lowered until the bottom of the weight contacts the water surface. At the point of contact, the weight causes the water surface to ripple slightly. Maintaining the weight in that position, record the counter value to the nearest whole number and the point indicated by the stylus on the graduated reel to the nearest hundredth of a foot. Determine if the gage is the movable type that can be moved to multiple locations on the bridge. This type is common on braided streams. A correction value is stamped on the bridge near each point that the gage can be attached.

Record the corrected value as the gage height in feet.

Bubble Gage

Bubble gages are locked in metal sheds that are approximately 4 ft wide x 4 ft deep x 6.5 ft tall. The gage houses are most frequently located on the shore near a bridge but sometimes are attached to bridge pillars near mid-stream or established on the stream bank far from any bridge. The gage house must be unlocked with a USGS key. Bubble gages in gage houses usually indicate the gage height in two or three locations. A counter attached to the manometer system indicates gage height in feet. Some gage houses have stilling wells that can be entered. Often there is a staff gage on the inside wall.

Most bubble gages are also equipped with digital recorders. Digital recorders consist of two white, coded discs, approximately 4 in. in diameter with a punch tape overlapping a portion of each disc. The discs are marked with 100 gradations. As the front of the digital recorder is viewed, the stylus at the disc on the left indicates height in feet. The stylus at the disc on the right indicates gage height in hundredths of feet. The gage height from both discs should be added and the number recorded in the field logbook as gage height to the nearest hundredth of a foot.

Many USGS metal sheds also contain a surface level recorder. This devise can be opened to determine how stable stream flow has been prior to the sampling event. Record observations concerning the flow hydrograph.

See Page 20 & 21 - Flow Estimate Procedure
(District standard practice)

Instantaneous Flow Measurement

Water quality monitoring visits to sites where there are no nearby USGS flow gauges will require water quality monitoring personnel to measure flow, when requested by Regional Water Quality Control Boards (Regional Boards).

Flow Measurement Equipment

Flow meter

One of the following or an equivalent:

- Marsh-McBirney Electronic meter
- Montedoro-Whitney Electronic meter
- Price Pigmy meter (with timer and beeper)
- Price meter, Type AA (with Columbus weight)

Additional Equipment

- Top-setting wading rod (preferably measured in tenths of feet)(see Figure 1).
- Tape measure (with gradations every tenth of a foot or every centimeter).

Flow Measurement Procedure (USGS, 1969)

Select a stream reach with the following characteristics:

- Straight reach with laminar flow (threads of velocity parallel to each other) and bank to bank. These conditions are typically found immediately upstream of riffle areas or places where the stream channel is constricted.

- The site should have an even streambed free of large rocks, weeds, and protruding obstructions that create turbulence. The site should not have dead water areas near the banks, and a minimum amount of turbulence or back eddies.

Flat Streambed Profile (cross section)

Stretch the measuring tape across the stream at right angles to the direction of flow. When using an electronic flow meter, the tape does not have to be exactly perpendicular to the bank (direction of flow). When using a propeller or pigmy type meter, however, corrections for deviation from perpendicular must be made.

If necessary and possible, modify the measuring cross section to provide acceptable conditions by building dikes to cut off dead water and shallow flows, remove rocks, weeds, and debris in the reach of stream one or two meters upstream from the measurement cross section. After modifying a streambed, allow the flow to stabilize before starting the flow measurement.

Record the following information on the flow measurement form (see example Flow Measurement Forms at end of this document):

- Station Location and Station ID
- Date
- Time measurement is initiated and ended
- Name of person(s) measuring flow
- Note if measurements are in feet or meters
- Total stream width and width of each measurement section
- For each cross section, record the mid-point, section depth and flow velocity

Measuring the Stream Width

Measure and record the stream width between the points where the tape is stretched (waters edge to waters edge).

Determining the Number of Flow Cross Sections

Determine the spacing and location of flow measurement sections. Some judgment is required depending on the shape of the stream bed. Measurements must be representative of the velocity within the cross-section. If the stream banks are straight and the depth is nearly constant and the bottom is free of large obstructions, fewer measurements are needed, because the flow is homogeneous over a large section. Flow measurement sections do not have to be equal width. However, they should be unless an obstacle or other obstruction prevents an accurate velocity measurement at that point. ***No flow measurement section should have greater than 10% of the total flow.***

If the *stream width is less than 5 ft*, use flow sections with a width of 0.5 ft (See example 1 on page 23 of this document). If the *stream width is greater than 5 ft*, the minimum number of flow measurements is 10. The preferred number of flow measurement cross sections is 20-30 (See Example 2 on page 24 on this document). The total stream width is 26 ft with 20 measurements, section widths will be 1.3 ft (26/20 = 1.3).

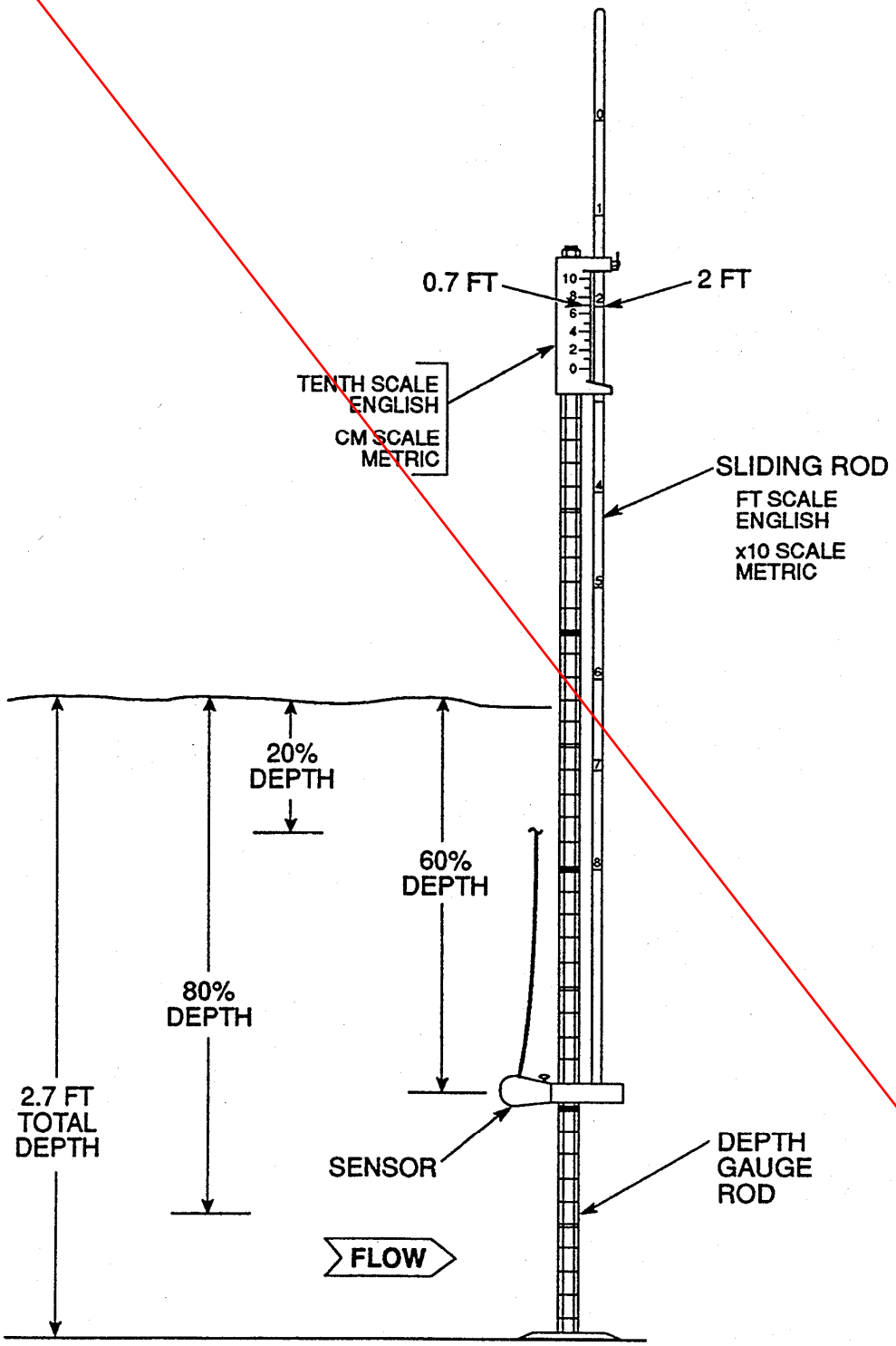
Determining the Mid-Point of the Cross Section

To find the mid-point of a cross section, divide the cross section width in half. Using Example 2 (see forms at end of document);

- The total stream width is 26 ft with 20 cross sections and each cross section width is equal to 1.3 ft.

- Divide 1.3 ft in half and the mid-point of the first section is 0.65 ft. In this example the tape at waters edge is set at zero (0) ft.
- By adding 0.65 to zero the mid-point of the first section is 0.65 ft.
- Each subsequent mid-point is found by adding the section width (1.3 ft) to the previous mid-point. For example; MIDPOINT #1 is 0.65 + 0.0 = 0.65; MIDPOINT #2 is 0.65 + 1.3= 1.95 ft; MIDPOINT #3 is 1.95 + 1.3 = 3.25 ft and … MIDPOINT # 20 is 24.05 +1.3.
- Place the top setting wading rod at 0.65 ft for the first measurement.
- Using a top setting wading rod, measure the depth at the mid-point of the first flow measurement section and record to the nearest 0.01 ft.

Figure 1. Top-Setting Wading Rod (Marsh-McBirney)



Adjusting the Sensor Depth at a Cross Section

Adjust the position of the sensor to the correct depth at each mid-point. The purpose of the top setting wading rod is to allow the user to easily set the sensor at 20%, 60%, and 80% of the total depth. The total depth can be measured with the *depth gage rod*. Each single mark represents 0.10 foot, each double mark represents 0.50 foot, and each triple mark represents 1.00 foot (see Figure 2).

For Depths < 2.5 Ft	If the depth is less than 2.5 ft, only one measurement is required at each measurement section. To set the sensor at 60% of the depth, line up the foot scale on the *sliding rod* with the *tenth scale*, located on top of the depth gage rod. If, for example, the total depth is 2.7 ft (as shown on Figure 2), then line up the 2 on the foot scale with the 7 on the tenth scale (Marsh-McBirney 1990).
For Depths > 2.5 Ft	If the depth is greater than 2.5 ft, measurements should be taken at 20% and 80% of the total depth.

Measuring Velocity (this has typically been measured at 6/10 of the total depth, for velocity-only measurements)

- Position the meter at the correct depth and place at the mid-point of the flow measurement section. Measure and record the velocity and depth. The wading rod is kept vertical and the flow sensor kept perpendicular to the tape rather than perpendicular to the flow while measuring velocity with an electronic flow meter. When using a propeller or pigmy-type meter, however, the instrument should be perpendicular to the flow.
- Permit the meter to adjust to the current for a few seconds. Measure the velocity for a minimum of 20 s with the Marsh-McBirney and Montedoro-Whitney meters. Measure velocity for a minimum of 40 s (preferably 2 min with the Price and pigmy meters).
- When measuring the flow by wading, stand in the position that least affects the velocity of the water passing the current meter. The person wading stands a minimum of 1.5 ft downstream and off to the side of the flow sensor.
- A flow sensor, equipped with cable and weight may be used to measure flows where the water is too deep to wade. Follow the procedure involving meters attached to wading rods.
- Report flow values less than 10 ft^2/s to two significant figures. Report flow values greater than 10 ft^3/s to the nearest whole number, but no more than three significant figures.
- In cases where the flow is low and falling over an obstruction, it may be possible to measure the flow by timing how long it takes to fill a bucket of known volume.

Avoid measuring flow in areas with back eddies. The first choice would be to select a site with no back eddy development. However, this can not be avoided in certain situations. Measure the

negative flows in the areas with back eddies. These negative values will be included in the final flow calculation.

Calculating Flow

To calculate flow, multiply the width x depth (ft^2) to derive the area of the flow measurement section. The area of the section is then multiplied by the velocity (ft/s) to calculate the flow in cubic feet per second (cfs or ft^3/sec) for that flow measurement section. When flow is calculated for all of the measurement sections, they are added together for the total stream flow (see Figure 2). Flow data transformers are also provided by the SWAMP data management team. The transformer provides the calculations needed to obtain a final flow value in cubic feet per second.

Q=Total Flow (or discharge), W=Width, D=Depth, V=Velocity.

$Q = (W_1 * D_1 * V_1) + (W_2 * D_2 * V_2) + ... (W_n * D_n * V_n)$

What to Do with Negative Values

Do not treat cross sections with negative flow values as zero. Negative values obtained from areas with back eddies should be subtracted during the summation of the flow for a site.

Flow Estimate (ft^3/s)

Flow estimate data may be recorded for a non-tidally influenced stream when it is not possible to measure flows by one of the methods described above. Flow estimates are subjective measures based on field personnel's experience and ability to estimate distances, depths, and velocities. If flow can not be measured at a routine non-tidal station, a new site should be selected where flow can be measured.

Flow Estimate Procedure

- Observe the stream and choose a reach of the stream where it is possible to estimate the stream cross section and velocity.
- Estimate stream width (ft) at that reach and record.
- Estimate average stream depth (ft) at that reach and record. Estimate stream velocity (ft/s) at that reach and record. A good way to do this is to time the travel of a piece of floating debris. If doing this method from a bridge, measure the width of the bridge. Have one person drop a floating object (something that can be distinguished from other floating material) at the upstream side of the bridge and say start. The person on the downstream side of the bridge will stop the clock when the floating object reaches the downstream side of the bridge. Divide the bridge width by the number of seconds to calculate the velocity. The velocity can be measured at multiple locations along the bridge. These velocities are averaged. ~~If this is done alone, watch for road traffic.~~
- Multiply stream width (ft) time's average stream depth (ft) to determine the cross sectional area (in ft^2) which when multiplied by the stream velocity (in ft/s) and a correction constant, gives an estimated flow (ft^3/s).

Example: A stream sampler conducted a sampling visit to a stream while the flow meter was being repaired. The sampler looked at the creek downstream from the bridge and saw a good place to estimate flow. The stream width was around 15 ft. It appeared the average depth on this reach was about 0.75 ft. The sampler timed a piece of floating debris as it moved a distance of 10 ft in 25 s downstream over the reach. An estimated flow with a smooth bottom was calculated using the following formula.

Width x Depth x Velocity x A (correction factor)= estimated flow
15 ft (width) x 0.75 ft (depth) x 2.5 ft/s (velocity) x A =25 ft^3/s (cfs)

A is a correction constant: 0.8 for rough bottom and 0.9 for smooth bottom

Estimated flow should be reported to one or two significant figures.

Experienced field personnel are able to estimate flow to within 20% of actual flow for total flows less than 50 ft^3/s. The best way to develop this skill is to practice estimating flow before making measurements at all monitoring visits to non-tidally influenced flowing streams and then compare estimated flows with those obtained from USGS gages or from instantaneous flow measurements

Figure 2. Stream Flow (Discharge) Measurement

District staff will use the program standard Field Data Sheet for collection and calculation of flow measurement.

Example 1.

Stream Flow (Discharge) Measurement

Small Stream < 5 Ft Wide and #2.5 Ft Deep

Stream:___**OAK CREEK**_____Date:__**5/29/91**___

Station Description:_____**at US Hwy 90A**_____

Time Begin:__**1545**_____Time End:__**1630**_____Meter Type:_**Marsh-McBirney**_____

Observers:_____**BK/MK**_____Stream Width*:____**5 ft**_____ Section Width:____**0.5 ft**_____

Observations:_____

Section Midpoint (ft)	Section Depth (ft)	Observational Depth** Ft	Velocity		Area W x D (ft^2)	Discharge (Q) V x A (ft^3/s)
			At Point (ft/s)	Average (ft/s)		
0.25	**0.55**			**0.05**		**0.01375**
0.75	**0.80**			**0.11**		**0.044**
1.25	**0.85**			**0.27**		**0.42635**
1.75	**0.90**			**0.49**		**0.2205**
2.25	**1.10**			**0.58**		**0.275**
2.75	**1.50**			**0.72**		**0.540**
3.25	**1.20**			**0.76**		**0.456**
3.75	**0.90**			**0.76**		**0.342**
4.25	**0.75**			**0.44**		**0.165**
4.75	**0.30**			**0.00**		**0.00**

m^3/s x 35.3 = ft^3/s

Total Discharge (3Q) (ft^3/s) **2.4826**

District staff will use the program standard Field Data Sheet for collection and calculation of flow measurement.

Example 2: Stream Discharge Measurement Example (Larger Stream > 5 Ft and #2.5 Ft Deep)

Stream:___**RED RIVER**_____Date:__**5/28/91**___

Station Description:_____**Post Oak Creek 40 m Below Sherman WWTP Outfall**_____

Time Begin:__**1542**_____Time End:__**1601**_____Meter Type:_**Marsh-McBirney**_____

Observers:_____**CM, EW, DO**_____Stream Width*:____**26 ft**___ Section Width:___**1.3 ft**_____

Observations:

Section Midpoint (ft)	Section Depth (ft)	Observational Depth** ft	Velocity		Area W x D (ft^2)	Discharge (Q) V x A (ft^3/s)
			At Point (ft/s)	Average (ft/s)		
0.65	0.55			2.03	0.715	1.451
1.95	0.40			2.04	0.520	1.061
3.25	0.42			2.02	0.546	1.103
4.55	0.38			1.77	0.494	0.874
5.25	0.40			1.75	0.520	0.910
7.15	0.42			1.93	0.546	1.054
8.45	0.40			1.99	0.52	1.035
9.75	0.37			1.92	0.481	0.924
11.05	0.37			1.56	0.481	0.750
12.35	0.43			1.32	0.559	0.738
13.65	0.40			1.36	0.520	0.707
14.95	0.42			1.33	0.546	0.726
16.25	0.40			1.35	0.520	0.702
17.55	0.45			1.64	0.585	0.959
18.85	0.48			1.70	0.624	1.061
20.15	0.48			2.00	0.624	1.248
21.45	0.50			1.95	0.650	1.268
22.75	0.40			2.18	0.520	1.134
24.05	0.48			1.71	0.624	1.067
25.35	0.50			0.60	0.650	0.390
m^3/s x 35.3 = ft^3/s				**Total Discharge (3Q) (ft^3/s)**		**19.162**

District staff will use the program standard Field Data Sheet for collection and calculation of flow measurement.

Example 3: Stream Flow (Discharge) Measurement (Larger Stream > 5 Ft and >2.5 Ft Deep)

Stream:____ARROYO COLORADO_____Date:__**6/16/98**__

Station Description:_____Downstream of Harlingen WWTP_____

Time Begin:__**1400**_____Time End:__**1445**_____Meter Type:__**Marsh-McBirney**_____

Observers:_____**JD, CK**_____Stream Width*:___**47.5 ft**___ Section Width:___**2.375 ft**_____

Observations: *Note that the starting point is at 4.7 ft on the measuring tape and not zero.

Section Midpoint (ft)	Section Depth (ft)	Observational Depth** ft	Velocity		Area W x D (ft^2)	Discharge (Q) V x A (ft^3/s)
			At Point (ft/sec)	Average (ft/sec)		
4.70	0.73			0.65	1.73	1.127
7.08	1.10			1.08	2.61	2.822
9.45	1.85			0.90	4.39	3.954
11.83	2.20			1.05	5.23	5.486
14.20	2.20			1.44	5.23	7.531
16.58	2.45			1.09	5.82	6.342
18.95	2.55	0.20	1.75	1.76	6.06	10.659
		0.80	1.76			
21.33	2.60	0.20	1.79	1.56	6.18	9.633
		0.80	1.32			
23.70	2.70	0.20	1.63	1.45	6.41	9.298
		0.80	1.26			
26.10	3.05	0.20	1.68	1.42	7.24	10.286
		0.80	1.15			
28.48	3.10	0.20	1.23	0.96	7.36	7.068
		0.80	0.69			
30.85	2.90	0.20	1.22	1.06	6.89	7.301
		0.80	0.89			
33.23	2.84	0.20	0.60	0.49	6.75	3.305
		0.80	0.37			
35.60	2.65	0.20	0.80	0.51	6.29	3.210
		0.80	0.21			
37.98	2.65	0.20	0.85	0.91	6.29	5.727
		0.80	0.96			
40.35	2.20			0.28	5.23	1.464
42.73	2.30			0.16	5.46	0.874
45.10	2.05			0.51	4.87	2.483
47.48	1.10			0.49	2.61	1.280
49.86	0.65			0.62	1.54	0.957

m^3/s x 35.3 = ft^3/s **Total Discharge (3Q) (ft^3/s)**

District staff will use the program standard Field Data Sheet for collection and calculation of flow measurement.

Stream Flow (Discharge) Measurement Form

Stream:_____Date:_____
Station Description:_____
Time Begin:_____ Time End:_____ Meter Type:_____
Observers:_____Stream Width*:_____ Section Width:_____
Observations:_____

Section Midpoint (ft) (m)	Section Depth (ft) (m) (cm)	Observational Depth** ft-m-cm	Velocity		Area W x D (ft^2) (m^2)	Flow (Q) V x A (m^3/s) (ft^3/s)
			At Point (ft/s) (m/s)	Average (ft/s)(m/s)		

Summary of Significant Figures for Reporting Field Parameters

Parameter	Field Data Reporting Requirements
Water Temperature (^{o}C)	Report temperature to the nearest tenth of a degree. Round insignificant figures 0 through 4 down and 5 thru 9 up.
pH (s.u.)	Report pH to the nearest tenth of a pH standard unit.
D.O. mg/L **D.O.** (% saturation)	Report dissolved oxygen to the nearest tenth of a mg/L. Report % saturation to the nearest tenth of a percent
Specific Conductance (micro siemens/cm)	Report specific conductance to only three significant figures if the value exceeds 100. Do not report ORP which is displayed by some multi-probes.
Salinity (ppt)	Report salinity values above 2.0 ppt to the nearest tenth of a part per thousand. In estuarine waters report the actual values displayed by the multi-probe above 2.0 ppt and values less than 2.0 as <2.0 or <1.0 only. Determine if a station is estuarine (i.e., experiences cases where salinity is >2.0 ppt) and always report salinity at this station, regardless of the salinity during periods of high flow.
Secchi Disk (meters)	Report Secchi depth transparency in meters to two significant figures.
Flow (ft^3/s)	Report instantaneous flow values less than 10 ft^3/s to two significant figures. Report flow values greater than 10 ft^3/s to the nearest whole number, but no more than three significant figures. When there is no flow (pools), report as 0.0. When there is no water, don't report a value, but report as "dry" in the observations.

NOT APPLICABLE: This is not a current practice under the District's Monitoring Program.

BEAUFORT SCALE: Specifications and equivalent speeds for

NOT APPLICABLE: This is not a current practice under the District's Monitoring Program.

use at sea

FORCE	EQUIVALEN SPEED 10 m above ground		DESCRIPTION	SPECIFICATIONS FOR USE AT SEA
	Miles/hour	knots		
0	0-1	0-1	Calm	Sea like a mirror
1	1-3	1-3	Light air	Ripples with the appearance of scales are formed, but without foam crests.
2	4-7	4-6	Light Breeze	Small wavelets, still short, but more pronounced. Crests have a glassy appearance and do not break.
3	8-12	7-10	Gentle Breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered white horses.
4	13-18	11-16	Moderate Breeze	Small waves, becoming larger; fairly frequent white horses.
5	19-24	17-21	Fresh Breeze	Moderate waves, taking a more pronounced long form; many white horses are formed. Chance of some spray.
6	25-31	22-27	Strong Breeze	Large waves begin to form; the white foam crests are more extensive everywhere. Probably some spray.
7	32-38	28-33	Near Gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.
8	39-46	34-40	Gale	Moderately high waves of greater length; edges of crests begin to break into spindrift. The foam is blown in well-marked streaks along the direction of the wind.
9	47-54	41-47	Severe Gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble, and roll over. Spray may affect visibility.
10	55-63	48-55	Storm	Very high waves with long over- hanging crests. he resulting foam, in great patches, is blown in dense white streaks along the direction of the wind. On he whole the surface of the sea takes on a white appearance. The 'tumbling' of the sea becomes heavy and shock-like. Visibility affected.

Last edited on 09 January, 1999 Dave Wheeler weatherman@zetnet.co.uk
Web Space kindly provided by Zetnet Services Ltd, Lerwick, Shetland.
http://www.zetnet.co.uk/sigs/weather/Met_Codes/beaufort.htm

Field Collection Procedures for Water Samples

Scope and Application

This protocol describes the techniques used to collect water samples in the field in a way that neither contaminates, loses, or changes the chemical form of the analytes of interest. The samples are collected in the field into previously cleaned and tested (if necessary) sample bottles of a material appropriate to the analysis to be conducted. Pre-cleaned sampling equipment is used for each site, whenever possible and/or when necessary. Appropriate sampling technique and measuring equipment may vary depending on the location, sample type, sampling objective, and weather. ~~Trade names used in connection with equipment or supplies do not constitute an endorsement of the product. Safety equipment is always used while water sampling including gloves, waders and eye protection. Safety equipment helps to protect the sampler from potential contaminants and to prevent sample contamination~~.

Safety requirements pursuant to the District's internal policies and procedures.

Summary of Method

Appropriate sample containers and field measurement gear as well as sampling gear are transported to the site where samples are collected according to each sample's protocol. Water velocity, turbidity, temperature, pH, conductivity, dissolved oxygen as well as other field data are measured and recorded using the appropriate equipment. These field data measurement protocols are provided in this Field Measurement SOP. Samples are immediately put on ice and appropriately shipped to the authorized laboratories. This procedure has been modified from the Texas Natural Resources Conservation Commission's Procedure Manual for Surface Water Quality Monitoring, with major input from the United State's Geological Survey's (USGS's) National Water Quality Assessment (NAWQA) Protocol for Collection of Stream Water Samples.

WATER SAMPLE COLLECTION

Water chemistry and bacteriological samples, as requested, are collected at the same location. *Water samples are best collected before any other work is done at the site*. If other work (e.g., sediment sample collection, flow measurement or biological/habitat sample collection or assessment) is done after or downstream of the collection of water samples, it might be difficult to collect representative samples for water chemistry and bacteriology from the disturbed stream. Care must be taken, though, to not disturb sediment collection sites when taking water samples. Don't be trampling where you are sampling.

The following general information applies to all types of water samples, unless noted otherwise:

Sample Collection Depth

Sub-Surface Grab Sample Samples are collected at 0.1 m below the water surface. Containers should be opened and re-capped under water in most cases. ... as site conditions allow.

Depth-integrated Sample If a depth-integrated sample is taken, the sample is pumped from discrete intervals within the entire water column.

Surface Grab Sample Samples are collected at the surface when water depth is <0.1 m. Since there is a difference in water chemistry on the surface, compared to subsurface, surface water should be noted on the field data sheet as 0 m.

Where to Collect Samples

Note: Due to safety concerns and site constraints, District staff may use scoops and/or buckets to collected water quality samples from flood control facilities, outfalls, and/or channels.

Water samples are collected from a location in the stream where the stream visually appears to be completely mixed. Ideally this would be at the centroid of the flow (*Centroid* is defined as the midpoint of that portion of the stream width, which contains 50% of the total flow), but depth and flow do not always allow centroid collection. For stream samples, the sampling spot must be accessible for sampling physicochemical parameters, either by bridge, boat or wading. Sampling from the shoreline of any water body (meaning standing on shore and sampling from there) is the least acceptable method, but in some cases is necessary.

In reservoirs, lakes, rivers, and coastal bays, samples are collected from boats at designated locations provided by Regional Water Quality Control Boards (Regional Boards). Samples from boats should be collected where the vessel does not interfere with the water being collected.

Sampling Order if Multiple Media are Requested to be Collected

The order of events at every site has to be carefully planned. For example, if sediment is to be collected, the substrate can not be disturbed by stepping over or on it; water samples can not be collected where disturbed sediment would lead to a higher content of suspended matter in the sample. *For the most part, water samples are best collected before any other work is done at the site*. This information pertains to walk-in sampling.

Sample Container Labels

Secure labels

Label each container with the station ID, sample code, matrix type, analysis type, project ID, and date and time of collection (in most cases, containers will be pre-labeled). After sampling, secure the label by taping around the bottle with clear packaging tape. ... unless said labels are waterproof and presented no prior issues.

Procedural Notes

Rinse scoops/buckets in ambient water before decanting sample water into bottles.

Do not rinse:
Bottles marked as having a preservative, and or they have a seal to be broken upon use, signifying sterilization.

For inorganic and organic water samples, bottles do not have to be rinsed if they are I-Chem 200 series or higher or ESS PC grade or higher. This means that the sample bottles are analyzed for contamination, and a certification of analysis is included with the bottles. Other sample containers are usually rinsed at least three times if the bottles do not meet these requirements. See filling instruction for each type of analyses if there is uncertainty. If applicable to the sample and analysis type, the sample container should be opened and re-capped under water. ... as site conditions allow.

Sample Short-term Storage and Preservation

Pack it on ice.

Properly store and preserve samples as soon as possible. Usually this is done immediately after returning from the collection by placing the containers on bagged, crushed or cube ice in an ice chest. Sufficient ice will be needed to lower the sample temperature to at least 6 °□C within 45 min after time of collection. Sample temperature will be maintained at 6 °□C until delivered to the laboratory. Care is taken at all times during sample collection, handling and transport to prevent exposure of the sample to direct sunlight. Samples are preserved in the laboratory, if necessary, according to protocol for specific analysis (acidification in most cases).

Field Safety Issues

Follow District Safety Procedures

Proper gloves must be worn to prevent contamination of the sample and to protect the sampler from environmental hazards (disposable polyethylene, nitrile, or non-talc latex gloves are recommended, **however, metals and mercury sample containers can only be sampled and handled using clean polyethylene gloves as the outer layer**). Wear at least one layer of gloves, but two layers help protect against leaks. One layer of shoulder high gloves worn as a first (inside) layer is recommended to have the best protection for the sampler. Safety precautions are needed when collecting samples, especially samples that are suspected to contain hazardous substances, bacteria, or viruses.

Sample Handling and Shipping

Not typical. District staff routinely deliver samples directly to the primary contracted laboratory.

Due to increased shipping restrictions, samples being sent via a freight carrier require additional packing. Although care is taken in sealing the ice chest, leaks can and do occur. Samples and ice should be bagged placed inside a large trash bag inside the ice chest for shipping. Ice should be double bagged to prevent melted ice water from leaking into the sample. The large trash bag can be sealed by simply twisting the bag closed (while removing excess air) and taping the tail down. Prior to shipping the drain plug of the ice chests have to be taped shut. Leaking ice chests can cause samples to be returned or arrive at the lab beyond the holding time.

Although glass containers are acceptable for sample collection, bubble wrap must be used when shipping glass.

Chain of Custody (COC) Forms

Every shipment must contain a complete Chain of Custody (COC) Form that lists all samples collected and the analyses to be performed on these samples.

Make sure a COC is included for every laboratory, every time you send a shipment of samples. Electronic COC's can also be emailed to the various laboratories but must be sent before the samples arrive at their destinations.
Include region and trip information as well as any special instructions to the laboratory on the COC.

The original COC sheet (not the copies) is included with the shipment (insert into ziplock bag) One copy goes to the sampling coordinator, and the sampling crew keeps one copy.

~~Samples collected should have the salinity (in parts per thousand) or specific conductivity (µS/cm), depth of collection, and date/time collected for each station on every COC~~.

Write a comment on this form, if you want to warn the laboratory personnel about possibly hazardous samples that contain high bacteria, chlorine or organic levels.

Field QC Samples for Water Analyses

Field duplicates are currently submitted at an annual rate of 5%. Field travel blanks are required for volatile organic compounds at a rate of one per cooler shipped. Field blanks are required for trace metals (including mercury and methyl mercury), DOC, and volatile organic compounds in water at a project rate of 5%. See the SWAMP Quality Control and

Sample Handling Guidelines for information regarding frequency and types of field QC samples.

SWAMP Field Data Sheets

The District's program standard Field Data Sheet (FDS) will be used per the District's Consolidated Monitoring Program, in lieu of a SWAMP Field Data Sheet.

~~Each visited field site requires a field observation completed SWAMP Field Data Sheet, even if no samples are collected (i.e. at a site which is found to be dry). If water and/or sediment samples are collected,~~ all elements of the ~~SWAMP~~ Field Data Sheet must be completely filled out. ~~Data sheets are provided from the SWAMP MPSL MLML website: http://swamp.mpsl.mlml.calstate.edu/resources-and-downloads/database-management-systems/swamp-25-database/templates-25/field-data-sheets#WQFieldData~~

FDSs will be submitted to the Data Manager for QA/QC.

General Pre-Sampling Procedures

District staff shall follow the manufacturer's recommendations for use and maintenance of field equipment. Refer to CMP Volume II (QAPP) Appendix H for Calibration instructions.

Instruments. All instruments must be in proper working condition. Make sure all calibrations are current. Multi-probe sondes should be pre-calibrated every morning prior to sampling and post-calibrated within 24 h of the original calibration. Conductivity should also be calibrated between stations if there is a significant change in salinity. Dissolved oxygen sensors should be re-calibrated if there is a 500 ft change in elevation.

Calibration Standards. Pack all needed calibration standards.

Sample Storage Preparations. A sufficient amount of cube ice, blue ice and dry ice as well as enough coolers of the appropriate type/size must be brought into the field, or sources for purchasing these supplies identified in advance.

Sample Container Preparation. After arriving at the sample station, pack all needed sample containers for carriage to the actual collection site, and label them with a pre-printed label containing Station ID, Sample Code, Matrix info, Analysis Type info, Project ID and blank fields for date and time (if not already pre-labeled).

Safety Gear. Pack all necessary safety gear like waders, protective gloves and safety vests.

Walk to the site. For longer hikes to reach a sample collection site, large hiking backpacks are recommended for transport of gear, instruments and containers. Tote bins can be used, if the sampling site can be accessed reasonably close to the vehicle.

GPS. At the sampling site, compare/record reconnaissance GPS reading with current site reading and note differences. GPS coordinates should be in Decimal Degrees (e.g. 38.12345 -117.12345).

COLLECTION OF WATER SAMPLES FOR ANALYSIS OF CONVENTIONAL CONSTITUENTS

In most streams, sub-surface (0.1 m below surface) water is representative of the water mass. A water sample for analysis of conventional constituents is collected by the grab method in most cases, immersing the container beneath the water surface with the cap on to a depth of 0.1 m. Remove cap and fill container replacing the cap before removing the container from the water. Sites accessed by bridge can be sampled with a sample container-suspending device. Extreme care must be taken to avoid contaminating the sample with debris from the rope and bridge. Care must also be taken to rinse the device between stations. If the centroid of the stream cannot be sampled by wading, sampling devices can be attached to an extendable sampling pole. It should be noted on the field data sheet if using a bucket sampler that surface water is entering the sample bottle.

In some cases, depth-integrated sampling is required, as requested by Regional Boards. This is useful when lakes or rivers are stratified and a sample is wanted that represents the entire water column. Depth-integrated sample collection is explained later in this document.

Conventional Water Constituents, Routinely Requested in SWAMP	Chloride, sulfate, nitrite, nitrate (or nitrate+nitrate), ortho-phosphate, fluoride, total phosphorus, ammonia, TKN, alkalinity, chlorophyll a. Parameter lists are program-specific.
Conventional Water Constituents, Occasionally Requested in SWAMP	Total Suspended Solids (TSS) or Suspended Sediment Concentration (SSC), Total Dissolved Solids (TDS--especially if total metals requested), Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC), hardness (if trace metals analysis is requested).
Conventional Water Constituents Sample Volume This is coordinated with the labs thru obtaining the bottle list.	Due to the potential for vastly different arrays of requested analyses for conventional constituents, ~~please refer to table at the end of this document, as well as the~~ Quality Control and Use District bottles lists as developed by the contracted laboratory for each region's monitoring program.

~~Sample Handling Guidelines for Conventional Parameters~~, ~~for information on the proper volume to collect for the various types of analyses~~.

Conventional Water Constituents Sample Container Type

This is coordinated with the labs thru obtaining the bottle list.

Due to the potential for vastly different arrays of requested analyses for conventional constituents, ~~please refer to table at the end of this document, as well as the~~ ~~Quality Control and Sample Handling Guidelines for Conventional Parameters~~, ~~for information on the proper type of sample containers~~.

Use District bottles lists as developed by the contracted laboratory for information on the proper type of sample containers.

Chlorophyll a Syringe Sample Method

Not conducted by District staff. May be conducted for TMDL Monitoring - sampling conducted by others.

Chlorophyll a syringe method: Chlorophyll a is sampled by forcing water with a 60-mL syringe through a filter holder containing a 25-mm glass microfiber filter. The 60-mL syringe and an in-line filter holder are rinsed three times with the ambient water before filtration. The syringe is then filled with 60 mL of ambient water. The filter holder is then removed and a 25-mm glass microfiber filter is placed inside. The filter holder is then screwed onto the syringe and the ambient water is then flushed through the filter. The filter holder is removed every time more water needs to be drawn into the syringe. The process is then repeated until the desired amount of Chlorophyll a is present (usually 60 to 360 mL depending on the water clarity). When filtering is complete the filter holder is opened and the filter is removed with tweezers without touching the Chlorophyll a. The filter is then folded in half, then again, in half with the Chlorophyll a inside the folds. The folded filter is then wrapped in aluminum foil and placed in an envelope labeled with the site information and the volume filtered. The envelope is then immediately placed on dry ice until transferred to the lab.

Collection of Water Samples for Analysis of Trace Metals (Including Mercury)

When deciding to measure total and dissolved metals in water the purpose of the sampling must be considered. Water quality standards for the protection of aquatic life are determined for the dissolved form of heavy metals in most cases, although this, too, can vary within different Basin Plans for different regions. The exception to routinely conducting dissolved metals analyses is usually mercury (and often selenium). Water quality standards usually apply to the total form of mercury (and often selenium), and not the dissolved form of these elements. Several regions are interested in conducting total metals analyses, in order to address specific issues. In order to budget inputs, transport, and accumulation of metals, it is necessary to know the concentration of total metals in the water column, sediments, effluent, etc. Sample collection for trace metals and mercury in water requires "Clean Hands/Dirty Hands" methodology.

Metals-in-water:

General Information

Sampling is based on District program frequency and required compliance activities.

Unless otherwise requested to collect for total metals analysis, dissolved metals are collected for all elements with the exception of mercury. Metals-in-water samples should **not** be collected during periods of abnormally high turbidity if at all possible. Samples with high turbidity are unstable in terms of soluble metals, and it is difficult to collect a representative grab sample. Special study sampling, however, may be an exception. For example, wet weather sampling is likely to include some samples with high turbidity.

Metals-in-water:

Sample Collection Depth

Collect a metals sample from a depth of 0.1 m using a sub - surface grab method, or at discrete depths using a depth-integrated sampling method with a peristaltic pump (described further down). In most streams, sub-surface water is representative of the water mass. For the purpose of determining compliance with numerical toxic substance standards, a sample taken at the surface is adequate.

Metals-in-water:

Sample Volume

This is coordinated with the labs thru obtaining the bottle list.

Refer to table at end of this document for specific information on the proper volume to collect for trace metals analyses. Generally, for procedures most commonly used for analysis of metals in water (total or dissolved metals); one 60-mL polyethylene container is filled with the salinity recorded on the field data sheet and COC. Generally, for the procedures most commonly used for analysis of mercury in water (whether total or dissolved), one 250-mL glass or teflon container is filled, regardless of the salinity. All containers are pre-cleaned in the lab using HNO_3.

Metals-in-water:

Sampling Equipment

The filtration is completed by the District's contracted laboratory(s). These grab samples are collected into a preserved container.

The method of choice for the collection of water samples for trace metals analysis in small, wadeable streams is the grab method, where the sampler submerges the sample bottle or syringe beneath the surface of the water until filled. The procedure for filtration of water samples for trace metals analysis must be performed within 15 minutes of collection to meet the required filtration holding time. For Mercury(Hg) samples, preservation may take place in the field or at the laboratory within 48 hours of collection. Extreme care must be taken to avoid contamination of the water sample. Considering these factors, it is best to use a **field** filtration system, such as a set-up with peristaltic pump with in-line filter, or a set-up with a syringe filter, if filtered water is required. Samples are pumped and/or filtered directly into the sample container. This minimizes contamination by using no intermediate sampling device. Samples can also be filtered in lab if need be Un-powdered (no-talc) polyethylene gloves are always worn during sampling for metals-in-water.
Depth-integrated sampling is useful when lakes or rivers are stratified and a representative sample is wanted which represents the entire water column. The method involves a peristaltic pump system with enough Teflon tubing to pump at the desired depth with an inline filter. Filter equipment blanks are analyzed for five percent of all cleaned equipment.

Equipment Preparation

Dissolved metals and total metals are collected in a conventional grab method, no filtration is conducted by District staff. These grab samples are collected into a preserved container.

It is best if the metals-in-water sampling materials are prepared by a laboratory that can guarantee contamination-free sampling supplies. If a laboratory assembles a Metals-in-Water Sample Collection Kit, it should contain the following items packaged together **for each sample**:

- Tubing with an in-line filter (disposable, 0.45 µm) attached for dissolved metals-in-water sampling. This same tubing is used for total metals-in-water samples without filter. If an in-line pumping system is not used, an acid cleaned syringe and filter are packed.
- Sample containers- polyethylene for total and dissolved samples and blanks; Glass or Teflon for total and dissolved mercury.
- Acid preservation is performed in the laboratory.
- Metals-free DI water (for blanks).
- Powder-free polyethylene gloves

If a laboratory is not assembling collection kits, individuals should take care to keep containers in the original packaging. When removed from the box, sample containers are placed in clean plastic bags (zipper closure bags). Although filters come individually wrapped, they should also be stored in new zipper closure bags to avoid possible contamination.

The filtering equipment is pre-cleaned according to laboratory protocol. Clean tubing is put into clean containers, such as large zipper closure bags. Metals-free filter cartridges with the capacity to filter several liters are commercially available. Equipment blanks are run at the laboratory on batches of metals-in-water sampling equipment prior to their distribution to field staff. One to two liter containers with metals-free deionized water are taken into the field for travel blanks. Metals-free deionized water is supplied by the laboratory performing metals analysis. The deionized water containers are kept clean and dust-free on the outside by wrapping in two

Dissolved metals and total metals are collected in a conventional grab method, no filtration is conducted by District staff. These grab samples are collected into a preserved container and submitted to the laboratory for filtration and analysis.

Dissolved and Total Metals-in-Water: Detailed Collection Techniques

- ***Sub-Surface Grab Method***
- ***Syringe Filtration Method (for sub- surface collection)***
- ***Peristaltic Pumping Method (Using Tubing/In-line Cartridge Filters)for sub- surface collection or for depth-integrated collection***

Metals-in-water Sample Collection:

Sub-Surface Grab Method

Clean Hands/Dirty Hands Technique

Note: Due to safety concerns, District staff may use scoops and/or buckets to collected water quality samples from flood control facilities, outfalls, and/or channels.

Unfiltered Samples (for total metals analysis, if requested, and for mercury almost always, unless otherwise requested): Some samples can be sampled directly from the ambient water either by wading into the stream and dipping bottles under the surface of the water until filled, or by sampling from a boat and dipping the bottle under the surface of the water until it is filled. The bottles are cleaned according to laboratory protocol. It is very critical that all the acid is rinsed out of the bottles before the samples are collected. Personnel involved in field sample collection/processing wear polyethylene gloves. The laboratory pre-cleaned glass or Teflon™ 250 mL (for mercury) or polyethylene 60 mL (for metals) sample bottles are taken from the double-wrapped

zipper closure plastic bags using "Clean Hands/Dirty Hands" techniques. The dirty hands collector opens the first outer bag, and the clean hands collector opens the inner bag around the bottle. The clean hands collector then removes the bottle from the inner bag. Clean hands collector then places the inner bag back inside the outer bag while sampling occurs. The clean hands collector dips the bottle into the ambient water, with the cap on, to approximately 0.1 m (avoiding disturbing surface scums), placing the cap back on the bottle before being removed from the water, rinses the bottle five times with ambient water, making sure the threads of the bottle get rinsed as well, and fills the bottle to the top. The lid is secured under the water surface and the bottle is put back into the inner clean bag and sealed by the clean hand collector. The sealed clean bag is then placed back inside the outer bag by the clean hands collector. The dirty hands collector then seals the outer bag.

Metals-in-water Sample Collection:

Syringe Filtration Method (for sub-surface collection)

The Laboratory conducts the filtration for District samples.

Filtered Samples (for dissolved metals analyses): Sub-surface water samples are filtered for dissolved trace metals analysis (not for mercury, however, in almost all cases) using the following syringe filtration method.

The syringe (60 cc size, pre-cleaned in the laboratory) and in-line filter are pre-packed in two zipper closure bags. The syringe and filter are taken out of the bags using "Clean Hands/Dirty Hands" technique, as previously described. The sub-surface water sample is collected by 1) wading out into the centroid portion of the stream, or by leaning over the edge of the boat, and aspirating water into the syringe, filling and rinsing the syringe five times with ambient water; 2) attaching the filter onto the syringe and filling the syringe body; 3) rinsing the filter with a few milliliters of the sample; 4) rinsing the sample bottle five times with the filtered ambient water; and 5) extruding the sample through the syringe filter and completely filling each bottle. The bottles are taken out of and put back into their bags using "Clean Hands/Dirty Hands".

Metals-in-water Sample Collection--

Peristaltic Pump

The basic "Clean Hands/Dirty Hands" technique is also applied in the use of a peristaltic pump with an in-line filter cartridge for metals-in-water sample collection. Dirty Hands removes the plastic cover from the end of the pump tubing and inserts the tubing into the sampling container. Dirty Hands holds the tubing in place. The in-line cartridge filter is attached to the outlet end of the tubing.

Clean Hands takes the plastic cover off the other end of the tubing. Dirty Hands turns on the pump and flushes lL of ambient water through the tubing to purge it for dissolved metals.

Clean Hands removes the cap from the sample bottle and uses the pump to fill it with ambient water. Clean Hands puts the cap back on the bottle and places it in the plastic bag.

Metals-in-water Sample Collection:

Depth-Integrated Sampling, using In-line Cartridge Filter and Peristaltic Pump

Not Applicable - Not a standard practice under the District's Monitoring Programs

Preparation for Depth-integrated sample collection:
Depth-integrated sampling is useful when lakes or rivers are stratified, and a representative sample is wanted that represents the entire water column to the extent possible. The method utilized to date for SWAMP involves a peristaltic pump system with enough Teflon tubing to pump from the desired depth. Regional Boards must request depth-integrated sampling.

The tubing set consists of a small length of CFLEX tubing that fits in the peristaltic pump, with an appropriate length of Teflon tubing on the suction side of the pump and a 3-ft section of Teflon tubing on the discharge side of the pump.

The tubing set is pre-cleaned in 10% reagent grade HCL at the laboratory, and to date in SWAMP, a new pre-cleaned tubing set is used for each site. However, the same peristaltic tubing set can be used at multiple sites, as long as it has been cleaned in the field between stations, according to protocol as outlined below. If this is to be done, however, and Dissolved or Total Organic Carbon samples are collected, equipment blanks should be collected at each site until it is determined that the blanks are acceptably low.

The field cleaning procedure for tubing that is to be re-used is:

- Pump phosphate free detergent through tubing.
- Pump 10% HCL through tubing.
- Pump methanol through tubing.
- Pump 1 l of blank water (Milli-Q) through.

All reagents must be collected in appropriate hazardous waste containers (separated by chemical), and transport, as well as disposal, must follow appropriate local, state, and federal

regulations.

If a field blank is needed, collect it after the 1 L of blank water is pumped through. Pump the amount of ambient water equivalent to 3 times the volume of the tubing before sampling the next site.

Filtered and Unfiltered Samples, Depth-integrated:
It is recommended to attach the tubing to a line with depth measurement markers (preferably in meters). At the end of this line should be a trace metal-safe weight, which hangs about one meter below the tubing end, avoiding any sediment intake from the bottom of the water column with the pump tubing.

At the site, Dirty Hands sets up the pump, while Clean Hands takes a bottle from the plastic bag and places it in a container holder or on a clean surface. A container holder can be anything trace metal clean that supports the bottle, freeing up the collector's hands. Clean Hands takes the outlet-end of the tubing (with the in-line filter cartridge attached) out of the bag, and places it in the peristaltic pump head. The outlet end is long enough to allow easy bottle filling; the other end is long enough to easily reach beneath the water surface and to the desired depth. Dirty Hands closes the pump head, locking the tubing in place.

Make sure that all bottles are filled with a depth-integrated water sample. This can be accomplished by dividing the total vertical length of the water column into 2 to 10 equal intervals, and sampling each interval equally, filling the bottles at each depth proportional to the number of intervals sampled. For example, if 10 intervals are sampled, every bottle is filled $1/10^{th}$ full at each depth sampled. A very common method of dividing the water column is by first determining the depth of the thermo-cline. Samples are taken at the midpoint between the surface and the thermo-cline, at the midpoint between the top of the thermo-cline and the bottom of thermo-cline, and at the midpoint between the bottom of the thermo-cline and just above the bottom of the water column. For these methods, all containers have to be filled at the same time. Note the number of intervals sampled on the data sheet.

When filling bottles, Clean Hands immerses the intake tube directly into the water at the appropriate depth, and Dirty Hands operates the pump to flush the tubing with a minimum of 1L of ambient water through the tubing and filter.

Clean Hands removes the cap from the sample bottle, holds the tubing outlet with the in-line filter cartridge over the container opening (without touching the container), and allows the container to fill. The container is filled and rinsed five times with ambient water, and is then filled to the top for the actual sample. Clean Hands puts the cap back on the bottle, and places the bottle back it in the zipper closure plastic bag. Whenever Clean Hands touches the boat or equipment, which may be contaminated, gloves should be changed immediately.

(Note for Unfiltered samples: *If an unfiltered sample is required for total metals, total mercury, conventional constituents, toxicity, or synthetic organics, the same procedure is used as described above, except the filter is detached from the end of the tubing before filling the bottles.)*

When sampling is finished, the tubing is brought to the surface, clean water (Milli-Q or deionized) is pumped through system, and the tubing is stored in a polyethylene bag.

The tubing set can be used at multiple sites, as long as it has been cleaned in the field between stations (see field cleaning procedure above). However, if Dissolved or Total Organic Carbon samples (in water) are collected, equipment blanks should be collected at enough sites until it is determined the blanks are appropriate.

Metals-in-water Sample Collection:

Collecting the Sample:

Composite Bottle

The sample collection methodologies are identical to those described above except the sample is collected first into a composite bottle(s). The sample is collected in an amber glass 4-L bottle for mercury and methyl mercury, and a 4-L polyethylene bottle for other trace metals. The compositing bottle is cleaned according to SWAMP SOP.SC.G.1. It is very critical that all the acid is rinsed out of the bottle and that the bottle is rinsed with sample water (five times) before the sample is taken. The sample is collected by the grab or pumping method after being rinsed five times with ambient

water and is brought inside the water quality vehicle or sampling box for processing. Personnel involved in sample processing don polyethylene gloves. During sampling the dirty hands person opens the bag holding the composite bottle and opens the outer plastic bag. The clean hands person opens the inner plastic bag, removes the bottle and holds the bottle while the Dirty Hands sampler controls the flow of water through the pump into the bottle.

Preparing sample aliquots from a composite bottle into smaller sample bottles using an inline pump and filter:

The dirty hands person opens the first bag, and the clean hands person opens the inner bag around the composite bottle. The clean hands person then removes the bottle from the inner bag and places the bags and the bottle in a designated clean place.

This process is repeated until all sample bottles are lined up on the clean bench with their tops still on.

The top of the bottles are loosened so that they fit very loosely on top of the bottles so the clean hands person can remove the caps and pour or pump water into the bottles easier.

The clean hands person shakes the 4-L sample in a steady and slow up and down motion for two full minutes.

Samples that are not to be filtered (including TSS/SSC) are sub-sampled out of the bottle by pouring out of the large compositing bottle into the sample bottles. The compositing bottle is shaken for 15 s between these subsamples.

Each sample bottle is rinsed five times with ambient water before filling.

For the clean pumping system setup procedure, see above.

(The equipment or field blank is processed exactly like a sample following the same steps.)

The clean end of the tubing used for suction is placed into 1 L bottle. Approximately 750 mL of Milli-Q are then pumped through the system to purge any residual contamination.

The 250-mL sample bottles are then filled to the neck and capped as soon as possible.

Note: if volatile organics are to be collected they should be pumped directly into the sample containers before the compositing procedure.

Metals-in-water: Short-term Sample Preservation

After collecting the sample, the double-bagged container is placed in another plastic bag for shipping, and placed on ice in the ice chest, cooled to 6 °C. This is to prevent possible contamination from other samples in the ice chest. Metals-in-water samples are acid-preserved in the lab.

Metals-in-water: Sample Container Label

Label each outer sample-bag with the station ID, sample code, matrix type, analysis type, project ID, and date and time of collection.

Metals-in-water: Field Equipment Blank

Pumping Method. If required, field blanks are collected at the last site of a sampling trip, with the same tube and filter used to collect the last dissolved metals-in-water sample of the day (before the ambient sample is collected); and with the tube used for the last total metals-in-water sample of the day. If each sample is taken using a new set of tubing, a separate tubing-set should be used for the blank.

The same Clean Hands/Dirty Hands collection techniques are followed for the field blank as the samples, pumping trace metal-free water from a clean container supplied by the laboratory.

Syringe Method. If required, field blanks are collected in much the same way as in the pumping method. "Clean Hands/ Dirty Hands" techniques are used. The syringe is taken out of the double bags, deionized water is aspirated into the syringe, syringe is rinsed five times with ambient water, the filter is attached, and the blank water is extruded into a sample bottle. A minimum of one blank per trip is taken, if required.

Grab Method. Bottles full of deionized water or Milli-Q are opened at the site for the same length of time the sample bottles are open.

COMPANION SAMPLES FOR METALS-IN-WATER

A hardness analysis should be requested by the Regional Water Control Board whenever metals-in-water are to be analyzed from an inland (freshwater) site. Estuarine/marine sites do not require hardness analysis.
If a total metals sample is collected, it is recommended to submit a sample for total suspended solids/suspended sediment concentration (TSS/SSC) in a companion sample for "conventionals in water".

Hexavalent Chromium

Very rarely, a request may be made for conducting hexavalent chromium analysis in water samples. Acidification alters the hexavalent form of chromium. A separate (un-acidified) sample must be submitted if hexavalent chromium is to be analyzed. Filter and submit a minimum of 500 mL water. The sample is collected in a DI-water-rinsed polyethylene or glass container, placed on ice, and shipped to the lab in time for analysis to begin within 24 h of collection. The lab must be notified when a hexavalent chromium sample will arrive. Hexavalent chromium is not usually analyzed on unfiltered samples.

FIELD QC SAMPLE COLLECTION REQUIREMENTS FOR METALS-IN-WATER

In order to assess contamination, "blanks" are submitted for analysis. Special projects may have other requirements for blanks. The same group of metals requested for the ambient samples are requested for the blank(s). Run a blank for each type of metal sample collected. Blanks results are evaluated (as soon as available) along with the ambient sample results to determine if there was contamination or not. See the Quality Control and Sample Handling Guidelines for Inorganic Analytes for information regarding frequency and types of field QC samples.

Field Equipment Blank (Ambient Blank) Equipment blank frequencies are specified by the District CMP.	Submit an equal volume (equal to the ambient sample) of metals-free deionized water that has been treated exactly as the sample at the same location and during the same time period. Use the same methods as described above (Grab sample, pumping method, syringe method). At least one ambient blank per field trip is required each for trace metal and Mercury samples in water. *If contamination is detected in field equipment blanks, blanks are required for every metals-in-water sample until the problem is resolved.*
Laboratory Equipment	Laboratory Equipment Blanks for pumping and sampling equipment (Metals-in-Water Sample Collection Kits and

Blank	Syringe Filtration Kits) are run by the laboratory that cleans and distributes the collection materials. It documents that the materials provided by the laboratory are free of contamination. When each batch of tubes, filters, bottles, acid and deionized water are prepared for a sampling trip, about five percent of the Mercury sampling materials are chosen for QC checks. Trace metal equipment needs to be subjected to an initial blank testing series. If these blanks are acceptable only occasional re-testing is required for TM equipment. The QC checks are accomplished by analyzing metals-free water which has been pumped through the filter and tube; collected in a sample container; and preserved.
Field Duplicates	Five percent Field Duplicates are submitted every year. (If fewer than 20 samples are collected during an event, submit one set of duplicates per event.)

Collection of Water Samples for Analysis of Synthetic Organic Compounds

Where site conditions allow...

Collect organic samples at a depth of 0.1 m by submerging the sample container by hand. If depth-integrated sampling is required, use the in-line peristaltic pump methodology described previously. Since organic compounds tend to concentrate on the surface of the sampling device or container, the sampling device and sample container are ***not*** to be rinsed with ambient water before being filled.

Container type and sample volumes are coordinated with the labs thru obtaining the bottle list.

Sample Containers and Collection

Also refer the Quality Control and Sample Handling Guidelines for Synthetic Organic Compounds in Fresh and Marine Water for a list of recommended container types.

The following are constituent specific and may not apply to all of the District's programs.

Pesticides/ Herbicides

The sample container for pesticides and herbicides is a new, clean, unused amber glass jar with a Teflon-liner inside the cap. Collect one liter of water for each of the three sample types (Organophosphorus Pesticides, Organochlorine Pesticides and Chlorinated Herbicides). **EACH ANALYSIS TYPE REQUIRES A SEPARATE JAR**. Minimize the air space in the top of the jar. Preserve immediately after collection by placing on ice out of the sunlight.

Semi-volatile Organics

The sample container for semi-volatile organics must also be new, clean, unused amber glass bottles with a Teflon-liner inside the cap, and pre-rinsed with pesticide-grade hexane, acetone, or methylene chloride. Fill jars to the top and place on ice in the dark. In addition to other sample information, label the jar Semi-volatiles.

Volatile Organics:

Volatile Organic Carbon (VOC), Methyl-Tert Butyl Ether (MTBE) and (BTEX)

The sample containers for volatiles are VOA vials. Fill the 40-mL VOA vials to the top and cap without trapping any air bubbles. If possible, collect directly from the water, keeping the vial under water during the entire collection process. To keep the vial full while reducing the chance for air bubbles, cap the vials under the water surface. Fill one vial at a time and preserve on ice. The vials are submitted as a set.

District staff may collect samples by submerging the bottles if conditions allow and preservatives are not compromised.

If the vial has been pre-acidified for preservation, fill the vial quickly, without shaking using a separate clean glass jar. Fill the vial till the surface tension builds a meniscus, which extends over the top end of the vial, then cap tightly and check for bubbles by turning the vial on its head. Ensure that the pH is less than 2. If the water may be alkaline or have a significant buffering capacity, or if there is concern that pre-acidified samples may have the acid wash out, take a few

practice vials to test with pH paper. It may take more than two drops, and it will then be known how to preserve the other samples that are being submitted to the lab. If an alternative method has proven successful, continue with that method.
Note: If vigorous foaming is observed following acidification, discard that sample and collect another set. Do not acidify the second set. Mark the sample clearly "not acidified" and the lab will run them immediately. Holding time is 14 days with acid, 7 days without acid.
Collect three VOA vials, if VOC, MTBE and BTEX are required, two vials, if only VOC is required and two vials, if only MTBE and BTEX are require. The vials may be taped together to keep them together.

Perchlorate

Surface water samples for perchlorate should be collected in a new unused polyethylene or glass container. Perchlorate samples should be placed immediately on ice to maintain temperature at 6 ^{o}C. The sample holding time is 28 days, under refrigeration.

Sample Treatment in Presence of Chlorine

If in stream chlorine residual is suspected, measure the chlorine residual using a separate water subsample. Free chlorine will oxidize organic compounds in the water sample even after it is collected. If chlorine residual is above a detectable level, (i.e., the pink color is observed upon adding the reagents) immediately add 100 mg of sodium thiosulfate to the pesticides, herbicides, semi-volatiles and VOA samples; invert until sodium thiosulfate is dissolved. Record the chlorine residual concentration in field logbook. If chlorine residual is below detectable levels, no further sample treatment necessary.

VOA Trip Blank

Per laboratory recommendations two trip blanks are used (one with preservative and one without).

Submit one Trip Blank for VOA samples (2- 40 mL VOA vials) for each sampling event. Trip Blanks are prepared in advance just before the sampling trip and transported to the field. Ask the laboratory for DI water and specify that it is for a VOA trip blank. VOA blanks require special purged water. Trip blanks demonstrate that the containers and sample handling did not introduce contamination. The trip blank vials are never opened during the trip.

Field QC Samples

If required, field Duplicates and field blanks are submitted at a rate subject to the discretion of the project manager. ~~Refer to the SWAMP Quality Control and Sample Handling Guidelines for details on required blanks and duplicates~~.

BACTERIA AND PATHOGENS IN WATER SAMPLES

Summary of Collection Procedure (Based on EPA water quality monitoring procedures)

Make sure the containers are sterilized; either factory-sealed or labeled.

Whirl-pak® bags

- Label the bottle as previously described for SWAMP.
- Tear off the top of the bag along the perforation above the wire tab just prior to sampling. Avoid touching the inside of the bag. If you accidentally touch the inside of the bag, use another one.
- If wading into the stream, try to disturb as little bottom sediment as possible. Be careful not to collect water that has sediment from bottom disturbance. Stand facing upstream. Collect the water sample on your upstream side, in front of you.
- If taking sample from a boat, carefully reach over the side and collect the water sample on the upstream side of the boat.
- Hold the two white pull-tabs in each hand and lower the bag into the water on your upstream side with the opening facing upstream. Open the bag midway between the surface and the bottom by pulling the white pull-tabs. The bag should begin to fill with water. You may need to "scoop" water into the bag by drawing it through the water upstream and away from you. Fill the bag no more than 3/4 full.
- Lift the bag out of the water. Pour out excess water. Pull on the wire tabs to close the bag. Continue holding the wire tabs and flip the bag over at least 4-5 times quickly to seal the bag. Don't try to squeeze the air out of the top of the bag. Fold the ends of the wire tabs together at the top of the bag, being careful not to puncture the bag. Twist them together, forming a loop.
- If the samples are to be analyzed in the lab, place them in a cooler with ice or cold packs for transport to the lab.

Screw cap containers

- ~~Label the bottle as previously described for SWAMP~~.
- Remove the plastic seal from the bottle's cap just before sampling. Avoid touching the inside of the bottle or cap. If you accidentally touch the inside, use another bottle.
- If wading into the stream, try to disturb as little bottom

sediment as possible. Be careful not to collect water that has sediment from bottom disturbance. Stand facing upstream. Collect the water sample on your upstream side, in front of you.

- ~~If taking sample from a boat, carefully reach over the side and collect the water sample on the upstream side of the boat~~.
- Hold the bottle near its base with polyethylene gloves and submerge the bottle in the water with the cap on. Open the bottle collecting the water sample 0.1m beneath the surface. When the bottle is filled to the desired level recap the bottle and remove from water. You can only use this method if the sample bottles do not contain sodium thiosulfate.
- Turn the bottle underwater into the current and away from you. In slow moving stream reaches, push the bottle underneath the surface and away from you in an upstream direction.

It is District standard practice to void lose of container preservatives. Scoops are typically used to decant sampling into the appropriate containers.

- Alternative sampling method: In case the sample bottle contains preservatives/chlorine removers (i.e. Sodium-Thiosulfate), it cannot be plunged opening down. In this case hold the bottle upright under the surface while it is still capped. Open the lid carefully just a little to let water run in. Fill the bottle to the fill mark and screw the lid tight while the bottle is still underneath the surface.
- Leave a 1-in. air space so that the sample can be shaken just before analysis. Recap the bottle carefully, remembering not to touch the inside.
- If the samples are to be analyzed in the lab, place them in a cooler with ice or cold packs for transport to the lab. Samples should be placed immediately on ice to maintain temperature at 6 ^{o}C

Pouring from another clean bottle

- Due to different sampling conditions (high turbidity, rough water etc.) it is sometimes easy to pour water from another clean bottle into the bacteria bottle. This helps to make sure that the sample water is only being filled to the desired line and no overfilling occurs.

TOXICITY IN WATER

Sample Collection

Using the standard grab sample collection method described previously for water samples, fill (for typical suite of water toxicity tests conducted) the required amount of 2.25-L amber glass bottles with sub surface water. Since the size of the 2.25-L amber bottle is bigger than your average sample bottle, find a spot in the centroid of the stream to completely submerge the toxicity bottle if possible. A clean water organics(1-L glass amber) bottle can be used if there is no sampling point deep enough to submerge a large toxicity bottle. If the stream is not deep enough to submerge any bottle, then comments should be made on the field data sheets that surface water was collected. Depth should also equal 0 for the sampling depth. All toxicity samples should be. put on ice, and cooled to 4 °C. Label the containers as described above and notify the laboratory of the impending sample delivery, since there is a 48-hr maximum sample hold time. Sample collection must be coordinated with the laboratory to guarantee appropriate scheduling.

Summary of Sample Container, Volume, Initial Preservation, and Holding Time Recommendations for Water Samples

Parameters for Analysis in WATER Samples	Recommended Containers (all containers pre-cleaned)	Typical Sample Volume (mL)	Initial Field Preservation	Maximum Holding Time (analysis must start by end of max)
Conventional Constituents in Water				
Alkalinity	Polyethylene bottles (see **NOTE(1)** below)	100 mL	Cool to ≤ 6 °C, dark	14 days at ≤ 6 °C, dark
Chloride (Cl), Sulfate (SO_4) and Fluoride (F)	Polyethylene bottles (see **NOTE(1)** below)	300 mL	Cool to ≤ 6 °C, dark	28 days at ≤ 6 °C, dark
Ortho-phosphate (OPO_4)	Polyethylene bottles (see **NOTE(1)** below)	150 mL	Filter within 15 minutes; Cool to ≤ 6 °C, dark	48 h at ≤ 6 °C, dark
Nitrate + Nitrite (00630) ($NO_3 + NO_2$)	Polyethylene bottles (see **NOTE(1)** below)	150 mL	Cool to ≤ 6 °C, dark	48 h at ≤ 6 °C, dark
Total Keldjahl Nitrogen (TKN)	Polyethylene bottles (see **NOTE(1)** below)	600 mL	Cool to ≤ 6 °C, dark; H_2SO_4 to pH<2	Unacidified: 7 days Acidified: 28 days Either one at ≤ 6 °C, dark
Total Dissolved Solids (TDS)	Polyethylene bottles (see **NOTE(1)** below)	1000 mL	Cool to ≤ 6 °C, dark Cool to 4°C, dark	7 days at ≤ 6 °C, dark
Ammonia (NH_3)	Polyethylene bottles (see **NOTE(1)** below)	500 mL	Cool to ≤6 ˚C; samples may be preserved with 2 mL of H_2SO_4 per L	Unacidified: 48 h Acidified: 28 days Either one at ≤ 6 °C, dark
Total Phosphorus (TPO_4)	Polyethylene bottles (see **NOTE(1)** below)	300 mL	Cool to ≤ 6 °C, dark	28 days at ≤ 6 °C, dark
(1)NOTE: **The volume of water necessary to collect in order to analyze for the above constituents is typically combined in four 1-L polyethylene bottles, which also allows enough volume for possible re-analysis and for conducting lab spike duplicates. This is possible since the same laboratory is conducting all of the above analyses; otherwise, individual volumes apply.**				
Total Organic Carbon (TOC), **Dissolved Organic Carbon (DOC)**	125 mL amber glass vial 250 ml amber for TOC/DOC	125 mL for TOC only 250 mL for TOC/DOC	Cool to ≤6 ◦C; acidify to pH<2 with HCl, H_3PO_4, or H_2SO_4 within 2 hrs Filter and preserve to pH<2 within 48 hours of collection; cool to ≤6 ˚C	28 days 28 days
Total Suspended Solids (TSS)	250 mL plastic bottle	250 mL	Cool to ≤6 ˚C, dark	7 days at ≤6 ˚C, dark
Suspended Sediment Concentration (SSC)	125 mL polyethylene bottle	Up to 125ml depending on	Cool to ≤6 ˚C, dark	7 days at ≤6 ˚C, dark

Parameters for Analysis in WATER Samples	Recommended Containers (all containers pre-cleaned)	Typical Sample Volume (mL)	Initial Field Preservation	Maximum Holding Time (analysis must start by end of max)
		turbidity of water		
Chlorophyll *a* **Pheophytin *a*** **Chlorophyll a** **Pheophytin *a***	1-L amber polyethylene bottle Aluminum Foil, GFC Filters	1000 mL (one bottle) 20-420 mL	Centrifuge or filter as soon as possible after collection; if processing must be delayed, keep samples on ice or at ≤6 °C; store in the dark	Samples must be frozen or analyzed within 4 hours of collection; filters can be stored frozen for 28 days
Non-Routine Compounds in Water Samples				
OIL AND GREASE	1-L glass jar with Teflon lid-liner, rinsed with hexane or methylene chloride	1000 mL (one jar)	Cool to ≤6 °C; HNO_3 or H_2SO_4 to pH<2	28 days at ≤6 °C, dark
PHENOLS	1-L glass jar with Teflon lid-liner	1000 mL (one jar)	Cool to ≤6 °C; H_2SO_4 to pH<2	28 days at ≤6 °C, dark
CYANIDE	1-L cubitainer	1000 mL (one cubitainer)	Cool to ≤6 °C; NaOH to pH>10; add 0.6 g $C_6H_8O_6$ if residual chlorine is present	14 days at ≤6 °C, dark
BIOCHEMICAL OXYGEN DEMAND (BOD)	4-L cubitainer	4000 mL (one cubitainer)	Cool to ≤6 °C; add 1 g FAS crystals per liter if residual chlorine is present	48 h at ≤6 °C, dark
CHEMICAL OXYGEN DEMAND (COD)	1-L cubitainer	110 mL (one cubitainer)	Cool to ≤6 °C; H_2SO_4 to pH<2	28 days at ≤6 °C, dark; biologically active samples should be tested as soon as possible
Trace Metals in Water Samples				
DISSOLVED METALS (except Dissolved Mercury)	60 mL polyethylene bottle, pre-cleaned in lab using HNO_3	60 mL (one bottle)	Filter at sample site using 0.45 micron in-line filter, or syringe filter (within 15 minutes of collection). Cool to 6°C, dark. Acidify in lab, within 48 hrs, using pre-acidified container (ultra-pure HNO_3) for pH<2.	Once sample is filtered and acidified, can store up to 6 months at room temperature

Parameters for Analysis in WATER Samples	Recommended Containers (all containers pre-cleaned)	Typical Sample Volume (mL)	Initial Field Preservation	Maximum Holding Time (analysis must start by end of max)
DISSOLVED MERCURY	250 mL glass or Teflon bottle, pre-cleaned in lab using HNO_3	250 mL (one bottle)	Filter within 15 minutes of collection. Cool to 6°C, dark. Acidify in lab within 48 hrs, with pre-tested HCL to 0.5%.	Once sample is filtered and acidified, can store up to 90 days at room temperature
TOTAL METALS (except Total Mercury)	60 mL polyethylene bottle, pre-cleaned in lab using HNO_3	60 mL (one bottle)	Cool to ≤6 ˚C, dark. Acidify in lab within 48 hrs, with pre-acidified container (ultra-pure HNO_3), for pH<2.	Once sample is acidified, can store up to 6 months at room temperature
TOTAL MERCURY	250 mL glass or Teflon bottle, pre-cleaned in lab using HNO_3	250 mL (one bottle)	Cool to ≤6 ˚C, dark. Acidify in lab within 48 hrs, with pre-tested HCL to 0.5%.	Once sample is acidified, can store up to 90 days at room temperature.
HEXAVALENT CHROMIUM (filtered)	600 mL plastic or glass bottle	600 mL (one bottle)	Cool to ≤6 ˚C, dark No acid	Keep at ≤6 ˚C, dark for up to 24 h; must notify lab in advance.
HARDNESS	200 mL polyethylene bottle	200 mL (one bottle)	Cool to 6°C, dark OR Cool to ≤6 ˚C; HNO_3 or H_2SO_4 to pH<2	48 h at 6°C, dark 6 months at ≤6 ˚C, dark
Synthetic Organic Compounds in Water Samples				
VOLATILE ORGANIC ANALYTES (VOA's) including VOC, MTBE and BTEX	40 mL VOA vials	120 mL (three VOA vials)	All vials are pre-acidified (50% HCl or H_2SO_4) at lab before sampling. Cool to 6°C, dark	unacidified: 7 days acidified: 14 days Both at 6°C, dark
PESTICIDES & HERBICIDES* □Organophosphate Pesticides □Organochlorine Pesticides □Chlorinated Herbicides **SEMI-VOLATILE ORGANICS*** **POLYCHLORINATED* BIPHEYNYL AND AROCHLOR COMPOUNDS** **TPH, PAH, PCP/TCP***	1-L I-Chem 200-series amber glass bottle, with Teflon lid-liner (per each sample type)	1000 mL (one container) ***Each sample type requires 1000 mL in a separate container**	Cool to 6°C, dark If chlorine is present, add 0.1g sodium thiosulfate	Keep at 6°C, dark, up to 7 days. Extraction must be performed within the 7 days; analysis must be conducted within 40 days.

Parameters for Analysis in WATER Samples	Recommended Containers (all containers pre-cleaned)	Typical Sample Volume (mL)	Initial Field Preservation	Maximum Holding Time (analysis must start by end of max)
Toxicity Testing Water Samples				
TOXICITY IN WATER	Four 2.25 L amber glass bottles	9000 mL	Cool to 4°C, dark	48 hrs at 4°C, dark
Bacteria and Pathogens in Water Samples				
E. Coli	Factory-sealed, pre-sterilized, disposable Whirl-pak® bags or 125 mL sterile plastic (high density polyethylene or polypropylene) container	100 mL volume sufficient for both E. coli and Enterococcus analyses	Sodium thiosulfate is pre-added to the containers in the laboratory (chlorine elimination). Cool to ≤ 10°C; dark.	STAT: 8 hrs at ≤ 10°C, dark if data for regulatory purposes; otherwise, 24 hrs at ≤ 10°C, dark if non-regulatory purpose.
Enterococcus	Factory-sealed, pre-sterilized, disposable Whirl-pak® bags or 125 mL sterile plastic (high density polyethylene or polypropylene) container	100 mL volume sufficient for both E. coli and Enterococcus analyses	Sodium thiosulfate is pre-added to the containers in the laboratory (chlorine elimination). Cool to ≤ 10°C ; dark.	STAT: 8 hrs at ≤ 10°C, dark if data for regulatory purposes; otherwise, 24 hrs at ≤ 10°C, dark if non-regulatory purpose.
FECAL COLIFORM	Factory-sealed, pre-sterilized, disposable Whirl-pak® bags or 125 mL sterile plastic (high density polyethylene or polypropylene) container	100 mL volume sufficient for both fecal and total coliform analyses	Sodium thiosulfate is pre-added to the containers in the laboratory (chlorine elimination). Cool to ≤ 10°C; dark.	STAT: 8 hrs at ≤ 10°C, dark if data for regulatory purposes; otherwise, 24 hrs at ≤ 10°C, dark if non-regulatory purpose.
TOTAL COLIFORM	Factory-sealed, pre-sterilized, disposable Whirl-pak® bags or 125 mL sterile plastic (high density polyethylene or polypropylene) container	100 mL volume sufficient for both fecal and total coliform analyses	Sodium thiosulfate is pre-added to the containers in the laboratory (chlorine elimination). Cool to ≤ 10°C; dark.	STAT: 8 hrs at ≤ 10°C, dark if data for regulatory purposes; otherwise, 24 hrs at ≤ 10°C, dark if non-regulatory purpose.

Field Collection Procedures for Bed Sediment Samples

Not Typical. This is not a standard practice of District staff, rather it may be conducted for a special effort under TMDL Monitoring Program or a special Study conducted by others. Refer to the corresponding project-specific sample and analysis plan as appropriate.

Not Typical. This is not a standard practice of District staff, rather it may be conducted for a special effort, refer to the corresponding project's sample and analysis plan as appropriate.

Bed sediment (hereafter termed "sediment") samples are collected after any water samples are collected where water and sediment are taken in the same reach. Care must be taken not to sample sediments that have been walked on or disturbed in any manner by field personnel collecting water samples. Sediment samples are collected into a composite jar, where they are thoroughly homogenized in the field, and then aliquoted into separate jars for chemical or toxicological analysis. Sediment samples for metals and organics are submitted to the respective analytical laboratories in separate glass jars, which have been pre-cleaned according to laboratory protocol.

Sediment chemistry samples give information regarding both trends in contaminant loading and the potential for adverse effects on sediment and aquatic biota. In order to compare samples over time and from site to site, they must be collected in a consistent manner. Recently deposited fine grain sediments (see attached table) are the target for sediment collection. If a suitable site for collecting sediments cannot be found at a station (it only contains larger grain material), sampling personnel should not collect the sediment sample, and should instead attempt to reschedule the sample collection or move to a different area that has more recently deposited fine sediment. If this is not possible, make a note so that the missing sample is accounted for in the reconciliation of monitoring events during preparation of sample collection "cruise reports". Sites that are routinely difficult to collect should be considered for elimination or relocation from the sample schedule, if appropriate.

Characteristics of Ideal Sediment Material to be Collected

Many of the chemical constituents of concern are adsorbed onto fine particles. One of the major objectives in selecting a sample site, and in actually collecting the sample while on site, is to obtain recently deposited fine sediment, to the extent possible. Avoid hard clay, bank deposits, gravel, disturbed and/or filled areas. Any sediment that resists being scooped by a dredge is probably not recently deposited fine sediment material. In following this guidance, the collection of sediment is purposefully being biased for fine materials, which must be discussed thoroughly in any subsequent interpretive reporting of the data, in regards to representation of the collected sample to the environment from which it was collected.

Characteristics of an Ideal Site

Quiescent areas are conducive to the settling of finer materials (EPA/USACOE, 1981).
Choose a sampling site with lower hydrologic energy, such as the inner (depositional) side of bends or eddies where the water movement may be slower. Reservoirs and estuaries are generally depositional environments, also.

Selecting the

Sediment will vary from site to site and can vary between sample

Appropriate Sediment Type for Analysis

events at a particular site.

Streams and Rivers: Sediment collection in flowing streams is often a challenge. In areas of frequent scouring there may not be sufficient sediment for collection during or following periods of high flow. Sediment collection during these times may prove unsuccessful and may have to be rescheduled or cancelled.

When the suspended load in rivers and streams precipitates due to reduction of velocity, most of the resulting sediment will be fine-grained. More often than not, a dredge or mechanical grab device does not function well for collection of sediment in smaller streams. In many cases, sediment will have to be collected using a pre-cleaned polyethylene scoop. Collect the top 2 cm for analysis. Five or more (depending on the volume of sediment needed for conducting analyses) fine-sediment sub-sites within a 100-m reach are sampled into the composite jar.

Reservoirs and Estuaries: Collect the top 2 cm for analysis. Grabs are composited for the sediment sample, depending on the volume of sediment needed for conducting analyses.

GENERAL PROCEDURE FOR COLLECTION OF BED SEDIMENT

After choosing an appropriate site, and identifying appropriate fine-grained sediment areas within the general reach, collect the sample using one or more of the following procedures, depending on the setting:

A. Sediment Scoop Method—Primary Method for Wadeable, Shallow Streams

- The goal is to collect the top 2 cm of recently-deposited fine sediment only.
- Wear gloves and protective gear, in areas of potential exposure hazards, per appropriate protocol (make sure gloves are long enough to prevent water from overflowing gloves while submerging scoop).
- Survey the sampling area for appropriate fine-sediment depositional areas before stepping into the stream, to avoid disturbing possible sediment collection sub-sites.
- Carefully enter the stream and start sampling at the closest appropriate reach, then continue sampling UPSTREAM. Never advance downstream, as this could lead to sampling disturbed sediment.
- Stir, do not shake, collected sediment with a polyethylene scoop for at least 5 min making sure all sediment is completely homogenized.
- Quickly scoop sediment out of the homogenizing jar into desired sampling jars making sure

to stir the sediment in the homogenizing jar in between each aliquot.

- Inspect each individual sediment jar making sure of consistent grain size throughout the entire sample collection.
- Single bag all sediment containers to prevent cross contamination.
- Make sure all containers are capped tightly and stored in a cooler on cube ice at 6 °C.

B. Hand Core Method-Alternate method for wadeable shallow streams with fine sediment

- A hand core is used in wadeable streams where there is very fine sediment.
- The hand core sampler consists of a 3-in. diameter polycarbonate core that is 8 inches long. Samplers push the core into the sediment to the desired depth, pull the core out of the sediment, and cap the bottom with a polyethylene core cap or by placing their hand underneath the cap to hold the sediment in place.
- Hand cores are usually measured and marked at 2 cm length so the sampler knows how far to deploy the core into the sediment.
- Sediment is then emptied into a homogenizing jug and aliquoted accordingly.

C. Sediment Grab Method—Primarily for Lake, River, Bridge, and Estuarine Settings (or deeper streams)

Description of sediment grab equipment:

- A mechanical sediment grab is used for the SWAMP bed sediment collection field effort for lake, river, bridge, and estuarine/coastal settings (or deeper, non-wadeable streams).
- The mechanical grab is a stainless steel “Young-modified Van Veen Grab", and is 0.5 m^2 in size.
- The mechanical grab is deployed primarily from a boat, and is used in deeper, non-wadeable waters, such as lakes, rivers, estuaries, and coastal areas.
- It is also deployed by field personnel from land in settings which allow its use: primarily from bridges; from smaller vessels in streams or drainage channels too deep or steep to wade into, but too shallow for a larger boat.

Deploying and retrieving the grab:

- Slowly lower the grab to the bottom with a minimum of substrate disturbance.
- Retrieve the closed dredge at a moderate speed (e.g., less than two feet per second).
- Upon retrieval, open the lids of the sediment grab, examine the sample to ensure that the sediment surface is undisturbed and that the grab sample should not be rejected.

Rejection Criteria—reject the sample if the following are not met:

- Mud surface must not be pressing out of the top of the sampler. If it is, lower the grab more slowly.
- Overlying water must not be leaking out along the sides of the sediment in the grab. This

ensures the surficial sediment is not washed out.

- Sediment surface is flat and level in the sampler. If it is not level, the grab has tilted over before closing.

Processing the sediment sample from the grab equipment:

- The water overlying the sediment in the grab is very gently decanted by slightly tipping the grab with the lid closed until the water runs out the top.
- The decanting process should remove all of the overlying water but not remove the surficial sediments. The laboratory reports percent water for the sample, so overlying water is not included in the sample container.
- The sediment is examined for depth of penetration, color and thickness of top aerobic zone, and texture. These observations are recorded on the field data sheet.
- Collect the top 2 cm from at least five sub samples, and otherwise, exclude the bottom-most layer and composite.
- In streams or other settings with excessive bottom debris (e.g., rocks, sticks, leaves) where the use of a grab is determined to be ineffective (e.g., dredge does not close, causing loss of sediment), samples may be collected by hand using a clean plastic scoop, or by a variety of coring methods, if appropriate for the situation.
- Sediment is handled as described below in the metals and organic sections.

Cleaning the Grab Equipment and Protection from Potential Contaminating Sources:

- The sediment sampler will be cleaned prior to sampling EACH site by: rinsing all surfaces with ambient water, scrubbing all sediment sample contact surfaces with Micro™ or equivalent detergent, rinsing all surfaces with ambient water, rinsing sediment sample contact surfaces with 5% HCl, and rinsing all sediment sample contact surfaces with methanol.
- The sediment grab will be scrubbed with ambient water between successive deployments at ONE site, in order to remove adhering sediments from contact surfaces possibly originating below the sampled layer, thus preventing contamination from areas beyond target sampling area.
- Sampling procedures will attempt to avoid exhaust from any engine aboard any vessel involved in sample collection. An engine will be turned off when possible during portions of the sampling process where contamination from engine exhaust may occur. It is critical that sample contamination be avoided during sample collection. All sampling equipment (e.g., siphon hoses, scoops, containers) will be made of non-contaminating material and will be appropriately cleaned before use. Samples will not be touched with un-gloved fingers. In addition, potential airborne contamination (e.g., from engine exhaust, cigarette smoke) will be avoided.

D. Core Method--alternative for fast-moving, wadeable streams

The core method is used in soft sediments when it is difficult to use the other methodologies. The cores can be used in depths of water from 0 to 10 ft by using a pole deployment device or in deeper water using SCUBA divers. The pole deployment device consists of a pole that attaches to the top

of the core. The top of the core is fitted with a one-way valve, which allows the core to be filled with sediment, but when pulled from the sediment catches the sediment within the core. The core is then brought to the surface and the sediments within the core are extruded out the top of the core so that 2 cm of sediment is above the top of the plastic core. The 2 cm of sediment is then sliced off and placed in the homogenizing jar. A new core, homogenizing jar, and device used to slice off the top two cm. are used at each station unless the equipment is cleaned using laboratory protocols.

E. Sediment Grab Method – Primarily used from bridges or for streams with restricted bank access.

Description and sampling procedure for the Eckman sediment grab

- The Eckman grab is 0.2 m^2 in size with a lead "messenger" that triggers the spring loaded doors.
- The primary use is for sampling from bridges or from small vessels in streams or drainage channels too deep or steep to wade into, but too shallow for a larger boat.
- The grab must be cleaned with a Micro™ and tap water rinse before sampling and in-between sample stations.
- To deploy the grab, pull the spring loaded doors open and hook the cables on the actuator plate.
- With a rope, lower the grab to the desired sample reach making sure that the grab has penetrated the sediment. Clip the "messenger" on the rope and release it while maintaining tension on the rope. Pull up the grab once the "messenger" has activated the doors.
- While wearing clean poly gloves, open the top hatch and remove the top 2 cm of sediment with a clean polyethylene scoop. Place the sediment into the homogenizing jug and repeat the sampling process until there is enough desired sediment. See general procedures for processing of bed sediment samples, once they are collected for sediment homogenization and aliquoting into sample jars.

GENERAL PROCEDURE FOR PROCESSING OF BED SEDIMENT SAMPLES, ONCE THEY ARE COLLECTED

Sediment Homogenization, Aliquoting and Transport

For the collection of bed sediment samples, the top 2 cm is removed from the scoop, or the grab, or the core, and placed in the 4-L glass compositing/homogenizing container. The composited sediment in the container is homogenized and aliquoted on-site in the field. The sample is stirred with a polyethylene scoop until sediment/mud appears homogeneous. All sample identification information (station numbers, etc.) will be recorded prior to homogenizing and aliquoting. Sediment samples will immediately then be cooled to 6 °□C and separated for preservation according to the: Summary of Sample Container, Volume, Preservation, and Storage Requirements for SWAMP Bed Sediment, Biota, and Tissue Samples (for contaminant analysis).Each container will be sealed in one large plastic bag to prevent contact with other samples or ice or water.

Metals and Semi-volatile Organics in Sediment	For trace metals and semi-volatile organics, a minimum of three grabs is distributed to the composite bottle and/or sample containers. Mixing is generally done with a polyethylene scoop. Make sure the sample volume is adequate, but the containers do not need to be filled to the top. Seal the jars with the Teflon liner in the lids.
Sediment Conventionals	Sediment conventionals are sometimes requested when sediment organics, sediment metals, and/or sediment toxicity tests are requested for analysis of samples. The collection method is the same as that for metals, semi-volatile organics, and pesticides. Sediment conventionals include: grain size analysis and total organic carbon. These are used in the interpretation of metals and organics in sediment data.
Sample Containers	See "Sediment Sample Handling Requirements" table at end of this document.
Sediment Sample Size	Must collect sufficient volume of sediment to allow for proper analysis, including possible repeats, as well as any requested archiving of samples for possible later analysis. See "Sediment Sample Handling Requirements" Table at end of this document.
Labeling	Label the jars with the station ID, sample code, matrix type, project ID, time, and date of collection, as well as the type of analysis requested (e.g., metals, conventionals, organics, or archives).
Short-term Field Preservation	Immediately place the labeled jar on ice, cool to 6 °□C, and keep in the dark at 4 °□C until delivery to the laboratory.
Field Notes	Fill out the SWAMP Sediment Data Sheet. Make sure to record any field notes that are not listed on the provided data sheets. This information can be reported as comments with the sediment analytical results.

Summary of Sample Container, Volume, Preservation, and Storage Requirements for SWAMP Bed Sediment, Biota, and Tissue Samples (for contaminant analysis)

Parameters for Analysis	Recommended Containers	Typical Sample Volume (mL)	Initial Field Preservation	Maximum Holding Time

Parameters for Analysis	Recommended Containers	Typical Sample Volume (mL)	Initial Field Preservation	Maximum Holding Time
Bed Sediment Samples				
Trace Metals, including Hg and As (except for Se--see below)	60-mL I-Chem 300- series clear glass jar with Teflon lid-liner; Pre-cleaned	60 mL (one jar)	Cool to ≤6 °C within 24 hours, then freeze to ≤-20 °C	12 months(1) (-20 °C)
Methylmercury	60-mL I-Chem 300- series clear glass jar with Teflon lid-liner; Pre-cleaned	60 mL (one jar)	Freeze to ≤-20 °C immediately	12 months(1) (-20 °C)
Selenium (separate container required)	60-mL I-Chem 300- series clear glass jar with Teflon lid-liner; Pre-cleaned	60 mL (one jar)	Cool to ≤6 °C within 24 hours, then freeze to ≤-20 °C	12 months(1) (-20 °C)
Synthetic Organic Compounds	250-mL I-Chem 300-series amber glass jar with Teflon lid-liner; Pre-cleaned	500 mL (two jars)	Cool to ≤6 °C within 24 hours, then freeze to ≤-20 °C	12 months(1) (-20 °C)
Sediment TOC	250-mL(3) clear glass jar; Pre-cleaned	125 mL (one jar)	Cool to ≤6 ˚C or freeze to ≤-20 ˚C	28 days at ≤6 ˚C; 1 year at ≤-20 ˚C (2)
Sediment Grain Size	250-mL(3) clear glass jar; Pre-cleaned	125 mL (one jar)	Wet ice to ≤6 ˚C in the field, then refrigerate at ≤6 ˚C	1 year (≤6 ˚C) ***Do not freeze***
Sediment Toxicity Testing	1-L I-Chem wide-mouth polyethylene jar with Teflon lid-liner; Pre-cleaned	2 (two jars filled completely)	Cool to 4 °C, dark, up to 14 days	14 days (4 °C) ***Do not freeze***

(1) Sediment samples for parameters noted with one asterisk (*) may be refrigerated at 6 °C for up to 14 days maximum, but analysis must start within the 14-day period of collection or thawing, or the sediment sample must be stored frozen at minus (-) 20 °C for up to 12 months.

(2) Sediment samples for sediment TOC analysis can be held at 4°C for up to 28 days, and should be analyzed within this 28-day period, but can be frozen at any time during the initial 28 days, for up to 12 months at minus (-) 20 °C.

(3) Sediment samples for TOC AND grain size analysis can be combined in one 250 mL clear glass jar, and sub-sampled at the laboratory in order to utilize holding time differences for the two analyses. If this is done, the 250 mL combined sediment sample must be refrigerated only (not frozen) at 4 °C for up to 28 days, during which time the sub-samples must be aliquoted in order to comply with separate storage requirements (as shown above).

APPENDIX F:

SWAMP BIOASSESSMENT SOP

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SWAMP
Surface Water Ambient Monitoring Program

SWAMP Bioassessment Procedures 2007

Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California

February 2007

California Water Boards

www.waterboards.ca.gov/swamp

Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California

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Preparation Date: January 23rd 2007

Approved by: Beverly van Buuren, SWAMP QA Officer

Approval Date: 01/17/07

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ACKNOWLEDGEMENTS

The protocols described here represent the contributions of a wide range of researchers and field crews. Most of the physical habitat methods are close modifications of those used in the U.S. Environmental Protection Agency's (EPA's) Environmental Monitoring and Assessment Program (EMAP) and developed by EPA's Office of Research and Development (ORD, Peck et al. 2004). The benthic macroinvertebrate collection methods are based on EMAP methods (EPA's targeted riffle methods were derived in turn from methods developed at Utah State University; Hawkins et al. 2003).

The current version of these protocols was established by Peter Ode (Department of Fish and Game's (DFG's) Aquatic Bioassessment Laboratory (ABL)) and David Herbst (UC Santa Barbara's Sierra Nevada Aquatic Research Laboratory) with significant contributions from staff at the ABL (Jim Harrington, Shawn McBride, Doug Post, Andy Rehn, and Jennifer York), the Surface Water Ambient Monitoring Program (SWAMP) Quality Assurance (QA) Team, Thomas Suk and other members of the SWAMP bioassessment committee (Mary Adams, Lilian Busse, Matt Cover, Robert Holmes, Sean Mundell, and Jay Rowan) and three external reviewers: Chuck Hawkins, Dave Peck, and Phil Kaufmann.

Ode, P.R.. 2007. Standard operating procedures for collecting macroinvertebrate samples and associated physical and chemical data for ambient bioassessments in California. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 001.

SWAMP GUIDANCE SG

SWAMP GUIDANCE FOR MACROINVERTEBRATE FIELD PROTOCOLS FOR WADEABLE STREAMS

Background: The SWAMP Bioassessment Committee met in December, 2004, and agreed that the SWAMP Quality Assurance Management Plan (QAMP) should be amended to provide greater consistency in bioassessment sampling protocols for wadeable streams. The Committee's recommendations were reviewed and accepted by the full SWAMP Roundtable[1] in February, 2005 (some of the key considerations are contained in Appendix A).

The current guidance for macroinvertebrate sampling under the SWAMP program is as follows:

1. For ambient bioassessment monitoring of wadeable streams in California, two methods are to be used at sites with riffle habitats (i.e., one "multihabitat" sample, and one sample that targets the "richest" habitat):
   - **For sites with sufficient riffle habitat,** the two samples shall be: (1) the reachwide benthos (RWB) method (also known as "multihabitat" sampling.); and (2) the targeted-riffle composite (TRC) method.
   - **For low-gradient sites that do not have sufficient riffle habitat**, the RWB method is the standard method, but we also recommend the option of collecting a sample with (2) the "Margin-Center-Margin" (MCM) method until ongoing methods comparisons are completed (see Appendix A).
   - **Notes:** (1) The protocols for each method are provided in this document; (2) Other appropriate method(s) will be allowed if the specific monitoring objectives require use of alternative method(s). (See Item #2, below.); (3) The protocol recommendations specified above will be reevaluated as results become available from ongoing methods comparison studies. (See Appendix A for more information.)

2. The SWAMP QAMP allows flexibility in sampling methods so that the most appropriate method(s) may be used to address hypothesis tests and project-specific objectives that differ from program objectives. Such situations may include, but are not necessarily limited to, special studies (e.g., evaluation of point source discharges, above/below comparisons where statistical replication is needed), stressor identification investigations, and long-term monitoring projects where consistent data comparability is desired and an alternative method is needed to achieve that comparability. In addition, in some rare cases where funding limitations would make it cost-prohibitive to complete a project in compliance with the protocols listed in #1, above, the project proponent may request to complete laboratory analysis of only one sample, and "archive" one of the macroinvertebrate samples (i.e., the RWB sample in streams with riffles) to reduce lab costs. Deviations from the protocols specified in #1 above may be granted by the SWAMP Bioassessment Coordinator or the full SWAMP Roundtable.

1. The SWAMP Roundtable is the coordinating entity for the program. Participants include staff from the State and Regional Water Boards, USEPA, the Department of Fish and Game, the Marine Pollution Studies Laboratory, Moss Landing Marine Laboratories, contractors, and other interested entities.

SECTION 1 INTRODUCTION

This document describes two standard procedures (TRC and RWB) for sampling benthic macroinvertebrate (BMI) assemblages for ambient bioassessments. This document also contains procedures for measuring instream and riparian habitats and ambient water chemistry associated with BMI samples. These sampling methods replace previous bioassessment protocols referred to as the California Stream Bioassessment Procedure (CSBP, Harrington 1995, 1999, 2002).

These procedures can produce quantitative and repeatable measures of a stream's physical/habitat condition and benthic invertebrate assemblages, but they require field training and implementation of QA measures throughout the field season.

The sampling layout described here provides a framework for systematically collecting a variety of physical, chemical, and biological data. The biological sampling methods are designed to nest within the overall framework for assessing the biotic, physical, and chemical condition of a reach. The layout used in these procedures and most of the physical habitat methods are close modifications of those used in EPA's EMAP and developed by EPA's ORD (Peck et al. 2004). Data collected using this methodology are generally directly comparable to equivalent EMAP data, except for the difference in reach length. Other exceptions are noted in the text.

The following steps are presented in an order suggested for efficient data collection. The specific order of collection for the physical parameters may be modified according to preferences of field crews, with the caveat that care must always be taken to not disturb the substrates within the streambed before BMI samples are collected.

PHYSICAL HABITAT METHODS

The physical habitat scoring methods described here can be used as a stand-alone evaluation or used in conjunction with a bioassessment sampling event. However, measurements of instream and riparian habitat and ambient water chemistry are essential to interpretation of bioassessment data and should always accompany bioassessment samples. This information can be used to classify stream reaches, associate physical and chemical condition with biotic condition, and explain patterns in the biological data.

Because bioassessment samples can be collected to answer a variety of questions, this document describes the component measures of instream and riparian habitat as independent modules. Although individual modules can be added or subtracted from the procedure to reflect specific project objectives, a standard set of modules will normally accompany bioassessment samples. This document describes two standard groupings of modules that represent two different levels of intensity for characterizing the chemical and physical habitat data (Table 1). The BASIC physical habitat characterization represents a minimum amount of physical and chemical data that should be taken along with any ambient BMI sample, the FULL physical habitat characterization represents the suite of data that should be collected with most professional level bioassessment samples (e.g., SWAMP regional monitoring programs). In addition to these data, we also briefly introduce additional data modules (e.g., excess sediment, periphyton) that can be collected as supplements to the full set (OPTIONAL). Table 1 lists the physical and chemical variables that should be measured under the different levels.

Note: *SWAMP intends to develop guidance for selecting appropriate physical habitat modules to the intended uses of data. Until this guidance is available, users of these protocols should consult with representatives of the Regional Water Quality Control Boards (Regional Boards) or the SWAMP Bioassessment Coordinator when selecting modules.*

FIELD CREW SIZE AND TIME ESTIMATES

These methods are designed to be completed by either two or three (or more) person field crews. A very experienced field crew can expect to complete the full suite of physical habitat measurements and the two BMI sampling protocols in approximately two hours. Less experienced crews will probably take closer to three or four hours to complete the work depending on the complexity of the reach. Note that this estimate includes only time at the site, not travel time between sites.

Equipment and Supplies

Recommended equipment and supplies are listed in Table 2.

Table 1. Summary of physical habitat and water chemistry and proposal for basic, full, and optional levels of effort.

Survey Task	Parameter(s)	Basic	Full	Option	Comments
REACH DELINEATION and WATER QUALITY [Conducted before entering stream to sample BMIs or conduct any habitat surveys]	Layout reach and mark transects, record GPS coordinates	X	X		Use 150-m reach length if wetted width ≤10 m; Use 250-m reach length if wetted width > 10 m
	Temperature, pH, specific conductance, DO, alkalinity	X	X		Multi-meter (e.g., YSI, Hydrolab, VWR Symphony)
	Turbidity, Silica			X	Use test kit or meter
	Notable field conditions	X	X		Recent rainfall, fire events, dominant local landuse
CROSS-SECTIONAL TRANSECTS BASIC Measurements at main 11 transects only FULL Measurements at 11 main transects (A, B, C, D, E, F, G, H, I, J, K) or 21 transects (11 main plus 10 inter-transects) for substrate size classes only	Wetted width	X	X		Stadia rod is useful here
	Flow habitat delineation	X	X		Record proportion of habitat classes in each inter-transect zone
	Depth and Pebble Count + CPOM		X		5 -point substrate size, depth and CPOM records at all 21 transects
	Cobble embeddedness		X		All cobble-sized particles in pebble count. Supplement with "random walk" if needed for 25
	Slope (%)	See reach scale	X		Average slope calculated from 10 transect to transect slope measurements. Use autolevel for slopes ≤ 1%; clinometer is OK for steeper gradients
	Sinuosity		X		Record compass readings between transect centers
	Canopy cover	X	X		Four densiometer readings at center of channel (facing L bank R bank, Upstream +Downstream)
	Riparian Vegetation		X		Record % or categories
	Instream Habitat		X		
	Human Influence		X		
	Bank Stability	X	X		Eroding / Vulnerable / Stable
	Bankfull Dimensions		X		
	Excess Sediment Transect Measures (optional)				
	Bankfull width and height, bank angles			X	
	Large woody debris counts			X	Tallies of woody debris in several size classes
	Thalweg profile			X	100 equidistant points along thalweg

Survey Task	Parameter(s)	Basic	Full	Option	Comments
DISCHARGE TRANSECT	Discharge measurements		X		Velocity-Area Method or Neutrally Buoyant Object Method
REACH SCALE MEASUREMENTS:	EPA-RBP visual scoring of habitat features	*		X	*Used for citizen monitoring and comparison with legacy data
	Selected RBP visuals:		X		Channel alteration, sediment deposition, epifaunal substrate (redundant if doing EPA-RBP scoring)
	Slope (%, not degrees)	X	See transect scale		Single measurement for entire reach only for BASIC. Use autolevel for slopes ≤ 1%, clinometer is OK for higher gradients
	Photo documentation	X	X		Upstream (A, F, K) Downstream (F)
OTHER OPTIONAL COMPONENTS					
FOOD RESOURCE QUANTIFICATION	Periphyton (3 replicates)			X	Qualitative characterization of diatom growth and filamentous algal growth, quantification of biomass (AFDM, chl-a)
	CPOM & FPOM (3 replicates)			X	CPOM field measure of wet mass >1 mm particles, FPOM as 0.25 – 1 mm fraction (AFDM in lab)

Table 2. Field equipment and supplies

Physical Habitat	BMI Collection	General/ Ambient Chemistry
• GPS receiver • topographic maps • measuring tape (150-m) • small metric ruler or gravelometer for substrate measurements • digital watch, random number table or ten-sided die • stadia rod • clinometer • autolevel (for slopes < 1%) • handlevel (optional) • current velocity meter • stopwatch for velocity measurements • convex spherical densitometer • flags/ flagging tape • rangefinder	• D-frame kick net (fitted with 500-µ mesh bag) • standard # 35 sieve (500-µ mesh) • wide-mouth 500-mL or 1000 mL plastic jars • white sorting pan (enamel or plastic) • 95% EtOH • fine tipped forceps or soft forceps • waterproof paper and tape for attaching labels • 10-20-L plastic bucket for sample elutriation • preprinted waterproof labels (e.g., Rite-in-the-Rain™) • disposable gloves/ elbow length insulated gloves	• sampling SOP (this document) • hip or chest waders, or wading boots/shoes • field forms printed on waterproof paper (e.g., Rite-in-the-Rain™) • clip board and pencils • digital camera • centigrade thermometer • pH meter • DO meter • conductivity meter • field alkalinity meter • water chemistry containers • calibration standards • spare batteries for meters • first aid kit

SECTION 2
REACH DELINEATION AND WATER QUALITY

REACH LAYOUT AND GENERAL DOCUMENTATION

The systematic positioning of transects is essential to collecting representative samples and to the objective quantification of physical habitat measures. The standard sampling layout consists of a 150-m reach (length measured along the bank) divided into 11 equidistant transects that are arranged perpendicular to the direction of flow (Figure 1, Figure 2). Ten additional transects (designated "inter-transects") located between the main transects give a total of 21 transects per reach. Main transects are designated A through K while inter-transects are designated by their nearest upstream and downstream transects (e.g., AB, BC, etc.). In extreme circumstances, reach length can be shorter than 150 m (e.g., if upstream and downstream barriers preclude a 150-m reach), but this should be avoided whenever possible. If the actual reach length is other than 150 m or 250 m this should be noted and explained on the field forms.

Note 1: *The standard reach length differs from that used in the EMAP design, in which reach length was defined as 40x stream width, with a minimum reach length of 150 m. The EMAP reach length approach is used to ensure that enough habitat is sampled to support accurate fish assemblage estimates and relatively precise characterization of channel characteristics (e.g., residual pool volumes and woody debris estimates, which that are critical for relative bed stability estimates). Programs wishing to sample fish assemblages or produce relative bed stability estimates should strongly consider adopting the EMAP guidance for setting reach length.*

Note 2: *Streams > 10 m wetted width should use a reach length of 250 m. Some very large streams (i.e., > 20-m wetted width) may not be adequately represented even by a 250-m reach. In these cases, field crews should define a reach length that is representative of the larger stream segment being studied (i.e., attempt to include two to three meander cycles, or four to six riffle-pool sequences when possible).*

Note 3: *When the exact reach location is not restricted by the sampling design, attempt to position reaches upstream of bridges to avoid this influence.*

Step 1. Upon arrival at the sampling site, fill out the reach documentation section of the field forms (site and project identification, stream and watershed name, crew members, and date/time). If known at the time of sampling, record the Site Code following SWAMP site code formats. Determine the geographic coordinates of the downstream end of the reach (preferably in decimal degrees to at least four decimal places) with a GPS receiver and record the datum setting of the unit (preferably NAD83/ WGS84).

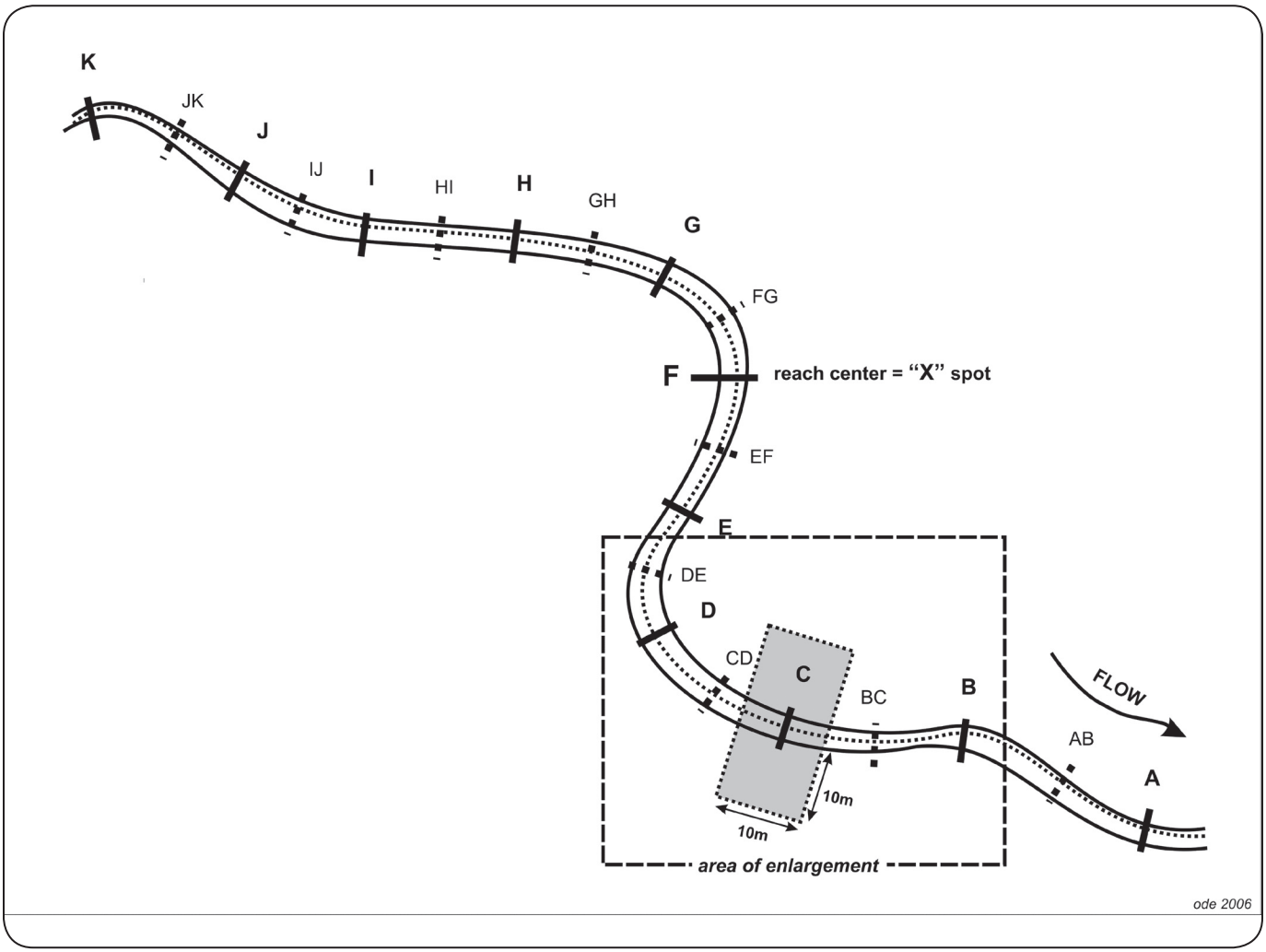

Figure 1. Reach layout geometry for physical habitat and biological sampling showing positions of 11 main transects (A – K) and the 10 supplemental inter-transects (AB- JK). The area highlighted in the figure is expanded in Figure 2. Note: reach length = 150 m for streams ≤ 10-m average wetted width, and reach length = 250 m for streams > 10-m average wetted width.

Step 2. Once a site has been identified, make an initial survey of the reach from the stream banks (being sure to not disturb the instream habitat). If TRC samples will be collected, identify all riffle habitats suitable for sampling (see Section IIIa for suitable habitat types) and note their positions so that a subset can be identified for sampling.

Step 3. Determine if the average wetted width is greater or less than 10 m. If the average wetted width ≤ 10 m, use a 150-m reach length. If the average wetted width > 10 m, use a 250-m reach length.

Step 4. Starting at one end of the reach, establish the position of the 11 main transects (labeled A-K from downstream to upstream) by measuring 15 m (25 m for streams > 10 m wetted width) along the bank from the previous transect. The 10 inter-transects should be established equidistant from the adjacent main transects (i.e., 7.5 m from main transects for 150-m reaches, 12.5 m for 250-m reaches). Since the data collection will start at the downstream end, is often easiest to establish transects starting from the upstream end. For easy setup and breakdown, mark the main transects with easily removable markers (e.g., large washers tied with strips of flagging, surveyor's flags).

Note 1: *While it is usually easiest to establish transect positions from the banks (this also reduces disturbance to the stream channel), this can result in uneven spacing of transects in complex stream reaches. To avoid this, estimate transect positions by projecting from the mid-channel to the banks.*

Note 2: *Flagging of a single bank is recommended to reduce mistakes caused by missed markers.*

Step 5. Measure and record common ambient water chemistry measurements (pH, DO, specific conductance, alkalinity, water temperature) at the downstream end of the reach (near same location as the GPS coordinates were taken). These are typically taken with a handheld water quality meter (e.g., YSI, Hydrolab), but field test kits (e.g., Hach) can provide acceptable information if they are properly calibrated. For appropriate calibration methods and calibration frequency, consult the current SWAMP QAMP (Appendix F), or follow manufacturer's guidelines.

Note 1: *If characteristics of the site prohibit downstream entry, measurements may be taken at other points in the reach. In all cases, ambient chemistry measurements should be taken at the beginning of the reach survey.*

Note 2: *Alkalinity test kits may not perform well in low ionic strength waters. Programs should consider collecting lab samples for these sites (see SWAMP QAMP for guidance on collecting water chemistry samples).*

Step 6. Take a minimum of four (4) photographs of the reach at the following locations: a) Transect A facing upstream, b) Transect F facing upstream, c) Transect F facing downstream, and d) Transect K facing downstream. It may also be desirable to take a photograph at Transect A facing downstream and Transect K facing upstream to document conditions immediately adjacent to the reach. Digital photographs should be used when possible. Record the image numbers on the front page of the field form.

Note 1: *When possible, photograph names should follow SWAMP coding conventions ("StationCode_yyyy_mm_dd_uniquecode"). The unique code should include one of the following codes to indicate direction: RB (right bank), LB (left bank), BB (both banks), US (upstream), DS (downstream). SWAMP suggests using unique codes created by the camera to facilitate file organization. Example: 603WQLB02_2004_03_20_RBDS1253.*

Step 7. Record the dominant land use and land cover in the area surrounding the reach (evaluate land cover within 50 m of either side of the stream reach).

Step 8. At the bottom of the form, record evidence of recent flooding, fire, or other disturbances that might influence bioassessment samples. Especially note if flow conditions have been affected by recent rainfall, which can cause significant under-sampling of BMI diversity (see note in the following section). If you are unaware of recent fire or rainfall events, select the "no" option on the forms.

SECTION 3
COLLECT BENTHIC MACROINVERTEBRATES

MULTIPLE HABITAT AND TARGETED RIFFLE PROTOCOLS

Note 1: *BMI samples intended for ambient bioassessments are generally collected when streams are at or near base flow (i.e., not influenced by surface runoff) as sudden flow increases can dramatically alter local community composition.*

Note 2: *Guidance for choosing among TRC sampling, RWB sampling or both will be provided in a separate document (see Appendix A for current guidance for sampling under SWAMP).*

Once the reach transects have been laid out, the biological samples (BMIs and algae if included) should be collected before any other physical habitat measures so that substrates are not disturbed prior to sampling. Both TRC and RWB methods use 500-µ mesh D-frame nets (see list of BMI sampling equipment in Table 2). The two samples can be collected at the same time by carrying two D-nets and compositing the material from the two samples in their respective nets. If a two person field crew is responsible for both the physical habitat data and benthic invertebrate samples, it is generally best to collect the benthos at each transect, then immediately record the physical habitat data before moving to the next transect. Obviously, this requires especially careful handling of the D-nets during the course of sampling to avoid loss or contamination of the samples. It can be helpful to clearly label the two D nets as RWB and TRC. Larger field crews may choose to split the sampling between biological team and a physical habitat team and have the biological team go through the reach first. The positions of the TRC and RWB subsampling locations are illustrated in Figure 2.

SECTION III A. TARGETED RIFFLE COMPOSITE PROCEDURE

The TRC method is designed for sampling BMIs in wadeable streams that contain fast-water (riffle/run) habitats and is not appropriate for waterbodies without fastwater habitats. The RWB protocol should be used in these situations. Riffles are often used for collecting biological samples (e.g., the old CSBP methods) because they often have the highest BMI diversity in wadeable streams. This method expands the definition to include other fast water habitats, however care should be taken when attempting to apply this method in low gradient streams.

Note: *Since all streams (even low gradient streams) have variation in flow habitats within the channel, this guidance should not be interpreted as including areas within low gradient streams that are only marginally faster than the surrounding habitats. The RWB protocol should be applied in these situations.*

The TRC was developed by the Western Center for Monitoring and Assessment of Freshwater Ecosystems (www.cnr.usu.edu/wmc) in Logan, Utah (Hawkins et al. 2003) and slightly modified by the EPA program (Peck et al. 2004). The TRC has been widely used in California (US Forest Service (USFS), the EMAP Western Pilot, and the California Monitoring and Assessment Program (CMAP)), and in the interest of methodological consistency between state and federal water resource agencies, has been adopted as the standard riffle protocol for bioassessment in California. The version described here is the EMAP modification, which distributes the sampling effort throughout the reach.

Sampling Locations – Acceptable Habitat Types

Riffles are the preferred habitat for TRC sampling, but other fast water habitats are acceptable for sampling if riffles are sparse. Common flow-defined habitat types are listed in Table 3 in decreasing order of energy. Most streams contain some or all of the following fast water habitat types: 1) cascades/falls, 2) rapids, 3) riffles, 4) runs. All of these are acceptable for TRC sampling if riffles are not available.

Note: *Because the common habitat types are arranged on a continuum between high to low energy environments, the categories grade into each other continuously and are not discrete. Thus, determination of habitat types requires somewhat subjective decision-making.*

Table 3. Common habitat types in stream channels, arranged in decreasing order of energy

Flow Habitat Type	Description
Cascades	Short, high gradient drop in stream bed elevation often accompanied by boulders and considerable turbulence
Falls	High gradient drop in elevation of the stream bed associated with an abrupt change in the bedrock
Rapids	Sections of stream with swiftly flowing water and considerable surface turbulence. Rapids tend to have larger substrate sizes than riffles
Riffles	Shallow sections where the water flows over coarse stream bed particles that create mild to moderate surface turbulence; (< 0.5 m deep, > 0.3 m/s)
Step-Runs	A series of runs that are separated by short riffles or flow obstructions that cause discontinuous breaks in slope
Runs	Long, relatively straight, low-gradient sections without flow obstructions. The stream bed is typically even and the water flows faster than it does in a pool; (> 0.5 m deep, > 0.3 m/s)
Glides	A section of stream with little or no turbulence, but faster velocity than pools; (< 0.5 m deep, < 0.3 m/s)
Pools	A reach of stream that is characterized by deep, low-velocity water and a smooth surface ; (> 0.5 m deep, < 0.3 m/s)

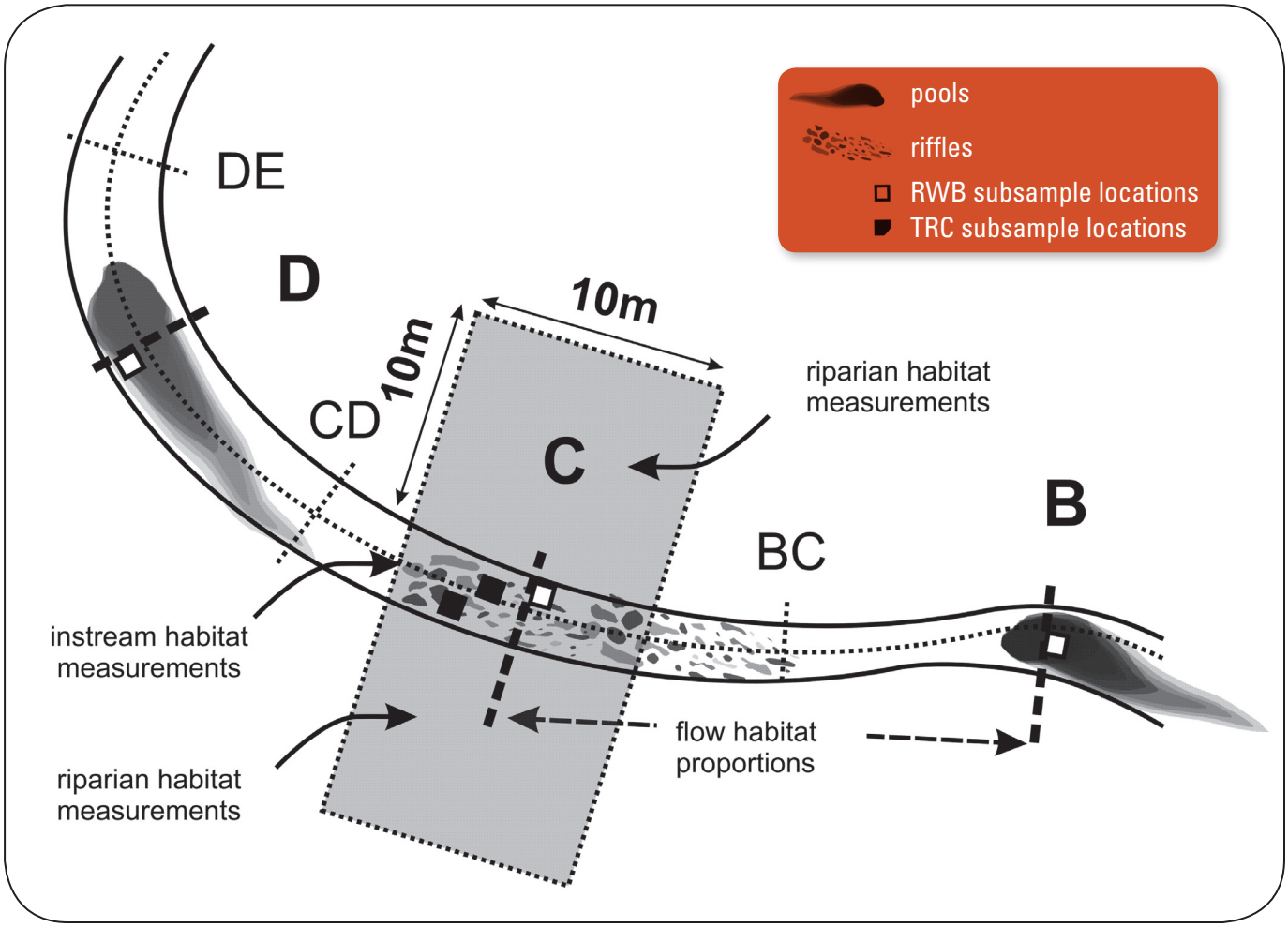

Figure 2. Section of the standard reach expanded from Figure 1 showing the appropriate positions for collecting benthic macroinvertebrate samples, instream and riparian habitat measurements and flow habitat proportion measurements.

Sampling Locations – Selecting Habitat Units

A TRC sample is a composite of eight individual kick samples of 1 ft^2 (0.09 m^2) of substrate each. During your initial layout of the reach, take a mental note of the number and position of the main riffles in a reach (and other fast water habitats if needed). Randomly distribute the eight sub-samples among the fast water habitats in the reach, giving preference to riffles where possible. Unless you are sampling in small streams, try to avoid very small riffle units (i.e., < 5 ft^2). If fewer than eight riffles are present in a reach, more than one sample may be taken from a single riffle, especially if the riffles are large.

Sampling Procedure

Begin sampling at the downstream end of the reach at the first randomly selected riffle and work your way upstream.

TRC-Step 1. Determine net placement within each habitat unit by generating a pair of random numbers between 0 and 9. Examples of convenient random number generators include the hundredths place on the stopwatch feature of a digital watch, a 10 sided die and a random number chart. The first number in each pair (multiplied by 10) represents the percent upstream along the habitat unit's length. The second number in each pair represents the percent of the riffle width from right bank. For example, if the two generated random numbers are 4 and 7, you will walk upstream 40% of the distance of the riffle and then go 70% of the distance across the riffle (see Figure 3). This position is the center of the 1 ft^2 (0.09 m^2) sampling quadrat for that riffle. If you are unable to sample this location because it is too deep or it is occupied by a large boulder, select a new pair of random numbers and pick a new spot.

TRC-Step 2. Position a 500-µ D-net (with the net opening perpendicular to the flow and facing upstream) quickly and securely on the stream bottom to eliminate gaps under the frame. Avoid, and if necessary remove, large rocks that prevent the sampler from seating properly on the stream bottom.

TRC-Step 3. Holding the net in position on the substrate, visually define a square quadrat that is one net width wide and one net width long upstream of the net opening. Since D-nets are 12 inches wide, the area within this quadrat is 1ft^2 (0.09 m^2). Restrict your sampling to within that area. If desired, a wire frame of the correct dimensions can be placed in front of the net to help delineate the quadrat to be sampled, but it is often sufficient to use the net dimensions to keep the sampling area consistent.

TRC-Step 4. Working backward from the upstream edge of the sampling plot, check the quadrat for heavy organisms such as mussels, snails, and stone-cased caddisflies. Remove these organisms from the substrate by hand and place them into the net. Carefully pick up and rub stones directly in front of the net to remove attached animals. Remove and clean all of the rocks larger than a golf ball ($\sim$3 cm) within your sampling quadrat such that all the organisms attached to them are washed downstream into your net. Set these rocks outside your sampling quadrat after you have cleaned them. If the substrate is consolidated or comprised of large, heavy rocks, use your feet to kick and dislodge the substrate to displace BMIs into the net. If you cannot remove a rock from the stream bottom, rub it (concentrating on cracks or indentations) thereby loosening any attached insects. As you are disturbing the plot, let the water current carry all loosened material into the net.

Note 1: *Brushes are sometimes used in other bioassessment protocols to help loosen organisms, but in the interest of standardizing collections, do not use a brush when following this protocol.*

Note 2: *In sandy-bottomed streams, kicking within run habitats can quickly fill the sampling net with sand. In these situations, follow the standard procedures but use care to disturb the substrate gently and avoid kicking.*

TRC-Step 5. Once the coarser substrates have been removed from the quadrat, dig your fingers through the remaining underlying material to a depth of about 10 cm (this material is often comprised of gravels and finer particles). Thoroughly manipulate the substrates in the quadrat.

Note: *The sampler may spend as much time as necessary to inspect and clean larger substrates, but should take a standard time of 30 seconds to perform Step 5.*

TRC-Step 6. Let the water run clear of any insects or organic material before carefully lifting the net. Immerse the net in the stream several times to remove fine sediments and to concentrate organisms at the end of the net, but be careful to avoid having any water or foreign material enter the mouth of the net during this operation.

TRC-Step 7. Move upstream to the next randomly selected habitat unit and repeat steps one through six, taking care to keep the net wet but uncontaminated by foreign material when moving the net from riffle to riffle. Sometimes, the net will become so full of material from the streambed that it is no longer effective at capturing BMIs. In these cases, the net should be emptied into sample jars as frequently as necessary, following guidelines described below in the "Preparation of BMI Sample Jars" section. Continue until you have sampled eight $1ft^2$ ($0.09\ m^2$) of benthos.

TRC-Step 8. PROCEED to Section IIIc. Filling and Labeling BMI Sample Jars.

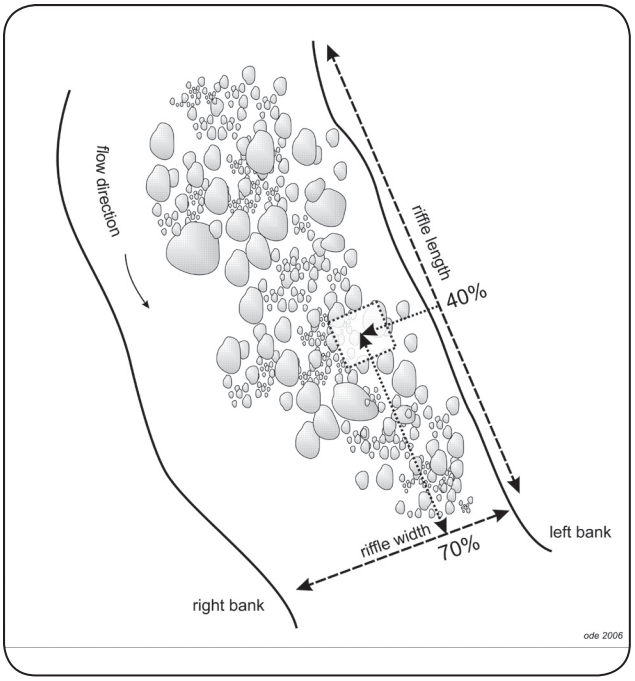

Figure 3. Example showing the method for selecting a subsampling position within a selected riffle under the TRC method. In this example, the random numbers 4 and 7 were selected

SECTION III B. REACHWIDE BENTHOS (MULTIHABITAT) PROCEDURE

The RWB procedure employs an objective method for selecting subsampling locations that is built upon the 11 transects used for physical habitat measurements. The RWB procedure can be used to sample any wadeable stream reach since it does not target specific habitats. Because sampling locations are defined by the transect layout, the position of individual sub-samples may fall in a variety of erosional or depositional habitats.

Note: *Sampling locations should be displaced one meter downstream of the transects to avoid disturbing substrates for subsequent physical habitat assessments.*

RWB -Step 1. The sampling position within each transect is alternated between the left, center and right positions along a transect (25%, 50% and 75% of wetted width, respectively) as you move upstream from transect to transect. Starting with the downstream transect (Transect

A), identify a point that is 25% of the stream width from the right bank (note that the right bank will be on your left as you face upstream). If you cannot collect a sample at the designated point because of deep water obstacles or unsafe conditions, relocate the point as close as possible to the designated position.

Note: *A modification to this procedure is currently being investigated by SWAMP. This "margin-center-margin" (MCM) modification replaces the samples at 25% and 75% of wetted width with samples of the marginal habitats (including emergent and submergent vegetation).*

RWB -Step 2. Place a 500-µ D-net in the water so the mouth of the net is perpendicular to and facing into the flow of the water. If there is sufficient current in the area at the sampling point to fully extend the net, use the normal D-net collection technique to collect the sub-sample (TRC-Step 3 through TRC-Step 6 above). If flow volume and velocity is not sufficient to use the normal collection technique, use the sampling procedure for "slack water" habitats (RWB-Step 3 through RWB-Step 7 below).

RWB -Step 3. Visually define a 1 ft^2 (0.09 m^2) quadrat that is one net-width wide and one net-width long at the sampling point.

RWB -Step 4. Working backward from the upstream edge of the sampling plot, check the quadrat for heavy organisms such as mussels and snails. Remove these organisms from the substrate by hand and place them into the net. Carefully pick up and rub stones directly in front of the net to remove attached animals. Remove and clean all of the rocks larger than a golf ball within your sampling quadrat such that all the organisms attached to them are washed downstream into your net. Set these rocks outside your sampling quadrat after you have cleaned them. Large rocks that are less than halfway into the sampling area should be pushed aside. If the substrate is consolidated or comprised of large, heavy rocks, use your feet to kick and dislodge the substrate to displace BMIs into the net. If you cannot remove a rock from the stream bottom, rub it (concentrating on cracks or indentations) thereby loosening any attached insects.

RWB -Step 5. Vigorously kick the remaining finer substrate within the quadrat with your feet while dragging the net repeatedly through the disturbed area just above the bottom. Keep moving the net all the time so that the organisms trapped in the net will not escape. Continue kicking the substrate and moving the net for 30 seconds. For vegetation-choked sampling points, sweep the net through the vegetation within a 1ft^2 (0.09 m^2) quadrat for 30 seconds.

Note: *If flow volume is insufficient to use a D- net, spend 30 seconds hand picking a sample from 1ft^2 of substrate at the sampling point, then stir up the substrate with your gloved hands and use a sieve with 500-µ mesh size to collect the organisms from the water in the same way the net is used in larger pools.*

RWB -Step 6. After 30 seconds, remove the net from the water with a quick upstream motion to wash the organisms to the bottom of the net.

RWB -Step 7. PROCEED to Section IIIc: Filling and Labeling BMI Sample Jars

SECTION III C. FILLING AND LABELING BENTHIC MACROINVERTEBRATE SAMPLE JARS

Step 1. Once all sub-samples (eight for TRC, 11 for RWB) have been collected, transfer benthos to a 500-mL or 1000-mL wide-mouth plastic sample jar using one of the following methods.

Note: *Field elutriation should only be used by well-trained field crews who are proficient at removing all benthic organisms from the discarded inorganic material. Training in the recognition of aquatic invertebrates is highly recommended.*

Step 1a. Complete Transfer of all Sampled Material – Invert the contents of the kick net into the sample jar. Perform this operation over a white enameled tray to avoid loss of any sampled material and make recovery of spilled organisms easier. If possible, remove the larger twigs and rocks by hand after carefully inspecting for clinging organisms, but be sure not to lose any organisms. Use forceps to remove any organisms clinging to the net and place these in the sample jar.

Step 1b. Field Elutriation of Samples – Empty the contents of the net into a large plastic bucket (10-20 L is sufficient). Use forceps to remove any organisms clinging to the net and place these in the bucket. Add stream water to the bucket and gently swirl the contents of the bucket in order to suspend the organic material (being certain to not introduce entrained organisms from the source water). Pour the organic matter from the bucket through a 500-µ sieve (or use the 500-µ net). Repeat this process until no additional material can be elutriated (i.e., only inorganic material is left in the bucket). If possible, remove the larger twigs and rocks by hand after carefully inspecting for clinging organisms, but be sure not to lose any organisms. Transfer all of the material in the sieve (invertebrates and organic matter) into the sample jar. Carefully inspect the gravel and debris remaining in the bottom of the bucket for any cased caddisflies, clams, snails, or other dense animals that might remain. Remove any remaining animals by hand and place them in the sample jar.

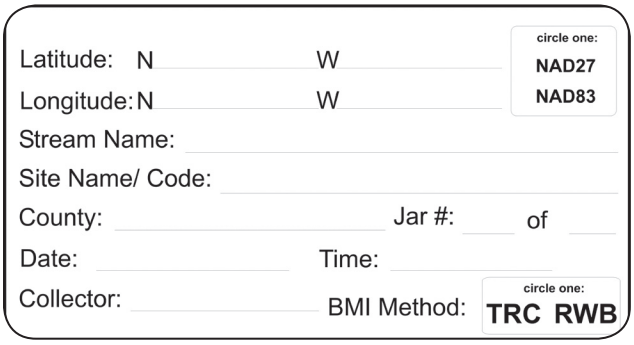

Figure 4. Example date - locality label for all BMI samples.

Step 2. Place a completed date/locality label (see Figure 4) on the inside of the jar (use pencil only as most "permanent" inks dissolve in ethanol) and completely fill with 95% ethanol. Place a second label on the outside of the jar. Note that the target concentration of ethanol is 70%, but 95% ethanol is used in the field to account for dilution from water in the sample. If organic and inorganic material does not accumulate in the net quickly, it may be possible to transfer all the material in the net into one jar. Otherwise, divide the material evenly among several jars

(being careful to clearly label them as part of a set). To ensure proper preservation of benthic macroinvertebrates it is critical that the ethanol is in contact with the BMIs in the sample jar. Never fill a jar more than 2/3 full with sampled material, and gently rotate jars that contain mostly mud or sand to ensure that the ethanol is well distributed. If jars will be stored for longer than a month prior to processing, jars should not contain more than 50% sample material.

SECTION 4
MAIN CROSS-SECTIONAL TRANSECT MEASURES

SECTION IVA. PHYSICAL MEASURES

The majority of physical habitat measurements in this protocol are made relative to the main cross-sectional transects (Figure 5). All the measures taken relative to each transect are recorded on forms specific to that transect. Start with the downstream transect (Transect A) and repeat steps 6-15 for all 11 main transects.

Module A. Transect Dimensions: Wetted Width and Bankfull Dimensions

Wetted Width – The wetted channel is the zone that is inundated with water and the wetted width is the distance between the sides of the channel at the point where substrates are no longer surrounded by surface water. Measure the wetted stream width and record this in the box at the top of the transect form.

Bankfull Width and Depth – The bankfull channel is the zone of maximum water inundation in a normal flow year (one to two year flood events). Since most channel formation processes are believed to act when flows are within this zone (Mount 1995), bankfull dimensions provide a valuable indication of relative size of the waterbody.

Note: *Bankfull dimensions are notoriously difficult to assess, even by experienced field crews (see Heil and Johnson 1995). It is often useful to discuss the interpretation of bankfull locations among the field crew members to reach a consensus. The USFS Stream Team provides a good set of instructional videos for improving consistency in accurate bankfull measurements (http://www.stream.fs.fed.us/publications/videos.html).*

Step 1. Scout along the stream margins to identify the location of the bankfull margins on either bank by looking for evidence of annual or semi-annual flood events. Examples of useful evidence includes topographic, vegetative, or geologic cues (changes in bank slope, changes from annual to perennial vegetation, changes in the size distribution of surface sediments). While the position of drift material caught in vegetation may be a helpful aid, this can lead to very misleading measurements.

Note: *The exact nature of this evidence varies widely across a range of stream types and geomorphic characteristics. It is helpful to investigate the entire reach when attempting to interpret this evidence because the true bankfull margin may be obscured at various points along the reach. Often the bankfull position is easier to interpret from one bank than the other; in these cases, it is easiest to infer the opposite bank position by projecting across the channel. Additionally, height can be verified by measuring the height from both edges of the wetted channel to the bankfull height (these heights should be equal).*

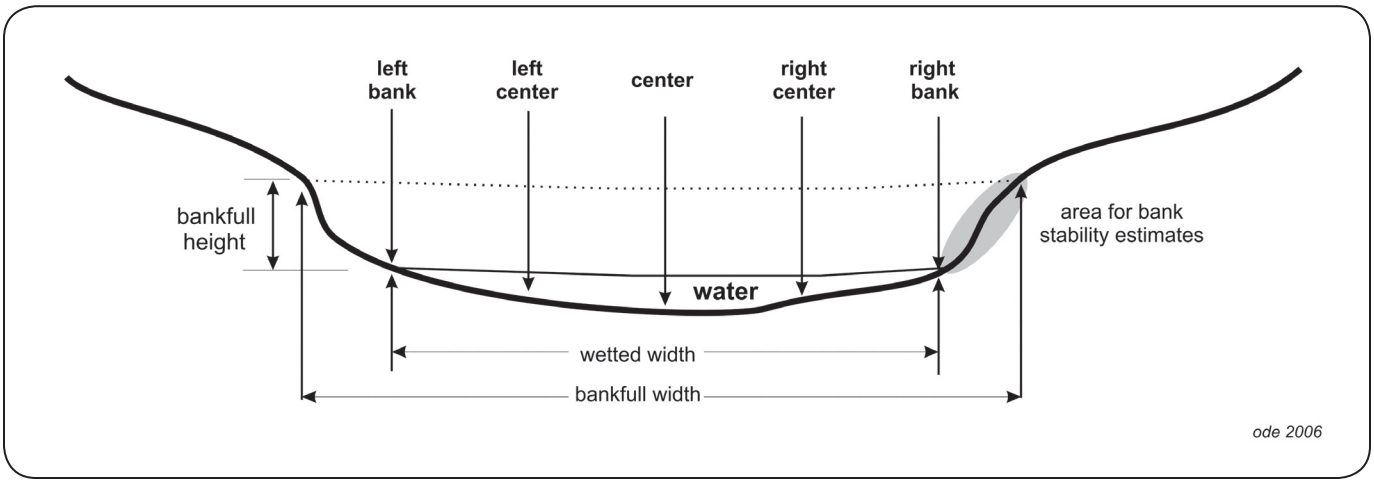

Figure 5. Cross sectional diagram of a typical stream channel showing locations of substrate measurements, wetted and bankfull width measurements, and bank stability visual estimates.

Step 2. Stretch a tape from bank to bank at the bankfull position. Measure the width of the bankfull channel from bank to bank at bankfull height and perpendicular to the direction of stream flow.

Step 3. Measure bankfull height (the vertical distance between the water height of the water and the height of the bank, Figure 5) and record.

Module B. Transect Substrate Measurements

Particle size frequency distributions often provide valuable information about instream habitat conditions that affect BMI distributions. The Wolman pebble count technique (Wolman 1954) is a widely used and cost-effective method for estimating the particle size distribution and produces data that correlates with costly, but more quantitative bulk sediment samples. The method described here follows the EMAP protocol, which records sizes of 105 particles in a reach (five particles from each of 11 main transects and 10 inter-transects).

Note: *The size cutoff for the finest particle sizes in the EMAP protocol (< 0.06 mm) differs from that used by the Sierra Nevada Aquatic Research Laboratory (SNARL) program (0.25 mm), although the narrative description for this cutoff is the same (the point at which fine particles rubbed between one's fingers no longer feel gritty).*

Coarse particulate organic matter (CPOM, particles of decaying organic material such as leaves that are greater than 1.0 mm in diameter) is a general indicator of the amount of allochthonous organic matter available at a site, and its measurement can provide valuable information about the basis of the food web in a stream reach. The presence of CPOM associated with each particle is quantified at the same time that particles are measured for the pebble counts.

Step 1. Transect substrate measurements are taken at five equidistant points along each transect (Figure 5). Divide the wetted stream width by four to get the distance between the five points (Left Bank, Left Center, Center, Right Center and Right Bank) and use a measuring device to locate the positions of these points (a stadia rod is especially helpful here). Once the positions are identified, lower a graduated rod (e.g., a marked ski pole) though the water column perpendicular to both the flow and the transect to objectively select the particle located at the tip of the rod.

Step 2. Measure the depth from the water surface to the top of the particle with the graduated rod and record to the nearest cm.

Step 3. Record the presence or absence of CPOM >1mm within 1 cm of the particle.

Step 4. If the particle is cobble-sized (64-250 mm), record the percent of the cobble that is embedded by fine particles (<2 mm) to the nearest 5% (see cobble embeddedness text below).

Step 5. Remove the particle from the streambed, then measure and record the length of its intermediate axis to the nearest mm (see Figure 6). Alternatively, assign the particle to one of the size classes listed in the bottom of the transect form. Particle sizes classes can be estimated visually or with a quantitative measuring device (e.g., pass/ no-pass template, "gravelometer"). Regardless of the method, all particles less than 0.06 mm should be recorded as fines, all particles between 0.06mm and 2.0 mm recorded as sand. Field crews may want to carry vials containing sediment particles with these size ranges until they are familiar with these particles.

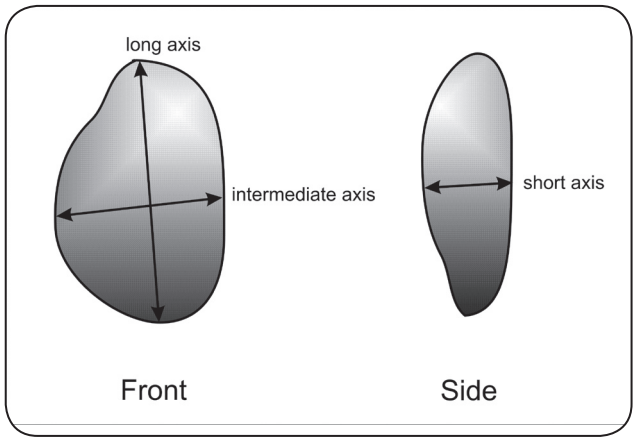

Figure 6. Diagram of three major perpendicular axes of substrate particles. The intermediate axis is recorded for pebble counts.

Module C. Cobble Embeddedness

The quantification of substrate embeddedness has long been a challenge to stream geomorphologists and ecologists (Klamt 1976, Kelley and Dettman 1980). It is generally agreed that the degree to which fine particles fill interstitial spaces has a significant impact on the ecology of benthic organisms and fish, but techniques for measuring this impact vary greatly (this is summarized well by Sylte and Fischenich 2002, http://stream.fs.fed.us/news/streamnt/pdf/StreamOCT4.pdf). Here we define embeddedness as the volume of cobble-sized particles (64-250 mm) that is buried by fine particles (<2.0 mm diameter).

Note: *This method differs from the EMAP method for measuring embeddedness, which measures embeddedness of all particles larger than 2 mm.*

Table 4. Size class codes and definitions for particle size measurements

Size Class Code	Size Class Description	Common Size Reference	Size Class Range
RS	bedrock, smooth	larger than a car	> 4 m
RR	bedrock, rough	larger than a car	> 4 m
XB	boulder, large	meter stick to car	1 - 4 m
SB	boulder, small	basketball to meter stick	25 cm - 1.0 m
CB	cobble	tennis ball to basketball	64 - 250 mm
GC	gravel, coarse	marble to tennis ball	16 - 64 mm
GF	gravel, fine	ladybug to marble	2 – 16 mm
SA	sand	gritty to ladybug	0.06 – 2 mm
FN	fines	not gritty	< 0.06 mm
HP	hardpan (consolidated fines)		< 0.06 mm
WD	wood		
RC	concrete/ asphalt		
OT	other		

Step 1. Every time a cobble-sized particle is encountered during the pebble count, remove the cobble from the stream bed and visually estimate the percentage of the cobble's volume that has been buried by fine particles. Since visual estimates of volume and surface area are subject to large amounts of observer error, field crews should routinely calibrate their estimates with each other and with other field crews.

Step 2. In the spaces to the right of the pebble count data, record the embeddedness of all cobble-sized particles encountered during the pebble count.

Note: *The cobble embeddedness scores do not correspond with the specific particles in the pebble count cells to the left, but are merely a convenient place to record the data.*

Step 3. If 25 cobbles are not encountered during the pebble count, supplement the cobbles by conducting a "random walk" through the reach. Starting at a random point in the reach, follow a transect from one bank to the other at a randomly chosen angle. Once at the other bank reverse the process with a new randomly chosen angle. Record embeddedness of cobble-sized particles in the cobble embeddedness boxes on the transect forms until you reach 25 cobbles. If 25 cobble-sized particles are not present in the entire reach, then record the values for cobbles that are present.

Module D. Canopy Cover

This method uses the Strickler (1959) modification of a convex spherical densiometer to correct for over-estimation of canopy density that occurs with unmodified readings. Read the densiometer by counting the number of line intersections that are obscured by overhanging vegetation (see Figure 7). Taping off the lower left and right portions of the mirror emphasizes overhead vegetation over foreground vegetation (the main source of bias in canopy density measurements). All densiometer readings should be taken with the bubble leveled and 0.3 m (1 ft) above the water surface.

Step 1. Using a modified convex spherical densitometer, take and record four 17-point readings all taken from the center of each transect: a) facing upstream, b) facing downstream, c) facing the left bank, d) facing the right bank.

Note: *This method deviates slightly from that of EMAP (in which two additional readings are taken at the left and right wetted edges to increase representation of bank vegetation).*

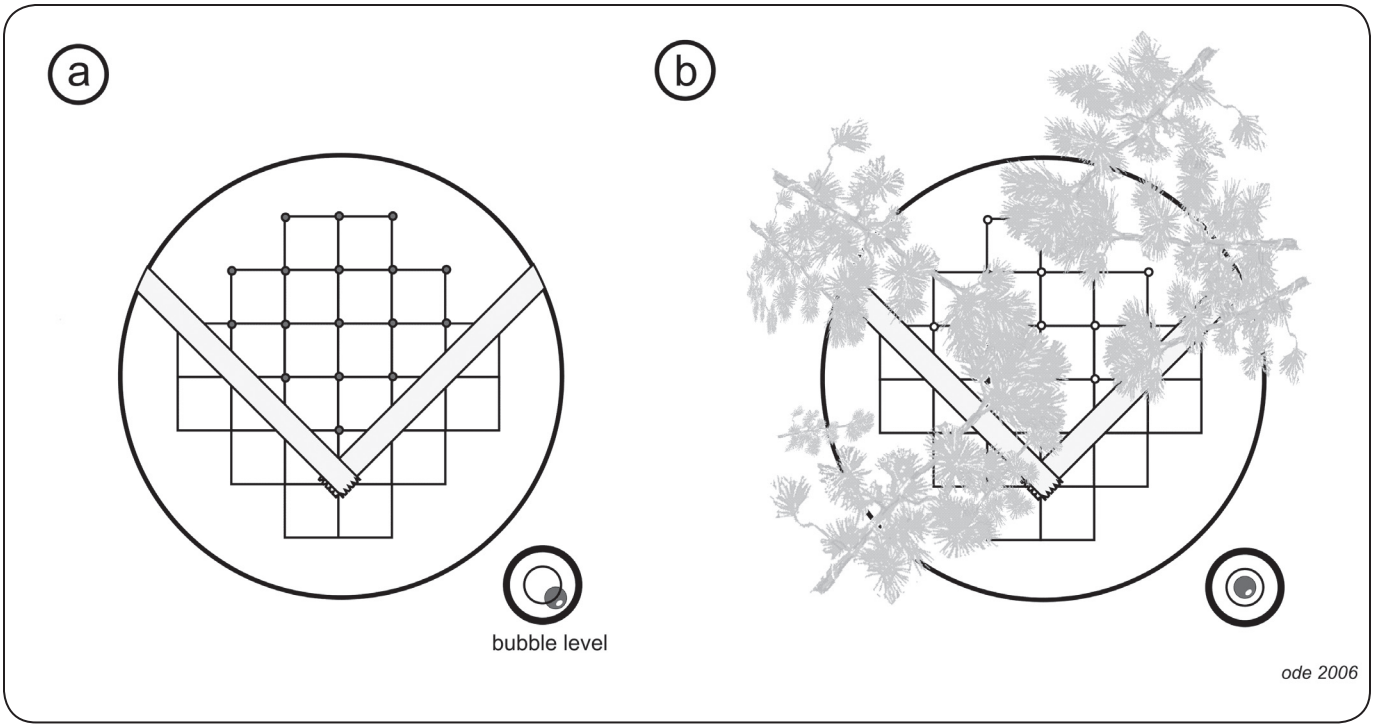

Figure 7. Representation of the mirrored surface of a convex spherical densiometer showing the position for taping the mirror and the intersection points used for the densiometer reading. The score for the hypothetical condition in (b) is 10 covered intersection points out of 17 possible. Note the position of the bubble level in (b) when the densiometer is leveled.

Module E. Gradient and Sinuosity

The gradient of a stream reach is one of the major stream classification variables, giving an indication of potential water velocities and stream power, which are in turn important controls on aquatic habitat and sediment transport within the reach. The gradient (slope) of a stream reach is often strongly correlated with many BMI metrics and other physical habitat measures and is therefore very useful when interpreting BMI data.

The "full" physical habitat method uses 10 transect to transect measurements to calculate the average slope through a reach. Although this is a little more time intensive than the reach-scale transect measures used in the "basic" protocol, it results in more precise slope determination and the ability to quantify slope variability within a reach. Sinuosity (calculated as the ratio of the length of the flow path between the ends of the reach and the straight line distance between the ends of the reach, Kaufmann et al. 1999) is measured at the same time as slope. These two measurements work best with two people, one taking the readings at the upstream transect ("backsighting") and the other holding a stadia rod at the downstream transect. If you cannot see the mid point of the next transect from the starting point, use the supplemental sections (indicating the proportion of the total length represented by each section). Otherwise, leave these blank.

Note 1: *An auto level should be used for reaches with a percent slope of less than or equal to 1%. All methods (clinometer, hand level, or auto level) may be used for reaches with a percent slope of greater than 1%. The following description is for clinometer-based slope measurements, but the same principles apply to use of an auto or hand level.*

Note 2: *In reaches that are close to 1%, you will not know whether you are above or below the 1% slope cutoff before taking readings. In these cases, default to use of an autolevel.*

Step 1. Beginning with the upper transect (Transect K), one person (the measurer) should stand at the water margin with a clinometer held at eye level. A second person should stand at the margin of the next downstream transect (Transect J) with a stadia rod flagged at the eye level of the person taking the clinometer readings. Be sure you mark your eye level while standing on level ground! Adjust for water depth by measuring from the same height above the water surface at both transects. This is most easily accomplished by holding the base of the pole at water level.

Note: *An alternative technique is to use two stadia rods pre-flagged at the eye-height of the person taking the readings.*

Step 2. Use a clinometer to measure the percent slope of the water surface (not the streambed) between the upstream transect and the downstream transect by sighting to the flagged position on the stadia rod. The clinometer reads both percent slope and degree of the slope. Be careful to read and record percent slope rather than degrees slope (these measurements differ by a factor of ~ 2.2). Percent slope is the scale on the right hand side as you look through most clinometers (e.g., Suunto models).

Note: *If an auto level or hand level is used, record the elevation difference (rise) between transects and the segment length (run) instead of the percent slope.*

Step 3. If the stream reach geometry makes it difficult to sight a line between transects, divide the distance into two or three sections and record the slope and the proportion of the total segment length between transects for each of these sections in the appropriate boxes on the slope form (supplemental segments).

Note: *Never measure slope across dry land (e.g., across a meander bend).*

Step 4. Take a compass reading from the center of each main transect to the center of the next main transect downstream and record this bearing to the nearest degree on the slope and bearing section of the form. Bearing measurements should always be taken from the upstream to downstream transect.

Step 5. Proceed downstream to the next transect pair (I-J) and continue to record slope and bearing between each pair of transects until measurements have been recorded for all transects.

SECTION IVB. VISUAL ESTIMATES OF HUMAN INFLUENCE, INSTREAM HABITAT, AND RIPARIAN VEGETATION

The transect-based approach used here permits semi-quantitative calculations from visual estimates even though most are categorical data (i.e., either presence/ absence or size classes) because we can calculate the percentage of transects that fall into different categories. These modules are adapted directly from EMAP protocols with some modifications as noted.

Module F. Human Influence

The influence of human activities on stream biota is of critical concern in bioassessment analyses. Quantification of human activities for these analyses is often performed with GIS techniques, which are very useful but are not capable of accounting for human activities occurring at the reach scale. Reach scale observations are often critical for explaining results that might seem anomalous on the basis of only remote mapping tools.

Step 1. For the left and right banks, estimate a 10 x 10 m riparian area centered on the edges of the transect (see Figure 2). Record the presence of 11 human influence categories in three spatial zones relative to this 10 x 10 m square (between the wetted edge and bankfull margin, between the bankfull margin and 10 m from the stream, and between 10 m and 50 m beyond the stream margins): 1) walls/rip-rap/dams, 2) buildings, 3) pavement/cleared lots, 4) roads/railroads, 5) pipes (inlets or outlets), 6) landfills or trash, 7) parks or lawns (e.g., golf courses), 8) row crops, 9) pasture/ rangelands, 10) logging/ timber harvest activities, 11) mining activities, 12) vegetative management (herbicides, brush removal, mowing), 13) bridges/ abutments, 14) orchards or vineyards. Circle all combinations of impacts and locations that apply, but be careful to not double-count any human influence observations.

Step 2. Record the presence of any of the 11 human influence categories in the stream channel within a zone 5 m upstream and 5 m downstream of the transect.

Module G. Riparian Vegetation

Riparian vegetation (vegetation in the region beyond the bankfull margins) has a strong influence on the composition of stream communities through its direct and indirect roles in controlling the food base, moderating sediment inputs and acting as a buffer between the stream channel and the surrounding environment. These methods provide a cursory survey of the condition of the riparian corridor. Observations are made in the same 10 x 10 m riparian area used for assessing human influence (see Figure 2).

Note: *Riparian vegetation measurements should only include living or recently dead vegetation.*

The riparian vegetation categories used here were condensed from the EMAP version, which further breaks the canopy classes into different components. However, because we have consolidated EMAP categories into fewer categories rather than creating new categories, existing EMAP data can be easily converted to this format simply by combining the appropriate categories.

Step 1. Divide the riparian zone into three elevation zones: 1) ground cover (< 0.5 m), 2) lower canopy (0.5 m - 5 m), and 3) upper canopy (> 5 m). Record the density of the following riparian classes: 1) Upper Canopy–Trees and Saplings, 2) Lower Canopy–Woody Shrubs and Saplings, 3) Woody Ground Cover–Shrubs, Saplings, 4) Herbaceous Ground Cover–Herbs and Grasses, and 5) Ground Cover–Barren, Bare Soil and Duff. Artificial banks (e.g., rip-rap, concrete, asphalt) should be recorded as barren.

Step 2. Indicate the areal cover (i.e., shading) by each riparian vegetative class as either: 1) absent, 2) sparse (< 10%), 3) moderate (10-40%), 4) heavy (40-75%), or 5) very heavy (> 75%).

Module H. Instream Habitat Complexity

Instream habitat complexity was developed by the EMAP program to quantify fish concealment features in the stream channel, but it also provides good information about the general condition and complexity of the stream channel. Estimates should include features within the banks and outside the wetted margins of the stream.

Step 1. Record the amount of nine different channel features within a zone 5m upstream and 5m downstream of the transect (see Figure 2): 1) filamentous algae (long-stranded algal forms that are large enough to see with the naked eye), 2) aquatic macrophytes (include mosses and vascular plants), 3) boulders (> 25 cm), 4 and 5) woody debris (break into two classes- larger and smaller than 30 cm diameter), 6) undercut banks, 7) overhanging vegetation, 8) live tree roots and 9) artificial structures (includes any anthropogenic objects including large trash objects like tires and shopping carts). Indicate the areal cover of each feature as either: 1) absent, 2) sparse (< 10%), 3) moderate (10-40%), 4) heavy (40-75%), or 5) very heavy (> 75%).

SECTION 5
INTER-TRANSECT MEASURES

While most measures are taken at or relative to the main transects, a few measures are recorded at transects located at the midpoint between main transects. These are called "inter-transects".

Module B (Part 2) Pebble Counts (same as for transects, but no cobble embeddedness measures)

Step 1. Divide the wetted stream width by four to get the distance between the five points (Left Bank, Left Center, Center, Right Center and Right Bank) and use a measuring device to locate the positions of these points (a stadia rod is especially helpful here, see Figure 5). Once the positions are identified, lower a graduated rod through the water column perpendicular to both the flow and the transect to objectively select the particle located at its tip.

Step 2. With the graduated rod, measure the depth from the water surface to the top of the particle and record to the nearest cm.

Step 3. Remove the particle from the streambed, then measure and record the length of its intermediate axis to the nearest mm (see Figure 6). Alternatively, assign the particle to one of the size classes listed in the bottom of the transect form (see Table 3 for a list of size classes). Particle size classes may be estimated visually or with a quantitative measuring device (e.g., pass/ no-pass template, gravelometer). Regardless of the method, all particles less than 0.06 mm should be recorded as fines, while all particles between 0.06 mm and 2.0 mm should be recorded as sand. Field crews may want to carry vials containing sediment particles with these size ranges until they are familiar with these particle size classes.

Step 4. Record the presence (P) or absence (A) of any CPOM within 1 cm of each particle.

Module J. Flow Habitats

Because many benthic macroinvertebrates prefer specific flow and substrate microhabitats, the proportional representation of these habitats in a reach is often of interest in bioassessments. There are many different ways to quantify the proportions of different flow habitats (for example, see text on EMAP's "thalweg profile" below). Like the riparian and instream measures listed above, this procedure produces a semi-quantitative measure consisting of 10 transect-based visual estimates.

Note: *The categories used here are based on those used in the EMAP protocol, with pools combined into one class and cascades and falls combined into another class.*

Step 1. At each inter-transect, identify the proportion of six different habitat types in the region between the upstream transect and downstream transect: 1) cascades/falls, 2) rapids, 3) riffles, 4) runs, 5) glides, 6) pools, 7) dry areas. Record percentages to the nearest 5% — the total percentage of surface area for each section must total 100%.

SECTION 6 DISCHARGE

Stream discharge is the volume of water that moves past a point in a given amount of time and is generally reported as either cubic meters per second (cms) or cubic feet per second (cfs). Because discharge is directly related to water volume, discharge affects the concentration of nutrients, fine sediments and pollutants; and discharge measurements are critical for understanding impacts of disturbances such as impoundments, water withdrawals and water augmentation. Discharge is also closely related to many habitat characteristics including temperature regimes, physical habitat diversity, and habitat connectivity. As a direct result of these relationships, stream discharge is often also a strong predictor of biotic community composition. Since stream volume can vary significantly on many different temporal scales (diurnal, seasonal, inter-annually), it can also be very useful for understanding variation in stream condition.

This procedure (modified from the EMAP protocol) provides for two different methods for calculating discharge. It is preferable to take discharge measurements in sections where flow velocities are greater than 0.15 m/s and most depths are greater than 15 cm, but slower velocities and shallower depths can be used. If flow volume is sufficient for a transect-based "velocity-area" discharge calculation, this is by far the preferred method. If flow volume is too low to permit this procedure or if your flow meter fails, use the "neutrally buoyant object/ timed flow" method.

Note: *Programs that sample fixed sites repeatedly may want to consider installing permanent discharge estimation structures (e.g., stage gauges, wiers).*

Module K. Discharge: Velocity Area Method

The layout for discharge measurements under the velocity-area (VA) method is illustrated in Figure 8. Flow velocity should be measured with either a Swoffer Instruments propeller-type flow meter or a Marsh-McBirney inductive probe flow meter. Refer to the manufacturers' instrument manuals for calibration procedures.

VA-Step 1. Select the best location in the reach for measuring discharge. To maximize the repeatability of the discharge measurement, choose a transect with the most uniform flow (select hydraulically smooth flow whenever possible) and simplest cross-sectional geometry. It is acceptable to move substrates or other obstacles to create a more uniform cross-section before beginning the discharge measurements.

VA-Step 2. Measure the wetted width of the discharge transect and divide this into 10 to 20 equal segments. The use of more segments gives a better discharge calculation, but is impractical in small channels. A minimum of 10 intervals should be used when stream width permits, but interval width should not be less than 15 cm.

VA-Step 3. Record the distance from the bank to the end of the first interval. Using the top-setting rod that comes with the flow velocity meter, measure the median depth of the first interval.

VA-Step 4. Standing downstream of the transect to avoid interfering with the flow, use the top-setting rod to set the probe of the flow meter (either the propeller or the electromagnetic probe) at the midpoint of each interval, at 0.6 of the interval depth (this position generally approximates average velocity in the water column), and at right angles to the transect (facing upstream). See Figure 8 for positioning detail.

VA-Step 5. Allow the flow velocity meter to equilibrate for 10-20 seconds then record velocity to the nearest m/s. If the option is available, use the flow averaging setting on the flow meter.

Note: *Under very low flow conditions, flow velocity meters may register readings of zero even when there is noticeable flow. In these situations, record a velocity of 0.5x the minimum flow detection capabilities of the instrument.*

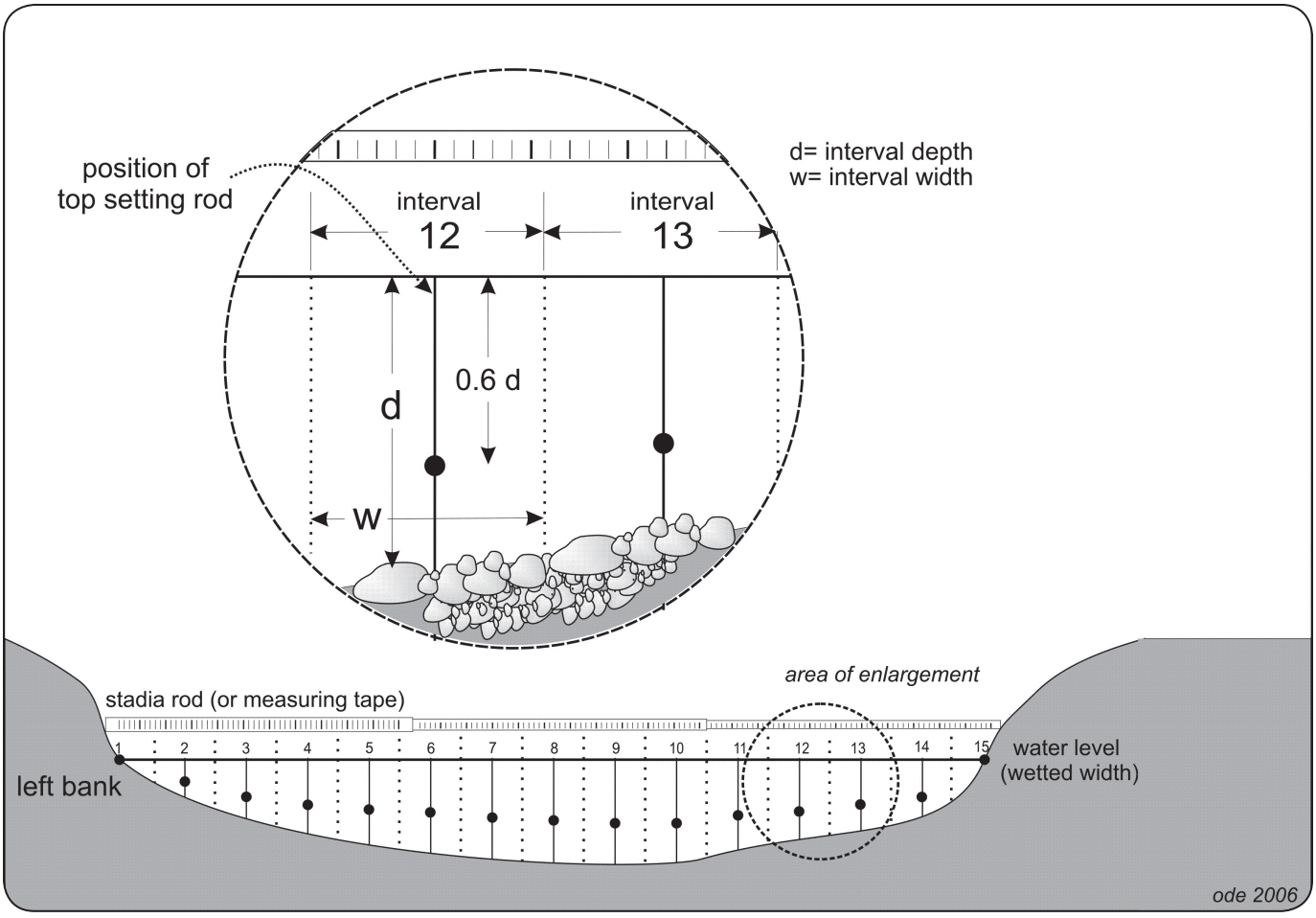

Figure 8. Diagram of layout for discharge measurements under the velocity-area method showing proper positions for velocity probe (black dots).

VA-Step 6. Complete Steps 3 through 5 on the remaining intervals.

Note: *The first and last intervals usually have depths and velocities of zero.*

Module L. Discharge: Neutrally Buoyant Object Method

If streams are too shallow to use a flow velocity meter, the neutrally buoyant object (NBO) method should be used to measure flow velocity. However, since this method is less precise than the flow velocity meter it should only be used if absolutely necessary. A neutrally buoyant object (one whose density allows it to just balance between sinking and floating) will act as if it were nearly weightless, thus it's movement will approximate that of the water it floats in better than a light object. To estimate the flow velocity through a reach, three transects are used to measure the cross-sectional areas within the test section sub-reach and three flow velocity estimates are used to measure average velocity through the test reach. To improve precision in velocity measurements, the reach segment should be long enough for the float time to last at least 10-15 seconds.

NBO-Step 1. The position of the discharge sub-reach is not as critical as it is for the velocity-area method, but the same criteria for selection of a discharge reach apply to the neutrally buoyant object method. Identify a section that has relatively uniform flow and a uniform cross sectional shape.

NBO-Step 2. The cross sectional area is estimated in a manner that is similar but less precise than that used in the velocity area method. Measure the cross sectional area in one to three places in the section designated for the discharge measurement (three evenly-spaced cross sections are preferred, but one may be used if the cross section through the reach is very uniform). Record the width once for each cross section and measure depth at five equally-spaced positions along each transect.

NBO-Step 3. Record the length of the discharge reach.

NBO-Step 4. Place a neutrally buoyant object (e.g., orange, rubber ball, heavy piece of wood, etc.) in the water upstream of the discharge reach and record the length of time in seconds that it takes for the object to pass between the upstream and downstream boundaries of the reach. Repeat this timed float three times.

SECTION 7
POST-SAMPLING OBSERVATIONS

Module M. Rapid Bioassessment Procedures Visual Assessment Scores (for Basic Physical Habitat, or optional supplement)

EPA's Rapid Bioassessment Procedures (RBPs, Barbour et al. 1999) include a set of 10 visual criteria for assessing instream and riparian habitat. The RBP has been used in the CSBP since its first edition (1995) and thus, this information is often valuable for comparison to legacy datasets. The criteria also have a useful didactic role since they help force the user to quantify key features of the physical environment where bioassessment samples are collected.

Module N. Additional Habitat Characterization (Full Physical Habitat only)

The RBP stream habitat visual estimates described in Step 1 are not included in the Full Physical Habitat version because they are generally replaced by more quantitative measurements of similar variables. However, we have found that three of the RBP measures are reasonably repeatable and include them in the reachwide assessment portion of the Full Physical Habitat version.

Note: *This is the only case in which a measurement included in the basic procedure is not included in the full.*

Module O. Reach Slope (for Basic Physical Habitat only)

Reach slope should be recorded as percent slope as opposed to degrees slope to avoid confusion. Slope measurements work best with two people, one taking the readings at the upstream transect and the other holding a stadia rod at the downstream transect. If you cannot see the mid point of the next transect from the starting point, use the supplemental sections (indicating the proportion of the total length represented by each section).

An auto level (with a tripod) should be used for reaches with a percent slope of less than or equal to 1%. All methods (clinometer, hand level, or auto level) may be used for reaches with a percent slope of greater than 1%. In reaches that are close to 1%, you will not know whether you are above or below the 1% slope cutoff. In these cases, default to use of an autolevel.

Step 1. Divide the reach into multiple segments such that stadia rod markings can be easily read with the measuring device to be employed (this is especially a factor for clinometer and hand level readings).

Step 2. Use a clinometer, hand level, or auto level to measure the percent slope of the water surface (not the streambed) between the top and bottom of each segment. Be sure to adjust for water depth by measuring from the same height above the water surface at both transects. Also be sure to record percent slope, not degrees slope. Record the segment length for each of these sections in the appropriate boxes on the BASIC slope form.

SECTION 8
OPTIONAL EXCESS SEDIMENT MEASURES

Future editions of these protocols will include supplemental modules, including a full discussion of the measurements used for calculating the excess sediment index (sometimes referred to as log relative bed stability, LRBS). However, since several of the measurements in EMAP's physical habitat protocols are interwoven into the layout of this protocol, a brief overview of the additional measurements collected for the LRBS calculations is included here for information purposes only. For detailed explanations of these measurements, consult Peck et al. 2004.

Woody Debris Tallies

Large woody debris (logs, snags, branches, etc.) that is capable of obstructing flow when the channel is at bankfull condition (just short of flood stage) contributes to the "roughness" of a channel. The effect of this variable is to reduce water velocity and thereby reduce the stream's competence to move substrate particles. The EMAP protocol tallies all woody debris with a diameter greater than 10 cm (~4") into one of 12 size classes based on the length and width of each object. Tallies are conducted in the zone between the main transects.

Thalweg Measurements

A stream's thalweg is a longitudinal profile that connects the deepest points of successive cross-sections of the stream. The thalweg defines the primary path of water flow through the reach. Thalweg measurements perform many functions in the EMAP protocols, producing measurements for the excess sediment calculations (residual pool volume, stream size, channel complexity) and flow habitat variability.

SECTION 9
OPTIONAL PERIPHYTON QUANTIFICATION

Periphyton Quantification

Characterization of periphyton has a dual role in bioassessments, as periphyton is both a food and habitat resource for benthic macroinvertebrates and fish and an effective bioindicator on its own. Quantification of periphytic resources will be covered under a separate SWAMP bioassessment protocol, but will include procedures for qualitative characterization of diatom assemblages, documentation of filamentous algal growth, and biomass quantification (e.g., ash-free dry mass and chlorophyll a).

SECTION 10
QUALITY ASSURANCE & CONTROL PROCEDURES

The SWAMP bioassessment group is currently developing guidelines for quality assurance and quality control for bioassessment procedures. Future revisions to this document will include guidance covering personnel qualifications, training and field audit procedures, procedures for field calibration, procedures for chain of custody documentation, requirements for measurement precision, health and safety warnings, cautions (actions that would result in instrument damage or compromised samples), and interferences (consequences of not following the standard operating procedure, SOP).

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DEFINITIONS OF TERMS USED IN SOP D

Terms & Definitions	
TERM	**DEFINITION**
ABL	California Department of Fish and Game's Aquatic Bioassessment Laboratory
Allocthonous	Derived from a source external to the stream channel (e.g., riparian vegetation) as opposed to autochthonous, which indicates a source inside the stream channel (e.g., periphyton).
Ambient Bioassessment	Biological monitoring that is intended to describe general biotic condition as opposed to a diagnosis of sources of impairment
Bankfull	The bankfull channel is the zone of maximum water inundation in a normal flow year (one to two year flood events)
BMI	Benthic macroinvertebrates: bottom-dwelling invertebrates large enough to be seen with the unaided eye
Cobble Embeddedness	The volume of cobble-sized particles (64-250 mm) that is buried by fine particles (<2.0 mm diameter)
CPOM	Coarse particulate organic matter (CPOM, particles of decaying organic material such as leaves that are greater than 1.0 mm in diameter)
CSBP	California State Bioassessment Procedures
DFG	California Department of Fish and Game
EMAP	The U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program
EPA	The U.S. Environmental Protection Agency
Fines	Substrate particles less than 0.06 mm diameter (not gritty to touch)
Inter-transects	Transects established at points equidistant between the main transects
MCM	Margin-Center-Margin alternative procedure for sampling low gradient habitats
ORD	EPA's Office of Research and Development
QAMP	Quality assurance management plan
RBP	EPA's Rapid Bioassessment Procedures
Reach	A segment of the stream channel
Riparian	An area of land and vegetation adjacent to a stream that has a direct effect on the stream.
RWB	Reach-wide benthos composite sampling method for benthic macroinvertebrates, also referred to as multi-habitat method
SCCWRP	Southern Coastal California Water Research Project
SNARL	Sierra Nevada Aquatic Research Laboratory
Substrate	The composition of a streambed, including both inorganic and organic particles
SWAMP	The State Water Resources Control Board's Surface Water Ambient Monitoring Program
Thalweg	A longitudinal profile that connects the deepest points at successive cross-sections of the stream. The thalweg defines the primary path of water flow through the reach

TERM	DEFINITION
Transects	Lines drawn perpendicular to the path of flow used for standardizing sampling locations
TRC	Targeted riffle composite sampling method for benthic macroinvertebrates
USFS	The United States Forest Service
Wadeable Streams	Streams that can be sampled by field crews wearing chest waders (generally less that 0.5 m - 1.0 meters deep)

APPENDIX A

FACTORS TO CONSIDER WHEN RECOMMENDING/ CHANGING BIOASSESSMENT METHODS

Beyond the primary considerations of precision and accuracy, there are at least five other key issues that SWAMP has considered and should consider in the future, when recommending or changing its official methods for bioassessment. These issues include:

1. Costs of Collecting Samples via Multiple Protocols – Collecting, processing, and interpreting samples using more than one method for each indicator (e.g., algae, macroinvertebrates, fish) per site adds significant costs to bioassessment monitoring programs. SWAMP should strive to identify the minimum set of protocols necessary for each indicator. However, this should not come at the expense of sound monitoring. If more than one method is needed to interpret the biological response, then this decision should be based on a cost-benefit assessment.

2. Costs of Maintaining Multiple SWAMP Protocols – While multiple methods for monitoring a given indicator may provide additional accuracy in specific habitats, there are significant costs to maintaining multiple protocols:

a. Need to maintain method-specific infrastructure (e.g., separate reference samples, separate indices of biotic integrity (IBIs), separate O/E models, etc.).
b. May lose or impair ability to compare across sites if different methods are used (see Issue 5 below).
c. Guidance on when to use methods becomes more complex. For example, we need to define very specifically which methods to use at each water body type; and thus, which tools can be used to interpret them.

Recommendation: *SWAMP should maintain as few protocols as necessary. If we elect to add new or modified protocols it should be because we have determined that the added value is worth all of the costs listed above.*

3. Separating Physical Impairment from Water Quality Impairment – One of the original reasons for adding a multihabitat component to SWAMP bioassessment programs was the potential for distinguishing physical and water quality impairment sources (see recommendations in Barbour and Hill 2002). In regards to macroinvertebrate indicators, the conventional wisdom has been that reachwide (RW, sometimes referred to as multihabitat or MH) samples should be relatively more responsive to physical habitat alteration (i.e., fine sediment inputs) than targeted-riffle (TR) samples because it is believed that erosional habitats take longer

to respond to sediment stresses, and because pockets of riffle habitat are thought to act as refugia from habitat loss. To the extent that this is true, RW and TR samples may offer complementary information that allows us to separate these sources of impairment.

While very few studies have addressed this conventional wisdom directly, recent studies suggest that this may not be as much a factor as previously believed. In a recent comparison of TR and RW samples at nearly 200 sites statewide, the ABL found at most weak evidence to support this notion (Rehn et al. 2007). Gerth and Herlihy (2006) came to the same conclusion in their analysis of ~500 sites in the eastern and western United States. However, this issue is far from resolved and SWAMP scientists currently are not in agreement regarding this issue. Since the majority of bioassessment programs in California have emphasized targeted riffle sampling, SWAMP will undoubtedly want to evaluate this question further before making any policy decision to discontinue TR sampling.

Recommendation: *Until this issue can be evaluated further and resolved to SWAMP's satisfaction, ambient macroinvertebrate sampling should include collection of both RW samples and richest targeted habitat (TR or MCM) samples at every site. (The TR method should be used where sufficient riffles are present, and the MCM method should be used at low-gradient sites where sufficient riffle habitat is not available.)*

4. Compatibility with Previous Data – To address this issue, at least three sets of macroinvertebrate sampling method comparisons have been conducted in California.

a. **Targeted Riffle Methods –** Comparisons are complete. Samples collected under the current TR protocols are considered interchangeable with both CSBP and SNARL samples (Ode et al. 2005, Herbst and Silldorff 2006).
b. **Low Gradient Sand-Dominated Streams –** Collaborative studies are currently underway between Water Board Regions 3 and 5, the Southern California Coastal Water Research Project (SCCWRP), and ABL to compare the performance of: (1) the "low-gradient" CSBP; (2) RW samples; and (3) a modification of the RW method designed to emphasize habitats along stream margins (MCM). The results of these low-gradient methods comparisons are not yet available.
c. **Targeted Riffle vs. Reachwide Methods –** A recent comparison of RW and TR samples collected from nearly 200 EMAP/ CMAP sites is in peer review press (Rehn et al. 2007). Results demonstrate remarkably similar performance of the methods across a wide range of habitats. Gerth and Herlihy (2006) recently published a similar analysis with the same conclusions. However, the bioassessment committee has yet to carefully review and discuss these analyses and their implications for SWAMP biomonitoring.

5. Comparability Among Sites – The ability to compare biological condition across sites is a common requirement of most ambient bioassessment programs. This type of analysis is confounded if different methods are used at these sites. One of the big advantages of reachwide (i.e., multihabitat) methods is that they can be applied anywhere because they don't require a specific habitat for sampling. Statewide

bioassessments and most regional programs will require the ability to compare their bioassessment results among multiple sites (e.g., within a watershed, within a region, statewide).

INTERIM RECOMMENDATIONS FOR MACROINVERTEBRATE SAMPLING (UPDATED DECEMBER 2006):

1. Until we can reach consensus on the outstanding issues (i.e., whether a single method for macroinvertebrate sampling will meet our needs, and the outcome of RW vs. MCM comparison studies for low-gradient wadeable streams/rivers), SWAMP recommends collecting both a reachwide (i.e., multihabitat) and a targeted habitat sample at each site. In high gradient streams, this means using both the RW and TR methods. In low-gradient streams, we recommend collecting both RW and MCM samples until the results are available from the low-gradient ("non-riffle") comparison. In rare cases where monitoring objectives cannot be met following these recommendations, the SWAMP Bioassessment Coordinator may authorize deviations. For example, where project-specific objectives differ from ambient monitoring, the SWAMP Bioassessment Coordinator may authorize alternate methods. In rare cases where funding is extremely limited and the cost of following the above recommendations would be prohibitive, the SWAMP Bioassessment Coordinator may authorize cost-saving options such as collecting both samples, but archiving one of the samples for later lab analysis.

2. SWAMP should develop guidance specifying when and where different methods should be used. For example, at "low gradient" sites, what is the slope cut-off (or other channel feature criteria to use) when deciding whether to apply TR or MCM? In addition, while SWAMP may eventually choose to adopt a single method (such as RW) at most sites, some regions may determine that the value of targeted habitat sampling merits continued sampling with supplemental protocols. In the latter case, or if SWAMP determines that distinct methods are needed for different habitat types, the guidance should specify the types of waterbodies or classes of waterbodies that require different methods.

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APPENDIX G:

SWAMP ALGAE FIELD SOP

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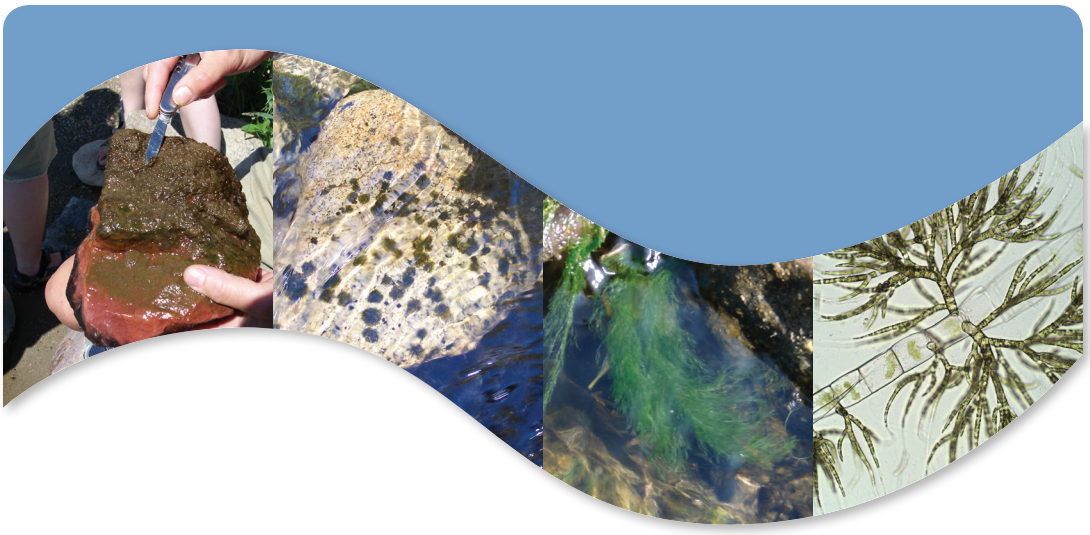

SWAMP
Surface Water Ambient Monitoring Program

SWAMP Bioassessment Procedures 2010

Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California

June 2009, updated May 2010

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Standard Operating Procedures for Collecting Stream Algae Samples and Associated Physical Habitat and Chemical Data for Ambient Bioassessments in California

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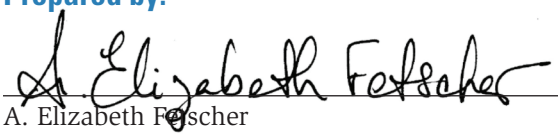

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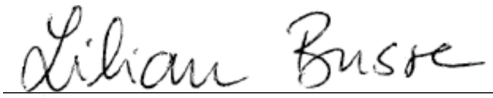

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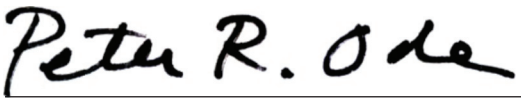

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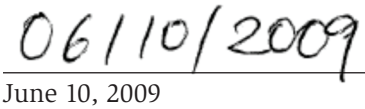

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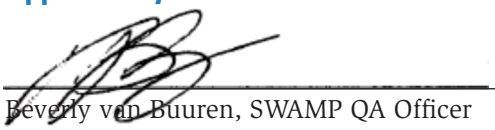

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This Standard Operating Procedures (SOP) manual represents the contributions of a wide range of researchers and field crews. The algal specimen collection methodology presented represents a modification of the U.S. Environmental Protection Agency's (EPA's) Environmental Monitoring and Assessment Program (EMAP) multihabitat sampling protocol (Peck et al. 2006). Point-intercept estimation of macroalgal cover has been adapted from the U.S. Geological Survey's (USGS's) National Water Quality Assessment (NAWQA) pilot procedures (J. Berkman, pers comm.), and assessment of microalgal thickness has been adapted from Stevenson and Rollins (2006). The physical habitat (PHab) methods are identical to those presented in the SWAMP Bioassessment protocol of Ode (2007), with the exception of the point-intercept method for determining algal cover, which is an add-on to the PHab pebble count procedure. The PHab procedures are, in turn, minor modifications of those used in EMAP and developed by EPA's Office of Research and Development (ORD, Peck et al. 2006).

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LIST OF ACRONYMS & ABBREVIATIONS L

Acronyms & Abbreviations	Definitions
AFDM	Ash-Free Dry Mass
BMI	Benthic Macroinvertebrate
chl a	Chlorophyll *a*
CPOM	Coarse Particulate Organic Matter
DO	Dissolved Oxygen
EMAP	Environmental Monitoring and Assessment Program (of the U.S. EPA)
GPS	Global Positioning System
IBI	Index of Biotic Integrity
MCM	Margin-Center-Margin
NAD	North American Datum
NAWQA	National Water Quality Assessment (of the U.S. Geological Survey)
NBO	Neutrally Buoyant Object
NNE	Nutrient Numeric Endpoints
OSPR	Office of Spill Prevention and Response (of the California Department of Fish and Game)
PHab	Physical Habitat
QAPrP	Quality Assurance Program Plan (of SWAMP)
ORD	Office of Research and Development (of the U.S. EPA)
RBP	Rapid Bioassessment Procedures
RWB	Reachwide Benthos
SOP	Standard Operating Procedures
SWAMP	Surface Water Ambient Monitoring Program
TRC	Targeted Riffle Composite

SECTION 1 INTRODUCTION

This document is the Standard Operating Procedure (SOP) for collecting and field-processing stream algae for the California State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP). Instructions are provided for the following:

- collection of samples for taxonomic identification of diatoms and soft-bodied algae
- collection of samples for determination of biomass based on chlorophyll *a* and ash-free dry mass (AFDM)
- estimation of percent algal cover

The document is designed to serve as a stand-alone SOP if algae are the only bioindicators being assessed at a given site. However, it can also serve as an add-on module to the existing SWAMP SOP for bioassessment using benthic macroinvertebrates (BMIs). Much of the procedure for collecting physical habitat (PHab) data is identical for these two assemblages. However, some PHab elements assessed in conjunction with BMI bioassessment are not included for algal bioassessment, because they are more specific to BMI habitat needs than to algae. Conversely, one PHab element for algal bioassessment (i.e., point-intercept estimation of algal cover) is not part of the BMI SOP. It should also be noted that, while the standard PHab protocol associated with BMI sampling includes both a "Full" and a "Basic" (simplified) version, a distinction between basic and full protocols for algae has not been established.

This SOP requires the reachwide benthos (RWB) sampling method to be used whenever algae bioassessment is conducted under the SWAMP program. Other appropriate sampling methods will be allowed if specific monitoring objectives require the use of alternative methods or if consistent data comparability in long-term monitoring projects is desired. For SWAMP funded projects, the project proponent must have the approval of the SWAMP bioassessment coordinator and the SWAMP Quality Assurance Officer before the use of alternative methods. For other projects and/or programs working towards SWAMP comparability, deviations should be approved by their project manager and project Quality Assurance (QA) officer.

For quick reference, Table 1 provides a list of elements common and distinct to the two SWAMP bioassessment assemblages. In general, if both BMIs and algae are being collected at a given site, the PHab procedure as described in Ode (2007) should be followed, with the exception of the pebble count, which should be conducted according to this SOP, because it incorporates instructions for algal cover point-intercept data collection. More specifically, if bioassessment involving the Full BMI protocol plus algae is to be implemented at a given site, practitioners should follow the Full protocol of Ode (2007), and add only Section 3.4 (re: water chemistry), Sections 4 and 5, and Sections 6.9-6.11 from this SOP.

Table 1
Sample and data collection elements included in algal and BMI bioassessment (Ode 2007).
X indicates elements included in algal bioassessment. F indicates elements that are part of the "Full" protocol for conducting BMI bioassessment, B corresponds to elements of the "Basic" BMI protocol, and O indicates elements that are "Optional".

Element	Algae[1]	BMIs
Layout of reach, marking transects, recording GPS coordinates	X	B, F
Notable field conditions	X	B, F
Temperature, pH, specific conductance, DO, alkalinity	X	B, F
Turbidity, Silica	O	O
Water chemistry for lab analysis (see list in Section 3.4)	X	
Algal Sampling for Taxonomic IDs	X	
Algal Sampling for Biomass Assessment	X	O
BMI Sampling for Taxonomic IDs		B, F
Wetted Width	X	B, F
Bankfull Dimensions	X	F
Depth and Pebble Count + CPOM	X	F
Percent Algal Cover (point-intercept with Pebble Count)	X	
Cobble Embeddedness	X	F
Canopy Cover	X	B, F
Gradient	X	B[2], F
Sinuosity		F
Human Influence	X	F
Riparian Vegetation		F
Instream Habitat		F
Bank Stability	X	B, F
Flow Habitat Delineation	X	B, F
Discharge	X	F
Photo documentation	X	B,F
Selected Rapid Bioassessment Procedure (RBP) visuals		F

1. A distinction between Basic and Full protocols for algae has not been established.
2. For BMIs, a single, reachwide measurement of gradient is required for Basic, but gradient is measured between all adjacent transect pairs for Full.

Depending upon the requirements of the monitoring effort, different components of this SOP might be incorporated or omitted. For instance, if stream productivity in terms of algae is the primary concern of the assessment, one may wish to collect only biomass samples and algal cover point-intercept data. Alternatively, one will need to collect algal assemblages (for quantification of diatom and/or soft-bodied algal taxa) in order to make more refined inferences about water quality and stream condition (e.g., by applying an algal Index of Biotic Integrity (IBI)).

This SOP is organized in such a way as to facilitate the inclusion or omission of certain elements based on the goals of the monitoring effort. A list of field supplies is provided in Appendix A. It is organized according to the materials needed for each type of sampling and data collection. In order to facilitate decisions about algal indicators to assess for program-specific needs, the introduction to Section 4 discusses what algal indicators serve which monitoring purposes.

SECTION 2 GETTING STARTED

Several considerations come into play when planning an algae-sampling effort. For instance, time of year can be an important determinant of stream algae abundance as well as the type of community likely to be encountered. Likewise, a minimum amount of surface water is a prerequisite to conducting bioassessment. The following section provides guidelines to help practitioners determine when sampling is appropriate for a given reach and also some pointers to help prepare for field work.

2.1 WHEN TO SAMPLE

It is recommended that sampling for stream algae be carried out during the same period as BMI sampling, generally from May through September, depending on the region. This time frame may eventually be modified (e.g., expanded) based on the results of ongoing index period studies.

It should be noted that high-velocity storm flows can remove macroalgae and biofilms from the stream bottom. Sampling must be done at least a month after any storm event that has generated enough stream power to mobilize cobbles and sand/silt capable of scouring stream substrates, in order to allow ample time for recolonization of scoured surfaces (Round 1991; Kelly et al. 1998; Stevenson and Bahls in Barbour et al. 1999).

2.2 BEFORE SETTING OUT FOR THE FIELD

- Proper precautions should be taken at all times in order to avoid transferring invasive organisms and pathogens between sites. This includes the implementation of effective equipment decontamination procedures. Refer to Appendix B for additional information.
- Use the equipment checklist provided in Appendix A to make sure all necessary supplies are brought along.
- Check with contract lab on sampling containers, and shipping and storage of samples.
- Have in mind at least three sites to visit per day (target two, but plan for at least one additional site as a back up if one of the first two sites is not useable.)
- Prepare, and double check, site dossiers to make sure they are complete with maps/directions to sites and scaled aerial photo(s). Bring along county maps, atlases, and Thomas Guides to further aid location of sites. Also bring along any site access permits, passes, and/or keys, as needed (and be aware that some landowners require notice prior to each site visit).

2.3 BEFORE LEAVING VEHICLE FOR SITE

Make sure the vehicle is parked in a safe spot and there are no "No Parking" signs. Stick a business card with cell phone number in the driver's window. Be sure to display the brown administrative pass placard if you are on National Forest land (or a letter of permission, if applicable).

2.4 DETERMINING WHETHER SITE IS APPROPRIATE FOR SAMPLING

Make an initial survey of the potential monitoring reach from the stream banks (being sure to not disturb the instream habitat). Ensure that there is sufficient water in the stream reach to facilitate collection of algae and water samples. In order for a reach to be in appropriate condition for sampling, at least half of the reach should have a wetted width of at least 1m, and there should be no more than 3 transects that are completely dry. If there is some flexibility in terms of where to place the sampling reach, strive for as few dry transects as possible (and preferably none).

Sites should be safe to sample and legally accessible. The time required to access the sampling sites should also be a consideration in planning which sites to visit, in order to ensure that sample holding times can be met (see Table 2 on page 11 for holding-time information).

3 REACH DELINEATION AND WATER CHEMISTRY SAMPLING

Before sample and data collection can begin, the monitoring reach must be identified and delineated. This requires setting up sampling transects along the stream reach of interest. Once the reach is delineated, information about reach location and condition will need to be documented. Water chemistry parameters must also be recorded, and certain samples collected.

A set of field forms for recording information about monitoring sites, algal samples, and associated water chemistry and PHab data is provided on the SWAMP website (see below). The field forms are also available in electronic version on an portable computer. It is imperative that you confirm throughout the data collection effort at each site that all necessary data have been recorded on the field forms correctly, by double-checking values, and confirming spoken values with your field partner(s). As a general practice, you should conduct a final check across all datasheets to confirm that there are no missing values before you leave the site, and rectify any blanks. *Note: Field forms may be updated periodically. It is imperative that field crews ensure that they are always using the most current field forms. Updated forms can be accessed from the SWAMP website at: http://swamp.mpsl.mlml.calstate.edu/resources-and-downloads*

3.1 DELINEATING AND DOCUMENTING THE MONITORING REACH

To delineate the monitoring reach, you will need to scout it in its entirety in order to make sure that it is of adequate length for sampling algae. During this process, try to stay out of the channel as much as possible, to avoid disturbing the stream bottom, which could compromise the samples and data that will be collected.

SWAMP's standard algae (and BMI) sampling layout consists of a 150 m reach or a 250 m reach, depending upon the average wetted width of the channel. In some circumstances (see below), reach length can be < 150 m, but this should be avoided whenever possible. If the actual reach length is other than 150 m or 250 m, this should be noted and explained on the field forms. Under these circumstances, you will need to determine the useable length of the reach, and how to space your transects so that you can fit them into the reach at equal distances from one to the next.

The wetted channel is the zone that is inundated with water and the wetted width is the distance between the sides of the channel at the point where substrates are no longer surrounded by surface water. Estimate the average wetted width of the reach. If this value is ≤ 10 m, you will end up using 150 m for your monitoring reach length. If the average wetted width is > 10 m, you will use a 250 m long reach.

To set up the monitoring reach, begin a little outside of what you anticipate will be the outer boundary (based on aerials and maps) and count 150 large steps, or 250 large steps (for most adults, a large step is roughly equal to a meter), by walking along the bank. This will give a rough idea about the location of the ends of the study reach. However, keep in mind that once this is determined, the actual distances between transects and intertransects (and consequently, the reach length) will need to be more accurately measured.

As you go, identify where hydrologic inputs that could potentially modify the water chemistry environment occur along the length of the reach. If possible, there should be no tributaries or "end-of-pipe" outfalls feeding into the channel within the monitoring reach. Other features that should not be present within a monitoring reach are: bridge crossings (which shade the stream bottom and can artificially reduce or prevent algal growth), changes between natural and man-made (i.e., concrete) channel bottoms, waterfalls, and impoundments (dams and weirs). If any of such features occur within the reach, and there is not enough room to accommodate a 150-m reach or 250-m reach entirely upstream or downstream of such a feature, then the reach can be somewhat < 150 m. Whatever the reach length turns out to be (150 m, 250 m, or other), record it on the datasheet under "Reach Length".

3.2 MARKING THE TRANSECTS

The monitoring reach will be divided into 11 equidistant main transects that are arranged perpendicularly to the direction of flow. There will also be 10 additional transects (designated "inter-transects"), one between each pair of adjacent main transects, to give a total of 21 transects per monitoring reach. Main transects are designated "A" through "K", while inter-transects are designated by their nearest upstream and downstream main transects ("AB", "BC", etc.).

Once you have identified the upper and lower limits of the monitoring reach, determine the coordinates of the downstream end using a Global Positioning System (GPS) set to the North American Datum 1983 (NAD 83)[3], and record this information in decimal degrees (to five decimal places) on the datasheet under "Reach Documentation". Install a colored flag at water's edge on one of the banks at this location to indicate the first "main transect", or "A". Establish the positions of the remaining transects and inter-transects by heading along the entire length of the monitoring reach (again, staying out of the water/channel as much as possible) and using the transect tape or a segment of rope of appropriate length to measure off successive segments of 7.5 m (for streams of wetted width ≤ 10 m), or 12.5 m (for streams > 10 m wetted width). For monitoring reaches of non-standard length, you will divide the total, targeted length of the reach by 20 to derive the distance between the adjacent main, and inter-, transects. As you measure off the distances, always follow the virtual, mid-channel line, and not the water's edge (which may be irregular, and not reflective of the true stream curvilinear distance).

3. Be aware that some GPS units re-set themselves to factory default settings when the batteries are changed. This can include the datum. Therefore, anytime you remove batteries from your unit, double check that the unit is still set to the NAD83 datum after the batteries have been replaced.

At the end of each measured segment as you head along the stream, mark the transect location on the bank with a flag. We recommend alternating between two different flag colors (e.g., orange could correspond to main transects, and yellow to inter-transects). Determine transect orientations, and where on the banks to place the flags, by visually projecting perpendicularly from the mid-channel to the banks. Refer to Figure 1 for a visual representation of proper transect alignment relative to the stream's direction of flow. When you have finished, the downstream-most flag will correspond to main transect "A", and the upstream-most flag (the 21st in the entire series of main and inter- transects) will correspond to main transect "K".

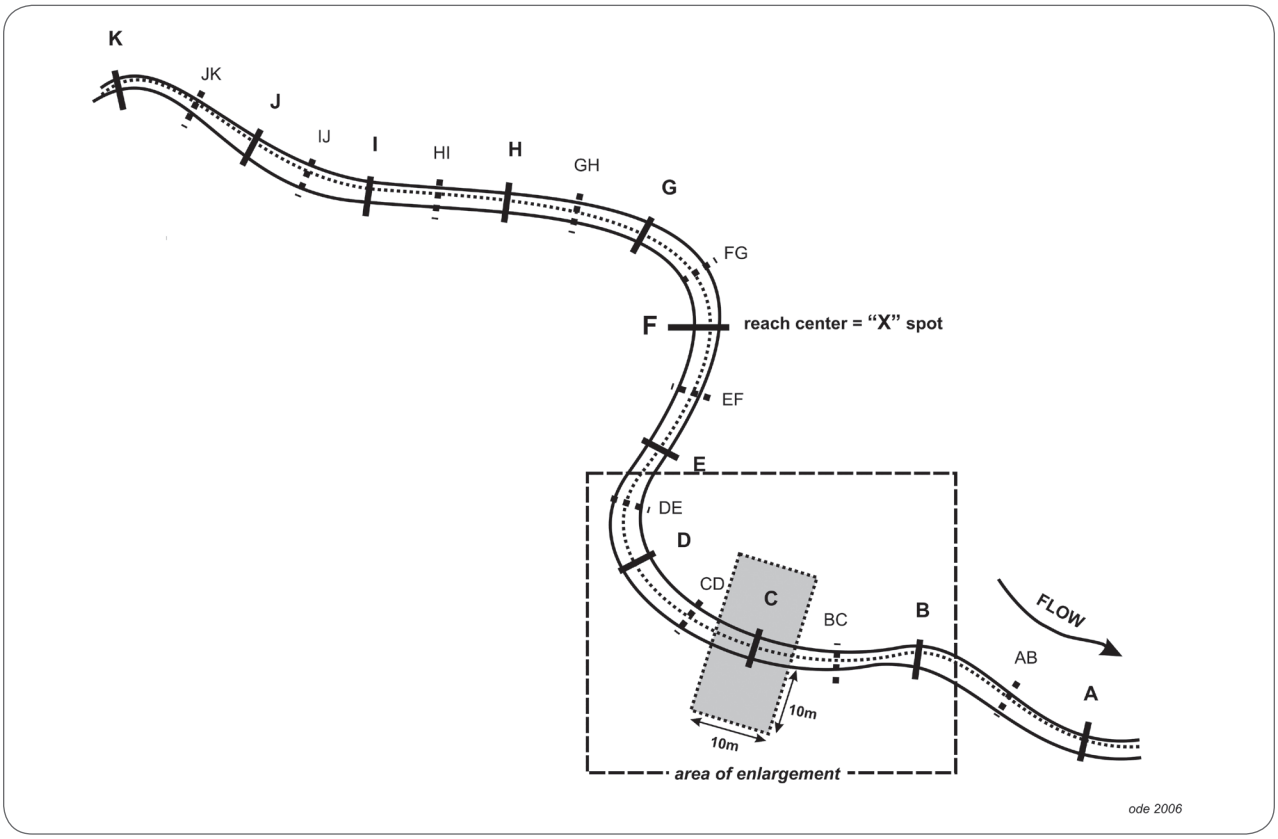

Figure 1. Reach layout geometry for physical habitat (PHab) and biological sampling showing positions of 11 main transects (A-K) and the 10 supplemental inter-transects (AB-JK). The area highlighted in the figure is expanded in Figure 11. Note: reach length = 150 m for streams ≤ 10 m average wetted width, and reach length = 250 m for streams > 10 m average wetted width (reprinted from Ode 2007).

3.3 NOTABLE FIELD CONDITIONS

Record under "Notable Field Conditions" any evidence of recent flooding, fire, or other disturbances that might influence algae samples. Especially note if flow conditions have been affected by recent rainfall, which can cause significant under-sampling of algal biomass and diversity. If you are unaware of recent fire or rainfall events, select the "no" option on the forms. Record the dominant land use and land cover in the area surrounding the reach by evaluating land cover within 50 m of either side of the stream reach. You can

use a scaled aerial photograph of the site and vicinity to guide you. *Note: Before heading out to the field, it is convenient to add a 150 m (or 250 m) line adjacent the stream to be sampled in order to get an idea about the anticipated approximate upstream and downstream boundaries of the monitoring reach.*

3.4 WATER CHEMISTRY

Measure and record common ambient water chemistry measurements (pH, dissolved oxygen (DO), specific conductance, alkalinity, and water temperature) just outside of the reach, at the downstream end, near the same location that the GPS coordinates were taken. This should be done in such a way that it does not interfere with biotic sampling and PHab data collection, but also in such a way that water samples are not compromised by other sampling activities upstream (e.g., by suspension of matter from the stream bottom into the water column, and consequently the introduction of this matter into the water chemistry samples).

Water chemistry measurements are typically taken with a handheld, water-quality meter (e.g., YSI, Hydrolab), but field test kits (e.g., Hach) can provide acceptable information if they are properly calibrated. For appropriate calibration methods, calibration frequency, and accuracy checks, consult the current SWAMP Quality Assurance Program Plan (QAPrP)[4], or follow manufacturer's guidelines. *Note 1: If characteristics of the site prohibit downstream entry, measurements may be taken at other points in the reach. In all cases, ambient chemistry measurements should be taken at the start of the survey (i.e., before algae sampling and PHab data collection). Note 2: A digital titrator (e.g., Hach) using low-concentration acid (such as 0.16N H_2SO_4) as the titrant is recommended for determining alkalinity in low-alkalinity streams (i.e., approximately 100 mg/L $CaCO_3$ or less).*

A suite of analytes must also be evaluated to aid in interpretation of the algal data. These are listed below. Consult the SWAMP QAPrP for specific instructions on the proper techniques for collecting, preserving, and storing these water samples until analysis.

- Nitrate as N (NO_3)
- Nitrite as N (NO_2)
- Ammonia as N (NH_3)
- Nitrogen, Total (TN)[5]
- Orthophosphate as P (dissolved; SRP)
- Phosphorous, Total (TPHOS)
- Dissolved Organic Carbon (DOC)
- Chloride (Cl)

- Silica as SiO_2, dissolved (Note: this analyte is recommended for research purposes, but is not part of the standard algae protocol)

4. This document is available online from the SWAMP website: http://www.swrcb.ca.gov/water_issues/programs/swamp/docs/qapp/swamp_qapp_master090108a.pdf
5. Total Nitrogen can be calculated from Total Kjeldahl Nitrogen (TKN), Nitrate (NO_3) and Nitrite (NO_2)

SECTION 4
REACHWIDE BENTHOS SAMPLING OF ALGAE

The following is a short introduction of several types of algal indicators that can be monitored as part of a bioassessment effort. For a more detailed discussion, see Fetscher and McLaughlin (2008). The most appropriate indicators to include in a given program will ultimately depend upon that program's goals, because the various indicators provide information at varying levels of resolution and applicability to different uses. Likewise, the various indicators require different levels of investment in terms of field work and lab work. Percent algal cover, for instance, is a rapid means of estimating algal primary productivity that can be carried out entirely in the field and is conducted in tandem with the PHab pebble count. Therefore, percent algal cover is an appropriate, fast, and inexpensive parameter for citizen monitoring groups if they are concerned about increased algal biomass. Other estimators of algal biomass include chlorophyll *a* and AFDM, which involve quantitative collection of algae, preservation, and subsequent laboratory analysis. Algal biomass is a key component of the California Nutrient Numeric Endpoints (NNE) framework. Higher resolution information about algal assemblages can be used in algal IBIs, and offers more in-depth insight into water quality. For this type of data, algal specimens must be collected quantitatively (and qualitatively, in the case of soft-bodied algae). The quantitative samples are then fixed/preserved carefully and subjected to taxonomic analysis.

While the percent algal cover data are recorded in conjunction with standard PHab procedures, and do not require the collection of samples, all the other types of data described in this protocol require reachwide benthos (RWB) sampling of algal specimens in a manner analogous to that which is carried out for BMIs.

All four of the algal samples described in this SOP: chlorophyll *a*, AFDM, diatom assemblage, and soft-bodied algal assemblage, can be obtained from a single composite sample generated by the RWB method. Which combination of these samples to prepare and submit for laboratory processing will depend on the needs of the monitoring program. To aid in the selection of algal indicators, Table 2 provides a summary of their attributes.

Table 2
Types of algal indicators and considerations for their assessment.

	Algal indicator for	Collection method	Collection vessel	Preservation/fixation methods and holding times	Qualitative live sample required?
Percent algal cover	Stream productivity measured as algal abundance	Point-intercept add-on to the PHab pebble count	N/A	N/A	N/A
Chlorophyll a[6]	Stream productivity measured as algal biomass; key indicator for the Nutrient Numeric Endpoints (NNE) framework	RWB sample collection	Glass-fiber filter	Wet ice, dark (foil-wrapped); freezing within 4h, and analysis within 28d	N/A
AFDM	Stream productivity measured as biomass of organic matter (including algae); indicator for the NNE framework	RWB sample collection	Glass-fiber filter (pre-combusted[7])	Wet ice, dark (foil-wrapped); freezing within 4h, and analysis within 28d	N/A
Diatoms	Used in IBIs. Indicative of factors such as trophic status; organic enrichment; low DO; siltation; pH; metals	RWB sample collection	50 mL centrifuge tube	Add 10% buffered formalin for a 2% final concentration immediately after collection; keep dark and away from heat	Optional
Soft-bodied algae[8]	Used in IBIs. Indicative of factors such as nitrogen limitation/ trophic status; siltation; pH; temperature, light availability, nuisance/ toxic algal blooms	RWB sample collection	50 mL centrifuge tube	Keep unfixed samples in dark on wet (NOT DRY) ice; add glutaraldehyde (to a 2.5% final concentration) as soon as possible, but no later than 4 days after sampling; after fixing, keep dark and away from heat	Required

6. It is valuable to assess both chlorophyll *a* and phaeophytin *a* (the degradation product of the former) content of algal samples, as this may provide a more robust assessment of algal biomass.
7. Precombustion is recommended in order to remove any possible residual organic matter from the filter.
8. For the purposes of this SOP, the soft-bodied assemblage includes cyanobacteria (an explanation of the rationale for this is provided in Fetscher and McLaughlin 2008)

4.1 GENERAL CONSIDERATIONS FOR SAMPLING ALGAE

This SOP describes the RWB method for collecting stream algae. It employs an objective approach for selecting sub-sampling locations that is built upon the 11 main transects described in the previous section. This approach is analogous to the SWAMP procedure for BMI sampling (Ode 2007), and is ultimately based on EPA's Environmental Monitoring and Assessment Program (EMAP; Peck et al. 2006). After collection, the 11 sub-samples are composited into a single sample per site (sampling reach).

The RWB method can be used to sample any wadeable stream reach since it does not target specific habitats. Because sampling locations are defined by the transect layout, the position of individual sub-sampling spots may fall within a variety of "erosional[9]" or "depositional[10]" habitats, each of which has implications for the type of substrate likely to be encountered and therefore the type of sampling device to use.

For the RWB method, the sub-sampling position alternates between left, center, and right portions of the transects, as one proceeds upstream from one transect to the next. These sampling locations are defined as the points at 25% ("left[11]"), 50% ("center") and 75% ("right") of the wetted width in high-gradient systems, and at "margin-center-margin" (MCM) positions in low-gradient systems. The RWB-MCM method should be only used in low-gradient streams where channel substrates are nearly uniform, resulting in low diversity within the channel. The interim cut-off between "low" and "high" gradient is 1%. Best professional judgment can be used to estimate whether the stream reach should be treated as low- or high-gradient. However, if there is uncertainty about the gradient, it should be measured prior to collecting the biotic assemblage samples. See Section 4.2 for specific instructions about where algae sampling locations should be positioned at the margins of low-gradient sampling reaches.

Algae should be sampled prior to PHab data collection (described in Sections 6-8), so as not to disturb the algae by trampling the transects, as occurs during the PHab process. Furthermore, to avoid disturbing the transects for eventual collection of PHab data, as with BMIs, algae should be collected at a location that is systematically offset from each transect (see Section 4.2).

4.2 COLLECTION OF ALGAE IN CONJUNCTION WITH BENTHIC MACROINVERTEBRATES

If only algae (or only BMIs) are being collected for bioassessment, then the specimens should be collected 1m downstream of the transects. If both assemblages are being sampled, then the algae should be collected upstream of the spot where the BMIs are collected, according to the schematic in Figure 2. BMIs must be collected BEFORE algae at each of the transects, in order to minimize the chances disturbing BMIs during algal collection. After the BMIs are collected at each spot, the algae sample should be taken ¼ m upstream

9. Erosional – habitats in the stream that are dominated by fast-moving water, such as riffles, where stream power is more likely to facilitate erosion (suspension) of loose benthic material than deposition; examples of "erosional" substrates include cobbles and boulders.
10. Depositional – habitats in the stream that are dominated by slow-moving water, such as pools, where deposition of materials from the water column is more likely to occur than erosion (or (re)suspension) of bed materials; examples of "depositional" substrates include silt and sand.
11. For our purposes, "left" is defined as the left bank when facing downstream.

from the center of the upper edge of the "scar" in the stream bottom left from the BMI sampling. It is important to make sure that the surface from which algae will be collected has not been disturbed (by the BMI sampling, or otherwise) prior to sampling the algae.

Note: If only algae (and not BMIs) are being collected in a low-gradient reach, the collection location should be 1 m downstream of the transect and, for each of the "margin" positions, at a distance of 15 cm from the wetted margin of the bank. Fifteen centimeters is chosen because it is approximately ½ the width of a D-frame net.

If duplicates are to be sampled (of either or both assemblages), locations for sampling them should be arranged as depicted in Figure 2 (the duplicates are shown in light grey). *Note: For convenience, only Transects A through C are shown, but the same pattern of placement should be rotated across all 11 transects.*

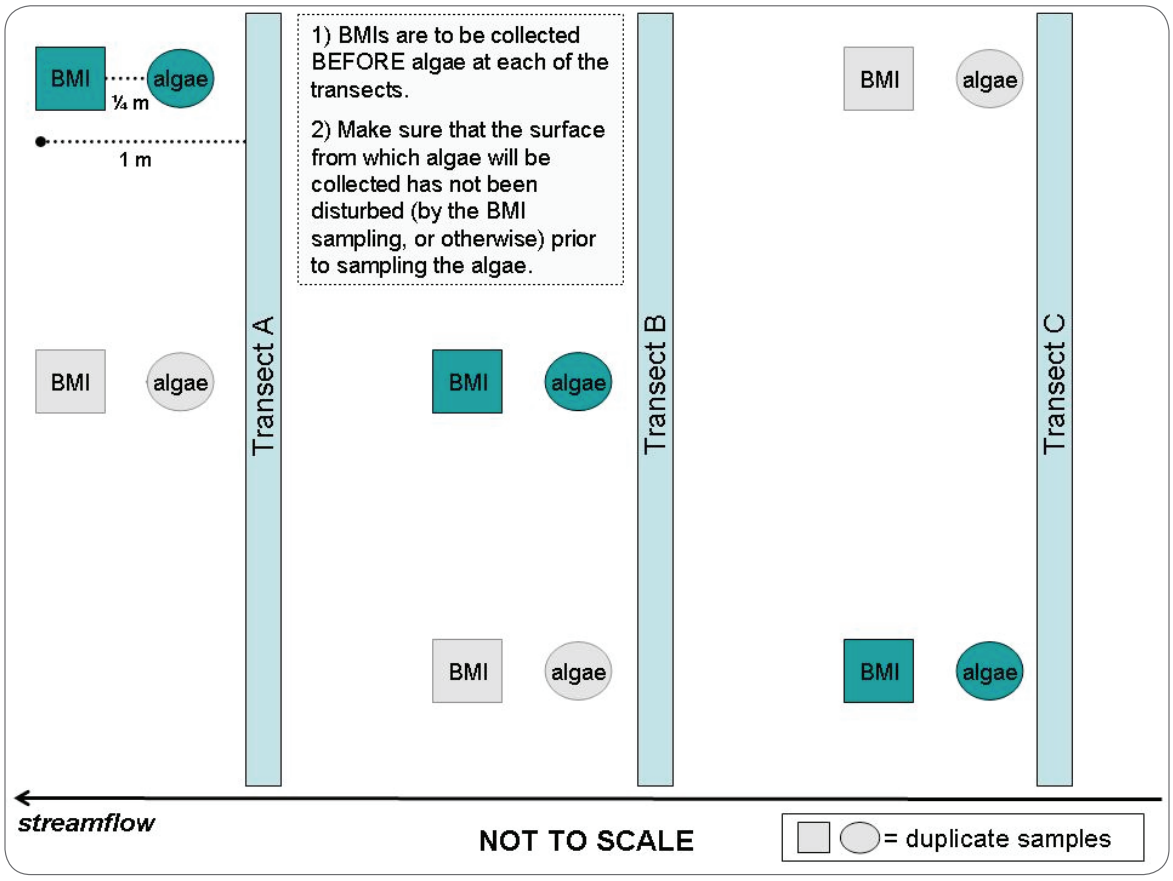

Figure 2. Sampling array for collection of algae, BMIs, and duplicates of each assemblage. For convenience, only Transects A through C are shown, but the same pattern of placement should be rotated across all 11 transects.

4.3 PROCEDURE FOR COLLECTION OF QUANTITATIVE ALGAL SAMPLES

During all phases of algae sampling and processing, in order to preserve specimen integrity, every attempt should be made to keep the sample material out of the sun, and in general, to protect the algae from heat and desiccation, as much as possible. This is necessary in order to reduce the risk of chlorophyll *a* degradation, limit cell division post-collection, and curb senescence/decay of live soft-bodied algae (especially for the qualitative samples; see Section 5.4). The need to maintain the integrity of the algal samples during collection and processing should always be borne in mind when planning the sampling scheme for a given site.

In addition, before sampling at any given site, the dish tub that will contain sample material must be scrubbed with a stiff-bristled brush or scouring pad and thoroughly rinsed with stream water, so that no algal material is carried over from the previous site to contaminate the current sample. The same applies to all other algae sampling apparati (toothbrushes for scrubbing, graduated cylinders, turkey basters, PVC and rubber delimiters, spatulas, syringe scrubbers, etc.).

4.3.1 Identifying the Sampling Locations

As with BMIs, algae sample collection should begin at Transect A and proceed upstream to Transect K. Except in circumstances in which the substrate to be sampled cannot be removed from the stream, a single sample of substrate material that corresponds to the objectively determined sampling point is gathered at each transect and placed in the plastic dish tub. The sample should always be collected from the substrate that is "uppermost" within the stream, and therefore has the highest probability of exposure to sun. For example, if at a given sampling point there is a thick layer of macroalgae above the stream bottom, the substrate collected at that point would be macroalgae itself, not the cobble, sand, or whatever other substrate lies beneath it. Proceeding from transect to transect with the dish tub, the sample collector rotates through the three collection positions in the following order: left at the first transect ("A"), center at the next transect ("B"), right at the next transect ("C"), then back to the left side ("D"), and so on through Transect K.

As substrates are gathered, a tally is taken of the number of samples that correspond to each of the classes of sampling device based on the surface area they sample: 1) 12.6 cm^2 for the PVC or rubber delimiters, and 2) 5.3 cm^2 for the syringe scrubber. The tallies are recorded in the Algae Samples field form under Collection Device. This information will ultimately be used to determine total stream surface area sampled at each site, which in turn will be used to calculate the soft-bodied algal biovolume and the biomass values. It may be helpful to use a tally meter in order to avoid having to carry a datasheet during substrate collection.

4.3.2 Collecting Erosional Substrates

If the substrate type that falls under the sampling spot is in erosional habitat and can be removed from the stream (e.g., a cobble, a piece of wood, or a piece of coarse gravel with an exposed surface area of at least 12.6 cm^2), carefully lift the substrate, moving slowly in an effort to disturb its top surface as minimally as

possible, and remove it from the stream. Then wipe any excess sand, silt, or BMIs, if present, off the bottom of the piece of substrate, and place it in the dish tub. It is helpful to place the substrate in such a way that makes it obvious what surface was facing upward when it was removed from the stream. Eventually, when you isolate a sample of algae from this substrate, you will want to obtain your sample from the portion of the substrate that had been exposed to the surface of the stream (and not buried) during the period leading up to the sampling event. For pieces of substrate with an exposed surface area that is < 12.6 cm^2, the PVC delimiter should be used (Section 4.3.3).

Be sure to place the substrate (e.g., cobble) in the dish tub in such a way that surfaces covered with non-target algae are not rubbing against anything, which could cause non-target algae to slough off into the tub, thus artificially inflating the amount of algae collected. To avoid this problem, and especially if a large number of cobbles are likely to be sampled across a given stream reach, one may choose to isolate the algal specimen from each cobble as it is selected, rather than collecting all the cobbles into the dish tub and then isolating the algal specimens from them after all transects have been sampled. See Section 4.3.9 for further elaboration on this alternative approach.



Figure 3. PVC Delimiter

4.3.3 Collecting Depositional Substrates

If the substrate type that falls under the sampling spot is removable and is in depositional habitat (e.g., silt, sand, fine gravel), and/or has an exposed surface area per particle that is < 12.6 cm^2, you will use a PVC delimiter. This is a plastic coring device with an internal diameter of 4 cm (Figure 3). Instructions for making a PVC delimiter are provided in Appendix C.

Isolate a specific quantity of sand/silt/gravel, centered on the sampling spot, by pressing into the top 1 cm of sediment with a PVC delimiter. Gently slide a masonry or kitchen spatula beneath the delimiter, being careful to keep the collected sediment contained within. Pull the PVC delimiter out of the water (with the spatula still in place) and remove any extra sediment from the spatula around the outside of the delimiter. Transfer the contents held in the delimiter by the spatula to the dish tub. Be sure not to pour the sediment sample on top of any cobbles that may be in the dish tub, as this could result in the sloughing of non-target algae from the cobbles into the dish tub, thus artificially inflating the amount of algae collected.

4.3.4 Collecting Sections of Macroalgae

If the substrate you hit on a given transect is a mass of macroalgae (e.g., a mass of attached filamentous algae underwater, or an unattached, floating mat that is believed to be native to the reach being sampled, and not imported from upstream), position the spatula directly under the macroalgae and press the PVC delimiter into the algae to define a 12.6 cm^2 area. Use a sharp razor blade or knife to cut away and discard any extra material from around the edges of the delimiter (do not simply pull it away, as this will distort the specimen and remove biomass from the targeted material). Add the macroalgal specimen that was isolated by the PVC delimiter to the dish tub.

When collecting a mass/mat of macroalgae, it is important to capture the full thickness of the macroalgae within the delimiter. To do this, from the side of the sampling area, slide your hand under the mat to feel where the bottom is, slide the spatula down to that spot, and then press the PVC delimiter downward slowly to "sandwich" the targeted section of macroalgae between the delimiter and the spatula. It is important to try not to bunch the macroalgae up nor stretch it out unnaturally, as the goal is to collect a representative sample of the algae as it occurs in the stream.

4.3.5 Collecting Sections of Macrophytes

If the substrate to be sampled is part of an immersed macrophyte, or old, dead leaves settled at the bottom of a pool, use the PVC delimiter/spatula combination to isolate a 12.6 cm^2 section of substrate that has been exposed to the surface of the stream. As with the macroalgae (Section 4.3.4), cut away and discard the extra material that falls outside the delimiter using a razor blade.



Figure 4. Syringe Scrubber

4.3.6 Collecting from Concrete, Bedrock, and Boulders

If the substrate falling under a sampling spot cannot be removed from the water (as in the case of bedrock, a boulder, or a concrete channel bottom), use a "syringe scrubber" device (Davies and Gee 1993; Figure 4) to collect an algae sample underwater. Instructions for making a syringe scrubber are provided in Appendix C.

To use this device, affix a fresh, white scrubbing pad circle onto the bottom of the syringe plunger using the Velcro® hooks on the end of the plunger. Press the plunger down so that the bottom of the scrubbing pad is flush with the bottom of the barrel. Then submerge the instrument, press the syringe firmly against the substrate, and rotate the syringe scrubber 3 times in order to collect the biofilm from the substrate surface onto the scrubbing pad. If the surface of the substrate where your sampling point fell is not flat enough to allow for a tight seal with the syringe barrel, objectively choose whatever sufficiently flat area on the exposed face of the substrate is closest to where the original point fell, and sample there.

After sampling, and before removing the syringe scrubber from the substrate, gently retract the plunger just slightly, so it is not up against the substrate anymore, but not so much that it pulls a lot of water into the barrel. Carefully slide the spatula under syringe barrel (which should be pulled just slightly away from the substrate on one side to allow the spatula to slide under), trying not to allow too much water to rush into the barrel. Then pull the instrument back up out of the water with the spatula still firmly sealed against the syringe-barrel bottom.

Hold the syringe scrubber over the dish tub and then remove the spatula, allowing any water to fall into the tub. Carefully detach the pad from the plunger and hold the pad over the tub. Using rinse water sparingly, remove as much algal material from the pad as possible by rinsing it off with the wash bottle, or a turkey baster, filled with stream water (from the current site—never carried over from a previous site), and

wringing it into the dish tub before discarding the used pad. Start this process by rinsing from the backside of the pad (the side that had been affixed to the plunger) to "push" the collected algae forward out of the front surface of the pad.

It is recommended that a fresh (new) pad be used each time a sample is collected, even within the same stream reach. Under no circumstances should the same pad be used at more than one site.

4.3.7 Collecting from Other Substrate Types

If other substrate types are encountered, they can be sampled from as long as there is good reason to believe that they were not recently introduced into the stream (e.g., by flowing from the upstream regions, or by recently falling into the stream), as they would then not be representative of the local instream environment. Use the collection instrument you deem to be most appropriate to sample the substrate and, as with any substrate, be sure to account for the surface area sampled (in this case, using the "Other" box on the Collection Device portion of the field forms).

4.3.8 Removal of Algae from Collected Substrates

After having sub-sampled substrates across the monitoring reach, there should be 11 transects' worth of material in the dish tub. Depending on the types of habitats in the stream and substrates encountered, the tub may contain cobbles, and/or sand, and/or gravel, and/or small pieces of wood, macroalgae, or macrophyte. Now a measured quantity of the algae clinging to these substrates must be removed and suspended in water to form a "composite sample" according to the instructions in the following sections.

For erosional substrate types that were removed from the stream (e.g., cobbles and small pieces of wood), use a rubber delimiter to isolate a 12.6 cm^2 area from which algae will be removed. A rubber delimiter can be made from a mountain bike tube with a hole cut out and reinforced with an appropriately sized rubber washer (Figure 5). Appendix C describes the procedure for making a rubber delimiter.

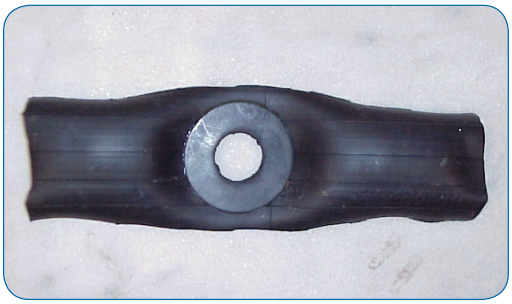

Figure 5. Rubber Delimiter

Wrap the rubber delimiter around the substrate to expose the desired sampling surface through the hole. Take care to ensure that the surface that will be scrubbed is truly the upper (generally at least somewhat "slimy") surface of the substrate as it had been oriented in the stream. Dislodge attached algae from this area by brushing it with a firm-bristled toothbrush (remember that this toothbrush must first have been thoroughly rinsed since the previous site to avoid contamination with algal specimens from other streams). If there is a thick mat of algae, or the algae is firmly encrusted on the surface of the substrate, use forceps or a razor blade first to dislodge the larger matter and put this in the dish tub. Then scrub the area with the brush.

Make sure that the entire surface within the delimiter has been scrubbed well in order to remove all the algae in that area. Fill a wash bottle or turkey baster with stream water from the current site (never carried over from a previous stream). Using as minimal a volume of water as possible, rinse the scrubbed algae from the sample area into the dish tub. Take care to squirt water only on the surface that is showing through the hole in the delimiter, and not anywhere else on the substrate's surface. It is helpful to invert the rock when rinsing so that the target surface is facing down toward the dish tub, and the rinsate drips off the sampling spot directly into the tub rather than flowing along the (non-target) sides of the substrate. Use water sparingly for each piece of substrate, because you should attempt to use no more than 400-500 mL total for the full suite of 11 samples collected along the transects (this includes any water used for rinsing algae off of sampling devices into the dish tub). After scrubbing is complete, rinse the delimiter and the brush into the dish tub, also. The scrubbed part of the substrate should feel relatively rough when you have finished, meaning that essentially all of the algae have been removed. After the sampling area on the piece of substrate has been thoroughly scrubbed and rinsed, the piece of substrate can be returned to the stream.

For depositional samples (e.g., silt, sand, or gravel), there is no need to isolate a specific area of the substrate within the dish tub, because the sample area was pre-isolated by using the PVC delimiter during collection. Simply massage all the sand and/or silt in the dish tub thoroughly between the fingers to dislodge any clinging algae. For pieces of gravel, use a toothbrush to remove algal material from surfaces.

Rinse the sediment thoroughly (but as sparingly as possible) with stream water so as to create a suspension of the dislodged microalgae (i.e., the sample). The final volume of the sample liquid in the dish tub will be measured before the algal taxonomic and biomass samples are prepared (described below). To do this, the liquid in the tub will be separated from the rinsed sediment such that the volume measured does not include sediment. After the liquid sample has been retrieved and measured, the rinsed sediment will be discarded back into the stream.

Other types of substrate, like pieces of macrophyte or dead leaves that had been collected with the PVC delimiter, should also be massaged between the fingers and rinsed into the tub in order to remove the algae coating them.

For macroalgal clumps there is a special step required for processing the samples. This procedure is described in detail in Section 5.3.

4.3.9 Alternative Approach: Processing Samples at Each Transect

It is also acceptable to isolate the algal specimens from each "piece" of substrate collected before moving on to the next transect. This approach has the disadvantage of requiring that all algae sampling/scraping tools be carried along with the collector as s/he proceeds up the stream, and that s/he pause to isolate the algae several times across the stream reach rather than one time at the end of all the transects. However, it limits the amount of substrate material that needs to be carried in the dish tub, thus making it lighter. This could be particularly important if a large number of cobbles are encountered across sampling points, such that it

could be difficult or impossible to carry them all to Transect K, or to carry them in such a way that non-target algae can easily be prevented from sloughing off into the tub via abrasion. For convenience, one may elect to wear a fisherman's vest to facilitate carrying all the algae sampling/scraping tools that will need to be brought along on the substrate sampling trip if employing this alternative approach.

SECTION 5
ALGAL SAMPLE PROCESSING

Four different types of laboratory samples may be prepared from the composite sample:

- Identification/Enumeration Samples
  1. Diatoms
  2. Soft-bodied algae
- Biomass Samples
  3. Chlorophyll *a* ("chl *a*")
  4. Ash-free dry mass ("AFDM")

5.1 GENERAL CONSIDERATIONS FOR PROCESSING ALGAL SAMPLES

The general process for sample preparation is as follows. The Identification/enumeration samples are each aliquoted into 50-mL centrifuge tubes and chemically fixed (preserved). Diatom samples are fixed in the field with formalin immediately following collection, and soft-bodied algae samples are fixed in a laboratory with glutaraldehyde within four days of collection. The chlorophyll *a* and AFDM samples are collected on filters in the field and stored on wet ice, and then frozen as soon as possible after returning from the field (and within four hours of collection). The filters are kept frozen until analysis, which should occur within 28 days of collection. If the field crew is spending the night in a hotel, it is necessary to buy dry ice to freeze the biomass filters upon finishing the day's fieldwork, and to keep them on dry ice until the samples can be transferred to the freezer back at the lab.

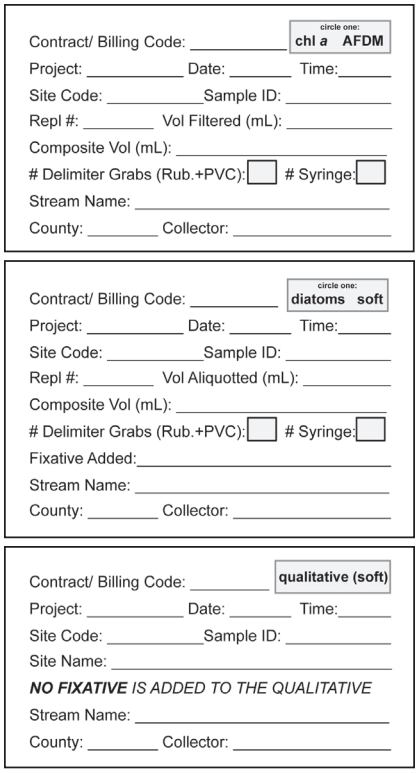

Figure 6. Labels for biomass and taxonomic identification samples.

Algae sample labels are shown in Figure 6. Recorded on each sample label are the volume of the composite sample (described in Sections 5.2.1 and 5.3.2), and the TOTAL area of stream bottom sampled (based on which sampling devices were used; described in Sections 4.3.2 - 4.3.7), as well as the volume of sample aliquoted (for the taxonomic ID samples) or filtered (for the chlorophyll *a* and ADFM samples). All of these values should be recorded on the field forms, as well, under the Algae Samples section. On the sample labels, the sample type: "chl *a*", "AFDM", "diatoms", or "soft" is circled, and all the remaining information on each label, like Site Code, Date, and site coordinates is filled out.

Before preparing the algae samples it is necessary to determine two things:

- Are there any clumps of macroalgae in the composite sample (as opposed to just microalgae suspended in liquid)?

AND

- Is a soft-bodied algal taxonomic sample going to be prepared?

The answers to these questions will determine the course of action for preparing the algae samples for a given site:

- If there is no macroalgal clump, liquid composite sample will simply be added to each taxonomic ID sample tube (40 mL for diatoms and 45 mL for soft-bodied algae). Biomass samples will also be prepared using the liquid composite sample, as is.
- If there is a macroalgal clump present, but no soft-bodied sample will be prepared, the entire clump will be chopped into fine bits (resulting in strands that are eyelash-length or shorter) and incorporated directly into the liquid portion of the composite sample, and the mixture will be shaken to homogenize it before preparing the diatom and/or biomass samples.
- If there is a macroalgal clump AND a soft-bodied algal taxonomic ID sample is to be prepared, then a more complex procedure must be employed in order to properly process the macroalgae before preparing the various samples.

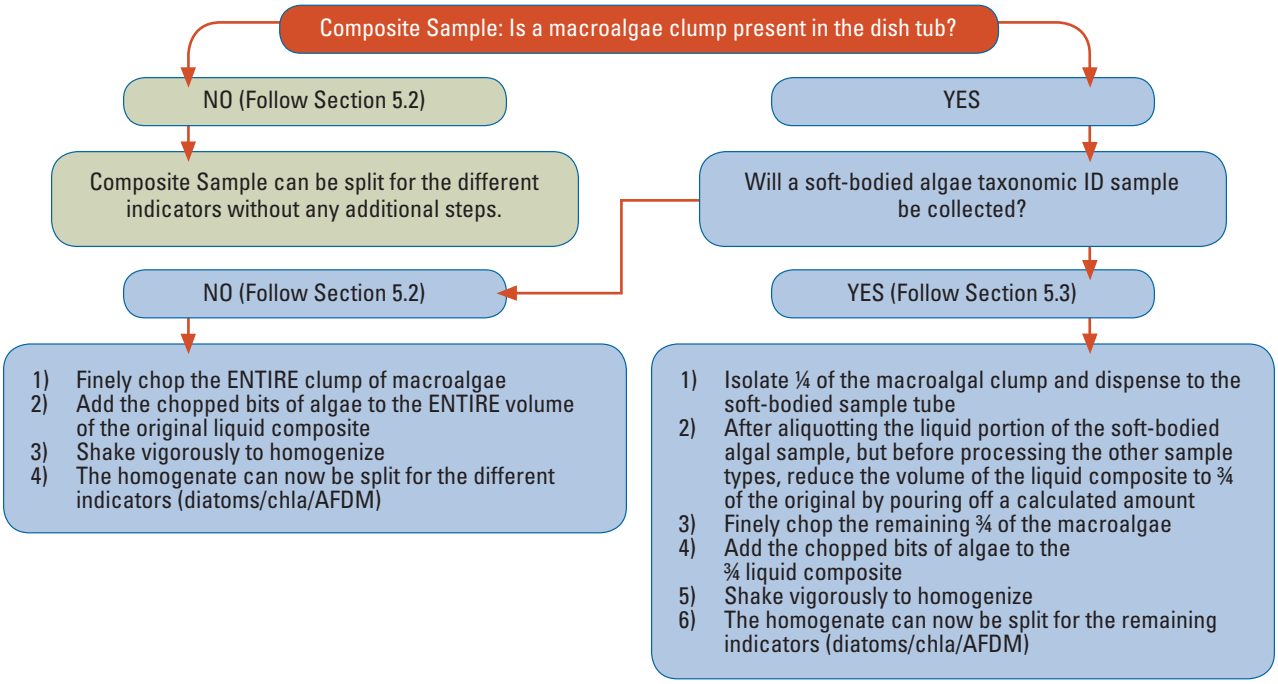

Figure 7. Summary of major sample-processing decision points based on presence of macroalgal clump(s) and need to prepare soft-bodied algal samples.

Figure 7 provides a summary of the various sample-processing steps that are involved, and the following sections describe the procedures in detail. Use Section 5.2. if there is NO macroalgal clump present in the dish tub OR a soft-bodied algal sample will be NOT be prepared. Use Section 5.3 if there IS a macroalgal clump present AND a soft-bodied algal sample will be prepared.

5.2 SAMPLE PROCESSING WHEN THERE IS NO MACROALGAL CLUMP OR WHEN NO SOFT-BODIED SAMPLE IS BEING PREPARED

This section describes the sample-processing procedure for the situation in which there was either 1) no macroalgal clump in the dish tub containing the composite sample material, or 2) no soft-bodied algal sample will be prepared. If there was no macroalgal clump but both soft bodied algae AND other sample types are to be prepared, follow all the instruction in this section with the exception of the final portion of Section 5.2.1 that is italicized and in orange font, and discusses how to process macroalgae when preparing only diatom and/or biomass samples.

If there is a macroalgal clump, but no soft-bodied algae sample is to be collected, follow the instructions in this section, including the final, italicized portion of Section 5.2.1, and skip Section 5.2.2, which deals with soft-bodied algal sample processing.

5.2.1 Measuring the Composite Liquid Volume

Once algal specimens have been removed from all the substrates (e.g., sand, gravel, cobble, wood, leaves) in the dish tub, according to the procedure described in Section 4, thoroughly agitate the liquid to get as much as possible of the microalgae into suspension, and then immediately pour the liquid into a CLEAN graduated cylinder to measure its volume. Try to leave all substrate material (e.g., silt, sand) behind. Transfer the measured liquid into a CLEAN 1L plastic bottle. Using a minimal amount of stream water, rinse the substrate once or twice with stream water until it appears that little to no additional suspended material (microalgae) is coming off. Add this rinsate to the graduated cylinder to measure it also. If necessary, repeat this process (regularly agitating the dish tub) until all the liquid has been measured and transferred to the sample bottle. Use water sparingly, because the total sample volume (plus rinsate) should be no more than about 400-500 mL.

Because you are leaving as much as possible of the silt, sand, and any large substrate material behind, the final volume should reflect only the liquid component of the sample plus rinse water. Record the total volume of all the liquid that had been in the dish tub, including any that was used for rinsing the substrates and sampling devices, on the field sheet under the Algae Samples section. This is the COMPOSITE VOLUME. This value will also be recorded on all algae sample labels (i.e., for the diatom and soft-bodied algae taxonomic ID samples, the chlorophyll *a*, and the AFDM).

Note: If no soft-bodied algae sample is to be prepared, but there is a macroalgal clump in the sample, separate the clump from the liquid portion of the sample, measure and record the composite volume of the liquid (as described above), then cut the macroalgal clump into very fine pieces (resulting in strands that are eyelash-length or shorter) with CLEAN scissors and add these pieces to the composite liquid. The pieces should be chopped small enough so that they practically "blend" into the liquid (i.e., distinct fragments of macroalgae are not easily discernible), because the goal is to "homogenize" the macroalgae into the liquid as much as possible. Shake vigorously to homogenize the macroalgal fragments into the liquid. Then proceed to Section 5.2.3 and beyond to prepare the diatom and/or biomass samples.

5.2.2 Preparing the Soft-Bodied Algae Taxonomic ID Sample

Pour freshly-agitated liquid composite sample into the soft-bodied algae sample tube to the 45 mL mark. Midway through pouring, the composite sample should be swirled some more (first clockwise, then counter-clockwise) to ensure that the microalgae are still fully suspended. Cap the tube tightly. Completely fill out a sample label and affix it to the sample tube. Cover the label completely with clear plastic tape to prevent the writing on the label from smearing. Place the tube in the wet ice chest to keep it in the dark and as cold as possible, but make sure it is never allowed to freeze.

Note: As soon as possible, and no longer than four days after collection of the sample, glutaraldehyde must be added to the tube (to a final concentration of 2.5%, by adding 5 mL of 25% glutaraldehyde to 45 mL of sample) and distributed throughout the sample by agitation and turning the tube upside down repeatedly. Glutaraldehyde is necessary for fixing soft-bodied algal samples in order to preserve fine morphological features and the color of pigments, as both can be crucial characters for taxonomic determination. Glutaraldehyde is a hazardous substance that poses a number of safety risks. As such, it should be handled in a fume hood by trained personnel wearing appropriate gear. Refer to Appendix D for an SOP for the use of glutaraldehyde.

Members of the field crew can either have the glutaraldehyde added to the samples back at their own lab, or arrange for the glutaraldehyde to be added to the samples by the taxonomy lab. In either case, the unfixed samples must be kept in the dark and on wet ice (but not allowed to freeze), and must be fixed within four days of collection (and preferably sooner). If the taxonomy lab will be adding the fixative, it is imperative to plan ahead to arrange for this to be done, and also to clearly mark which tubes will need to have fixative added to them. Once the samples are fixed, it is no longer imperative to store them on wet ice. Following fixation, they can simply be stored in a cool, dark place.

5.2.3 Preparing the Diatom Taxonomic ID Sample

Diatom samples should be fixed as soon as possible after collection to reduce the possibility of cell division post-sampling. A 10% solution of buffered formalin is used to fix diatoms, and instructions for preparing this solution are provided in Appendix C.

To prepare the diatom sample, aliquot 40 mL of freshly-agitated composite liquid into the diatom ID sample tube, swirling the composite sample bottle again midway through pouring to keep the microalgae suspended. Add 10 mL of the 10% buffered formalin to the sample. This can be done using a small syringe or bulb pipette. Alternatively, if preferred, the centrifuge tubes for the diatom samples can be pre-loaded with 10 mL of the 10% buffered formalin and 40 mL of sample can be added carefully to the fixative, to avoid having to dispense the fixative in the field.

Notes: Fixatives such as formalin must be used with great care. Be sure to wear formalin-safe gloves and safety goggles when using the fixative, as it should never be touched with bare hands or allowed to splash onto skin or into eyes. Also make sure it is used only in a very well-ventilated place and avoid breathing in any fumes. Minimize the amount of time that vessels containing formalin are open. Fixative added to the sample must not be allowed to ooze outside the vessel that contains it, including the sample tubes. Refer to Appendix E for an SOP for the use of formalin.

Cap the tube tightly and shake it to mix the formalin into the sample. Fill out a sample label and affix it to the sample tube. Cover the label completely with clear plastic tape to prevent the writing on the label from smearing. Keep the fixed diatom samples in the dark and away from extreme heat.

5.2.4 Preparing the Biomass Samples

The remaining composite sample liquid can be used to prepare the chlorophyll *a* and AFDM filters as described below.

Chlorophyll *a* samples:

The procedure to filter chlorophyll *a* samples should be carried out quickly, and in the shade as much as possible, to minimize exposure of the sample to light, and minimize chlorophyll *a* degradation thereby. For the chlorophyll *a* samples, use CLEAN filter forceps (rinsed with DI water three times) to center a glass fiber filter (47 mm, 0.7 µm pore size) onto the mesh platform of a CLEAN filtering tower apparatus (rinsed with DI water three times), and rinse the filter a little with DI water to seat it well into the mesh before attaching the filter reservoir on top. Never touch the filters with hands or anything other than clean forceps.

Agitate the composite sample to resuspend all the microalgal material. Carefully measure 25 mL using a small, CLEAN graduated cylinder (rinsed with DI water three times). Midway through pouring the 25 mL, swirl the composite sample again to ensure that the material is still fully suspended. Pour the remainder of the 25 mL, and then pour the measured sample into the filter reservoir. Once empty, rinse the graduated cylinder with a few mL of DI water, and add this to the reservoir.

To filter the sample, create a gentle vacuum with the hand pump. Be sure to proceed very slowly, and pump only one stroke at a time until all of the liquid in the sample is passed through the filter. Pressure on the sample should never exceed 7 psi, as this could cause cells to burst and release contents, including chlorophyll *a*, into the filtrate and be lost. If it becomes impossible to filter a whole 25 mL of the sample and

remove the water efficiently, discard the filter and try again with a smaller volume (e.g., 10 mL). It is not necessary to collect on multiple filters to try to achieve a total volume of 25 mL. Simply filter as much as possible on a single filter, up to 25 mL, and then use that filter as the sample. Be sure to record the volume of the composite sample that was actually filtered, both on the datasheet, and on the sample label.

Rinse the sides of the filter reservoir with a few mL of DI water, and continue filtering until the water is drawn down. The filter should not be sucked dry, but rather left slightly moist, in order to avoid applying excessive pressure to the sample, which could cause algal cells to burst. After the liquid has passed through, check the filter to see if there are any bits of non-algal plant matter (like tiny seedlings or bits of leaves). If so, remove them with clean forceps, being careful not to remove any algae in the process. If possible, rinse the removed items with DI water onto the filter before discarding them. Remove the filter from the filtering device. *Note: Always thoroughly rinse the sides of the filter reservoir and the interface between the mesh filter seating and the screw-on part of the reservoir with DI water between samples.*

Being careful not to remove any of the collected material from the filter, fold the filter in half (with the sample material on the inside) using the forceps, and place it inside a clean, snap-top Petri dish[13]. Envelop the Petri dish completely within a small sheet of aluminum foil in order to prevent any light from reaching the filter. Place the covered Petri dish and its corresponding, completely filled-out sample label (face outward) into a 100 mL Whirl-pak bag[14], purge as much of the air out of the bag as possible, "whirl" it shut, and seal it tightly with its wire tabs, so that water in the cooler will not be able to enter the bag. *Note 1: If the Whirl-pak bags contain a lot of air, they will float on top of the ice water in the cooler, and they then run the risk of not being kept cold enough. Shove the sample packet down into the ice in the cooler. Note 2: A clean, clear plastic centrifuge tube is also an acceptable container in which to store the filter. It must also be properly labeled, wrapped in aluminum foil, and kept submerged in wet ice.*

Keep chlorophyll *a* filters as cold as possible and place in the freezer or dry ice as soon as possible (and within four hours of collection); the holding time for the chlorophyll *a* filters is 28 days from collection, when kept frozen.

Ash-free dry mass (AFDM) samples:

For the AFDM samples, you should use glass-fiber filters (47 mm, 0.7 µm pore size) that have been precombusted. Never touch the filters with hands or anything other than a CLEAN forceps (rinsed with DI water three times). The filters to use should be labeled "for AFDM", and stored in aluminum sleeves. Follow the same process as that used for chlorophyll *a* sample filtering. After all the liquid has passed through, check the filter to see if there are any pieces of non-algal plant matter (such bits of leaves or wood). If so, remove them with a clean forceps (rinsed with DI water three times), being careful not to remove any algae in the process. The goal with AFDM, for the purposes of this SOP, is to target the ALGAL portion of the organic matter in the sample, and therefore field crews should do their best to remove non-algal contributors

13. It may be beneficial to write the Site Code or sample ID code on the Petri dish itself, in addition to filling out the full sample label.
14. Other bag types are acceptable only if they are water-tight (note that Ziploc bags often leak when submerged).

of organic matter from the sample. Remove the filter from the filtering device. *Note: Always thoroughly rinse the sides of the filter reservoir and the interface between the mesh filter seating and the screw-on part of the reservoir with DI water between samples.*

Use the forceps to fold the AFDM filter in half (with the sample material on the inside) and wrap it loosely in a small sleeve of clean aluminum foil. Be careful not to squeeze the filter, which could cause the sample to ooze from the filter onto the aluminum sleeve. Store the filter in a sealed 100 mL Whirl-pak bag containing a completely filled-out sample label, including the volume that was filtered (i.e., 25 mL or otherwise). As with the chlorophyll *a*, purge as much of the air out of each bag as possible, "whirl" it shut, and seal tightly with the wire tabs. Shove the sample packet down into the ice in the cooler. *Note: A clean, clear plastic centrifuge tube is also an acceptable container in which to store the filter. It must also be properly labeled and kept submerged in wet ice.*

Keep AFDM filters as cold as possible until the samples can be frozen back at the lab that evening, or place on dry ice until they can be stored in the lab freezer. The holding time for the AFDM samples is 28 days from collection, when kept frozen.

5.3 PROCESSING SOFT-BODIED AND OTHER SAMPLE TYPES WHEN A MACROALGAL CLUMP IS PRESENT

The following is a description of how to proceed when a soft-bodied algal taxonomic ID sample is to be prepared AND macroalgal clump(s) are present in the sample in the dish tub. A flowchart of this procedure is provided in Appendix F. It is recommended that this flowchart be printed out in color, laminated (if possible) or printed out on water-proof paper, and brought along to the field for quick reference on handling macroalgal clumps in the composite sample. The reason for the extra step in the processing of the macroalgae for the purposes of the soft-bodied algae sample is that it maintains larger, more intact macroalgal specimens for examination in the laboratory, rather than chopping up all of the macroalgal specimens before sending them to the lab. This is important, because availability of intact specimens greatly improves the chances that the taxonomist will be able to identify the soft-bodied algae to low taxonomic levels.

5.3.1 Isolating and Dividing the Macroalgal Clump

For this procedure, the macroalgal clump is first removed from the dish tub, wrung out gently, and rolled into a cylinder shape that is relatively even in thickness along its length. If there is more than one type of macroalgae in the sample, the various types should be layered on top of one another lengthwise so that they are represented in roughly constant proportions across the length of the "cylinder". The cylinder is measured with a ruler and a quarter of its length is cut off with scissors and put into the (still empty) soft-bodied algae ID centrifuge tube[15]. The clump is pushed down into the tube, and the top is flattened, so that the volume

15. It is unlikely that the ¼ macroalgal clump will occupy all the space in the sample tube, but if it does, a second tube will be needed in order to accommodate all the sample material plus liquid. If such an action is taken, it should be noted in the Comments section of the field sheets and the tubes should be clearly identified as belonging to the same sample, for record keeping purposes.

of the clump can be estimated using the graduations on the tube. The estimated volume of this clump will be used in a calculation (see Equation 1 and Figure 8). The remaining three-quarters length of cylinder is set aside in the shade/cool. It is recommended that this section be placed in a Ziploc bag, sealed, and put in the wet ice cooler.

5.3.2 Measuring the Composite Liquid Volume

Once algal specimens have been removed from all the substrates (e.g., sand, gravel, cobble, wood, leaves) in the dish tub, according to the procedure described in Section 4, gently agitate the dish tub to suspend the microalgae in the liquid, and then start pouring this suspension into a CLEAN graduated cylinder to measure the volume of the liquid. Try to leave all substrate material (e.g., silt, sand) behind. Transfer the measured liquid into a CLEAN 1L plastic bottle. Using a minimal amount of stream water, rinse the substrate once or twice with stream water until it appears that little to no additional suspended material (microalgae) is coming off. Add this rinsate to the graduated cylinder to measure it also. If necessary, repeat this process (regularly agitating the dish tub) until all the liquid has been measured and transferred to the sample bottle. Use water sparingly, because the total sample volume plus rinsate should be no more than about 400-500 mL.

Because you are leaving as much of the silt, sand, and any large substrate material behind as possible, the final volume should reflect only the liquid component of the sample plus rinse water. Record the total volume of all the liquid that had been in the dish tub, including any that was used for rinsing the substrates and sampling devices, on the field sheet under the Algae Samples section. This is the COMPOSITE VOLUME. This value will also be recorded on all algae sample labels (i.e., for the diatom and soft-bodied algae taxonomic ID samples, the chlorophyll *a*, and the AFDM).

5.3.3 Preparing the Soft-Bodied Algae Taxonomic ID Sample

Pour freshly-agitated liquid composite sample from the 1-L bottle into the soft-bodied algae sample tube (on top of the clump of macroalgae) up to the 45 mL mark. Midway through pouring, the composite sample should be swirled some more (first clockwise, then counter-clockwise) to ensure that the microalgae are still fully suspended. Cap the tube tightly. Completely fill out a sample label and affix it to the sample tube. Cover the label completely with clear plastic tape to prevent the writing on the label from smearing. Place the tube in the wet ice chest to keep it in the dark and as cold as possible, but make sure it is never allowed to freeze.

Note: As soon as possible, and no longer than four days after collection of the sample, glutaraldehyde must be added to the tube (to a final concentration of 2.5%, by adding 5 mL of 25% glutaraldehyde to 45 mL of sample) and distributed throughout the sample by agitation and turning the tube upside down repeatedly. Glutaraldehyde is necessary for soft-bodied algal samples in order to preserve fine morphological features and the color of pigments, as both can be crucial characters for taxonomic determination. Glutaraldehyde is a hazardous substance that poses a number of safety risks. As such, it should be handled in a fume hood by trained personnel wearing appropriate gear. Refer to Appendix D for an SOP for the use of glutaraldehyde.

Members of the field crew can either have the glutaraldehyde added to the samples back at their own lab, or arrange for the glutaraldehyde to be added to the samples by the taxonomy lab. In either case, the unfixed samples must be kept in the dark and on wet ice (but not allowed to freeze), and must be fixed within four days of collection (and preferably sooner). If the taxonomy lab will be adding the fixative, it is imperative to plan ahead to arrange for this to be done, and also to clearly mark which tubes will need to have fixative added to them. Once the samples are fixed, it is no longer imperative to store them on wet ice. Following fixation, they can simply be stored in a cool, dark place.

5.3.4 Preparing the Diatom Taxonomic ID Sample

After the soft-bodied algal sample has been prepared, and before preparing the diatom sample (and biomass samples, which will be discussed in the next section), the volume of the remaining composite liquid must be reduced to equal ¾ of the original volume[16]. This is necessary because ¼ of the macroalgae clump was taken out of the composite sample but a full ¼ was not removed from the water portion. As such, the original ratio between water and macroalgae must be restored before further sample preparation.

The following procedure is used to reduce the volume of liquid composite to ¾ of the original. For convenience, you can use this formula (Figure 8) to calculate how many mL to pour off and discard from the composite:

Equation 1. Adjusting the volume of composite sample

volume (mL) of composite to pour off = (0.25 * C) – 45 + A

where "C" is the original composite volume and "A" is the approximate volume of the clump of macroalgae that was placed in the soft-bodied algae sample tube (tamped down and flattened). You may wish to fill out a copy of the Ratio Restoration worksheet shown in Figure 8 to calculate the amount of composite to pour off.

Liquid Portion of Composite Sample: _____ mL = C

Volume of 1/4 macroalgal chunk: _____ mL = A

Volume of Liquid Composite to Pour Off: (0.25 * _____ C) – 45 + _____ A = _____ mL

Figure 8. Ratio restoration worksheet.

16. For example, if the original composite volume was 480mL, you will be discarding enough composite liquid to get down to 360 mL.

As always, be sure to agitate the composite liquid adequately in order to resuspend any settled microalgae before pouring off the calculated volume.

Once the required amount of composite liquid has been discarded, the remaining ¾ of the macroalgal clump ("cylinder") is cut into very fine pieces with a scissors (resulting in strands that are eyelash-length or shorter), and these are added to the reduced-volume composite liquid. The pieces should be chopped small enough so that they practically "blend" into the liquid (i.e., distinct fragments of macroalgae are not easily discernible), because the goal is to "homogenize" the macroalgae into the liquid as much as possible. Now the ratio of macroalgae to liquid from the original sample in the dish tub is restored. Cap the composite bottle and shake vigorously to homogenize the bits into the liquid as much as possible, while not agitating so hard as to risk busting cells and releasing chlorophyll.

Diatom samples should be fixed as soon as possible after collection to reduce the possibility of cell division post-sampling. A 10% solution of buffered formalin is used to fix diatoms, and instructions for preparing this solution are provided in Appendix C.

To prepare the diatom sample, aliquot 40 mL of freshly-agitated sample homogenate into the diatom ID sample tube, swirling the composite sample bottle again midway through pouring to keep the algal material suspended. Add 10mL of the 10% buffered formalin to the sample. This can be done using a small syringe or bulb pipette. Alternatively, if preferred, the centrifuge tubes for the diatom samples can be pre-loaded with 10 mL of the 10% buffered formalin and 40 mL of sample can be added carefully to the fixative, to avoid having to dispense the fixative in the field.

Note: Fixatives such as formalin must be used with great care. Be sure to wear formalin-safe gloves and safety goggles when using the fixative, as it should never be touched with bare hands or allowed to splash onto skin or into eyes. Also make sure it is used only in a very well-ventilated place and avoid breathing in any fumes. Minimize the amount of time that vessels containing formalin are open. Fixative added to the sample must not be allowed to ooze outside the vessel that contains it, including the sample tubes. Refer to Appendix E for an SOP for the use of formalin.

Cap the tube tightly and shake it to mix the formalin into the sample. Fill out a sample label and affix it to the sample tube. Cover the label completely with clear plastic tape to prevent the writing on the label from smearing. Keep the fixed diatom samples in the dark and away from extreme heat.

5.3.5 Preparing the Biomass Samples

The remaining composite sample homogenate can be used to prepare the chlorophyll *a* and AFDM filters according to the following procedure.

Chlorophyll *a* samples:

The procedure to filter chlorophyll *a* samples should be carried out quickly, and in the shade as much as possible, to minimize exposure of the sample to light, and minimize chlorophyll *a* degradation thereby. For the chlorophyll *a* samples, use CLEAN filter forceps (rinsed with DI water three times) to center a glass fiber filter (47 mm, 0.7 µm pore size) onto the mesh platform of CLEAN filtering tower apparatus (rinsed with DI water three times), and rinse the filter a little with DI water to seat it well into the mesh before attaching the filter reservoir on top. Never touch the filters with hands or anything other than clean forceps.

Agitate the composite sample homogenate to resuspend all the macroalgal fragments and microalgal material. Carefully measure 25 mL using a small, CLEAN graduated cylinder (rinsed with DI water three times). Midway through pouring the 25 mL, swirl the homogenate again to ensure that the material is still fully suspended. Pour the remainder of the 25 mL, and then pour the measured homogenate into the filter reservoir. Once empty, rinse the graduated cylinder with a few mL of DI water, and add this to the reservoir.

To filter the sample, create a gentle vacuum with the hand pump. Be sure to proceed very slowly, and pump only one stroke at a time until all of the liquid in the sample is passed through the filter. Pressure on the sample should never exceed 7 psi, as this could cause cells to burst and release contents, including chlorophyll *a*, into the filtrate and be lost. If it becomes impossible to filter a whole 25 mL of the sample and remove the water efficiently, discard the filter and try again with a smaller volume (e.g., 10 mL). It is not necessary to collect on multiple filters to try to achieve a total volume of 25 mL. Simply filter as much as possible on a single filter, up to 25 mL, and then use that filter as the sample. Be sure to record the volume of the composite sample that was actually filtered, both on the datasheet, and on the sample label.

Rinse the sides of the filter reservoir with a few mL of DI water, and continue filtering until the water is drawn down. The filter should not be sucked dry, but rather left slightly moist, in order to avoid applying excessive pressure to the sample, which could cause algal cells to burst. After all the liquid has passed through, check the filter to see if there are any bits of non-algal plant matter (like tiny seedlings or bits of leaves). If so, remove them with clean forceps, being careful not to remove any algae in the process. Remove the filter from the filtering device. *Note: Always thoroughly rinse the sides of the filter reservoir and the interface between the mesh filter seating and the screw-on part of the reservoir with DI water between samples.*

Fold the filter in half (with the sample material on the inside) using the forceps, and place it inside a clean, snap-top Petri dish. Envelope the Petri dish completely within a small sheet of aluminum foil in order to prevent any light from reaching the filter. Place the covered Petri dish and its corresponding, completely filled-out sample label (face outward) into a 100 mL Whirl-pak bag, purge as much of the air out of the bag as possible, "whirl" it shut, and seal it tightly with its wire tabs, so that water in the cooler will not be able to enter the bag. *Note: If the Whirl-pak bags contain a lot of air, they will float on top of the ice water in the cooler, and they then run the risk of not being kept cold enough. Shove the sample packet down into the ice in the cooler.*

Keep chlorophyll *a* filters as cold as possible and place in the freezer or dry ice as soon as possible (and within four hours of collection); the holding time for the chlorophyll *a* filters is 28 days from collection, when kept frozen.

Ash-free dry mass (AFDM) samples:

For the AFDM samples, you should use glass-fiber filters (47 mm, 0.7 µm pore size) that have been precombusted. Never touch the filters with hands or anything other than a clean forceps (rinsed with DI water three times). The filters to use should be labeled "for AFDM", and stored in aluminum sleeves. Follow the same process as that used for chlorophyll *a* sample filtering. After all the liquid has passed through, check the filter to see if there are any bits of non-algal plant matter (such as bits of leaves or wood). If so, remove them with clean forceps (rinsed with DI water three times), being careful not to remove any algae in the process. Remove the filter from the filtering device. *Note: Always thoroughly rinse the sides of the filter reservoir and the interface between the mesh filter seating and the screw-on part of the reservoir with DI water between samples.*

Use the forceps to fold the AFDM filter in half (with the sample material on the inside) and wrap it loosely in a small sleeve of clean aluminum foil. Be careful not to squeeze the filter, which could cause the sample to ooze from the filter onto the aluminum sleeve. Store the filter in a sealed 100 mL Whirl-pak bag containing a completely filled-out sample label, including the volume that was filtered (i.e., 25 mL or otherwise). As with the chlorophyll *a*, purge as much of the air out of each bag as possible, "whirl" it shut, and seal tightly with the wire tabs. Shove the sample packet down into the ice in the cooler.

Keep AFDM filters as cold as possible until the samples can be frozen back at the lab that evening, or place on dry ice until they can be stored in the lab freezer. The holding time for the AFDM samples is 28 days from collection, when kept frozen.

5.4 PROCEDURE FOR COLLECTING QUALITATIVE ALGAL SAMPLES

If your program calls for the collection of soft-bodied taxonomic ID samples, then you will also need to collect a "qualitative" sample at every monitoring reach. The qualitative samples consist of a composite of all types of soft-bodied algae visible within the reach. This is of value because it can provide a fairly exhaustive list of soft-bodied algal taxa present at the site and can also aid identification of taxa captured in the RWB sampling, since it allows larger, more intact specimens to be collected than those that may end up in the more heavily processed quantitative sample (described above). In addition, if the qualitative sample is kept cool and in the dark, and is delivered to the lab in a timely manner (i.e., as quickly as possible, and within two weeks of collection), the live specimens can be cultured, which can also aid in identification. For example, some taxa in the Zygnematales cannot be identified to species level unless they are in a sexual phase during examination. If asexual at the time of collection (which is the typical situation), live specimens could be induced to a sexual phase in the lab. Collection of a qualitative diatom sample is optional, and is typically not needed for general bioassessment purposes.

For qualitative soft-bodied algal samples, collect specimens of all obviously different types of macroalgal filaments and mats, as well as microalgae (in the forms of scrapings using a razor blade or knife), and depositional samples (suctioned from along the surface of sediments using a clean turkey baster). Note that some algae (e.g., species of *Chara*, *Paralemanea*, and *Vaucheria*) have morphologies similar to submerged macrophytes or mosses. In addition, algae are not always green, and may instead be dark-brownish, golden, reddish, or bluish-green. Some cyanobacteria (which should also be collected for the qualitative sample), such as members of the genus *Nostoc*, look like gelatinous globules, or sacs, ranging in size anywhere from smaller than a pea to larger than a lime. Online image searches of these taxa and others will help the collector develop an eye for the variety of types of algae that may be encountered in streams. If you suspect something may be algae, but are not sure, it is always preferable to collect some of it for the qualitative sample. The laboratory will determine whether it qualifies for inclusion in the species list. Collect from as many distinct locations as possible throughout the reach so as to capture as much of the apparent diversity in the reach as you can. Also, when possible, try to grab part of the holdfast structures that attached the macroalgae to the substrate, as these structures can be useful for taxonomic identification.

Since these samples are merely qualitative, and not quantitative, you need not worry about collecting them in a manner that is representative of their relative abundances within the reach. *Note: If there is only a small amount of macroalgae in the stream, it should be allocated preferentially to the soft-bodied algae laboratory sample, as opposed to the diatoms (if a diatom qualitative sample is being collected), because it is primarily needed for the soft-bodied algal identification work (although diatoms can live as epiphytes on macroalgae, so macroalgal samples are also of values for the diatom work).*

Using a thick, waterproof marker, label a Whirl-pak bag with the Site Code, Date, Sample ID, and "soft" (or "diatom", if also collecting a diatom sample). Fill the bag with a total volume of up to 100 mL of qualitative algae sample + water. Purge any extra air from the bag, seal with the wire tabs by twisting them together (not just folding them, as this can result in leakage), tuck the ends of the wire tabs inward so that they cannot poke other bags, and store in the cooler on wet ice in the field. Be careful not to place the bags right up against ice or frozen blue-ice bags, because this could cause the algae to freeze and thus destroy the sample. Unlike with the quantitative samples, **do not add glutaraldehyde or formalin** (or any other fixative) to these qualitative samples. Keep the qualitative samples on wet ice and refrigerate immediately upon return to the lab. Because they are not preserved, these samples should be examined by a taxonomist as soon as possible (and within two weeks, at most), as they can decompose fairly rapidly. Decomposition is of particular concern for the soft-bodied algae sample.

If it is impossible to get the soft-bodied qualitative samples to a taxonomist within two weeks of sample collection, then split the qualitative samples in half, transfer one half to a 50 mL centrifuge tube and preserve it with glutaraldehyde (to a 2.5% final concentration) and leave the other half un-fixed (but continue to store in the cold/dark until examination by a taxonomist). This should be done in order to preserve part of the sample for morphological identification, but still maintain some possibility of keeping some specimens alive, in case culturing is necessary. *Note: Glutaraldehyde is a hazardous substance that can*

pose health and safety risks. Add glutaraldehyde in a fume hood, wearing safety goggles and glutaraldehyde-safe gloves. Refer to Appendix D for more detailed instructions on the safe handling of glutaraldehyde.

5.5 ALGAL SAMPLING QUALITY ASSURANCE / QUALITY CONTROL

The SWAMP bioassessment group is currently developing guidelines for quality assurance and quality control for bioassessment procedures. Future revisions to this document will include more specific information covering personnel qualifications, training and field audit procedures, procedures for field calibration, procedures for chain of custody documentation, requirements for measurement precision, health and safety warnings, cautions (actions that would result in instrument damage or compromised samples), and interferences (consequences of not following the SOP).

It is recommended that duplicate sampling of algae occur at 10% of study sites. The recommended method for collecting duplicates is at adjacent positions along the sampling transect according to the scheme depicted in Figure 2. Both samples should be collected at each transect before moving on to the next transect. When duplicate samples are collected at a site, the full suite of information about the algae samples (composite volume, numbers of each sampling device used, amount filtered, etc.) will need to be recorded for each replicate. This information can be recorded on a duplicate copy of the "Algae Samples" field sheet. Alternatively, the data cells on this sheet can be divided in half to accommodate information for each replicate. If the latter, it is important to keep track of which values go with which replicate.

In addition to including composite volume, area sampled (total, for all sampling devices used), and amount filtered (for the biomass samples) on the sample labels and field sheets, this information should also be included on the chain-of-custody sheets that are submitted to the algae analytical and taxonomy laboratories. This will facilitate efficient calculation of several types of data output, because this information is needed both for the biomass results and for the soft-bodied algae biovolume results.

6 PHYSICAL HABITAT TRANSECT-BASED MEASUREMENTS TO ACCOMPANY ALGAL BIOASSESSMENT

Once all algae samples have been collected at a given transect, PHab data collection can begin there. PHab data are designed to assess the physical habitat conditions of the stream reach being sampled. Knowledge about the PHab parameters can aid interpretation of the biotic assemblage data collected. Data for the following PHab parameters will be entered on transect-specific datasheets (corresponding to each of the 11 main transects along the monitoring reach). These datasheets are provided on the SWAMP website.

It should be noted that the data collection procedures for the parameters below reflect those that are described in the SWAMP BMI Bioassessment SOP (Ode 2007). With respect to PHab assessment, the only deviation between this SOP and that of Ode (2007) is in terms of omission of certain parameters. However, where there is overlap in parameters between the two SOPs, they are assessed in exactly the same manner. The one exception to this is the addition, in this SOP, of percent algal cover determination to the pebble count as described in Ode (2007). Also, note that because the datasheets are multi-purpose datasheets, developed for both BMIs and algae, they include some PHab parameters that are not a part of this SOP. Specifically, the following PHab data that appear on the datasheets are not collected when only algae are being sampled: 1) Riparian vegetation, and 2) Instream habitat complexity. As such, these sections are not filled out on the datasheets when only algae samples are being collected.

6.1 WETTED WIDTH

The wetted channel is the zone that is inundated with water and the wetted width is the distance between the sides of the channel at the point where substrates are no longer surrounded by surface water. Measure the wetted stream width and record this in the box at the top of the Transect data form.

6.2 BANKFULL WIDTH

The bankfull channel is the zone of maximum water inundation in a normal flow year (one-to-two year flood events). Since most channel formation processes are believed to act when flows are within this zone, bankfull dimensions provide a valuable indication of relative size of the waterbody.

Scout along the stream margins to identify the location of the bankfull margins on either bank by looking for evidence of annual or semi-annual flood events. Examples of useful evidence include topographic, vegetative, or geologic cues (changes in bank slope, changes from annual to perennial vegetation, changes in the size distribution of surface sediments). While the position of drift material caught in vegetation may be

a helpful aid, this can lead to very misleading measurements. *Note: The exact nature of this evidence varies widely across a range of stream types and geomorphic characteristics. It is helpful to investigate the entire reach when attempting to interpret this evidence because the true bankfull margin may be obscured at various points along the reach. Often the bankfull position is easier to interpret from one bank than the other; in these cases, it is easiest to infer the opposite bank position by projecting across the channel. Additionally, height can be verified by measuring the height from both edges of the wetted channel to the bankfull height (these heights should be equal).*

Stretch a tape from bank to bank at the bankfull position. Measure the width of the bankfull channel from bank to bank at bankfull height and perpendicular to the direction of stream flow.

6.3 BANKFULL HEIGHT

Measure bankfull height (the vertical distance between the **water surface** and the height of the bank, Figure 9) and record in the boxes at the top of the Transect data form under "Bankfull Width" and "Bankfull Height".

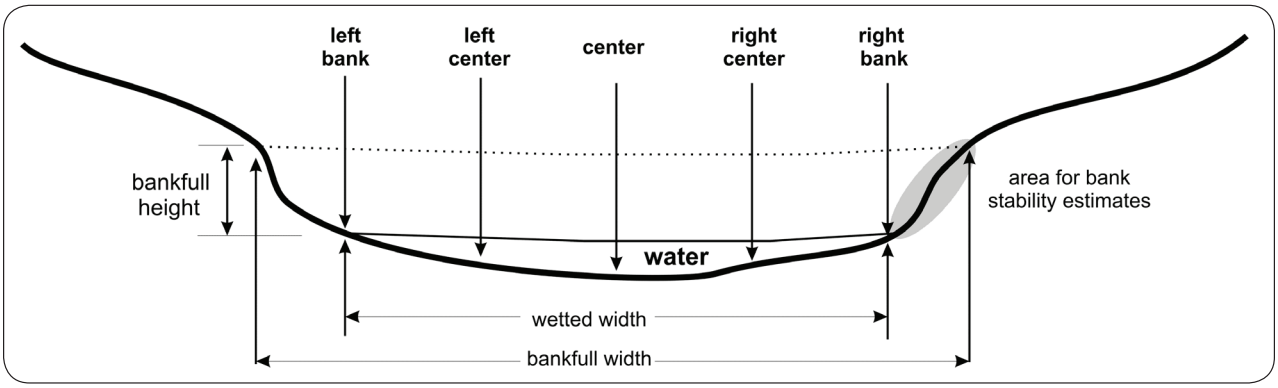

Figure 9. Cross sectional diagram of a typical stream channel showing locations of substrate measurements, wetted and bankfull width measurements, and bank stability visual estimates (reprinted from Ode 2007).

6.4 "PEBBLE COUNT": TRANSECT SUBSTRATES

Particle size frequency distributions often provide valuable information about instream habitat conditions that affect benthic communities. The Wolman pebble count technique is a widely used and cost-effective method for estimating the particle size distribution and produces data that correlate with costly, but more quantitative bulk sediment samples. Coarse particulate organic matter (CPOM, particles of organic material such as leaves that are greater than 1.0 mm in diameter) is a general indicator of the amount of

allochthonous organic matter available at a site, and its measurement can provide valuable information about the basis of the food web in a stream reach. The presence of CPOM associated with each particle is quantified at the same time that particles are measured for the pebble counts.

Transect substrate measurements are taken at five equidistant points along each transect (Figure 9). Divide the wetted stream width by four to get the distance between the five points (Left Bank, Left Center, Center, Right Center and Right Bank) and use a measuring device to locate the positions of these points (e.g., a stadia rod or measuring tape). Once the positions are identified, lower a folding meter stick through the water column perpendicular to both the flow and the transect to identify the particle located at the tip of the meter stick. *Note: It is important that you are not subjective about selecting a particle, as this will result in failing to generate an accurate assessment of the size class distribution of particles present in that stream reach.*

6.5 DEPTH

With the folding meter stick, measure the depth from the water surface to the top of the particle to the nearest cm and record on the datasheet.

Table 3
Particle size class codes, descriptions, and measurements (adapted from Ode 2007)

Size Class	Code Size Class Description	Common Size Reference	Size Class Range
RS	bedrock, smooth	larger than a car	> 4 m
RR	bedrock, rough	larger than a car	> 4 m
XB	boulder, large	meter stick to car	1 - 4 m
SB	boulder, small	basketball to meter stick	25 cm - 1.0 m
CB	cobble	tennis ball to basketball	64 - 250 mm
GC	gravel, coarse	marble to tennis ball	16 - 64 mm
GF	gravel, fine	ladybug to marble	2 – 16 mm
SA	sand	gritty to ladybug	0.06 – 2 mm
FN	fines	not gritty	< 0.06 mm
HP	hardpan (consolidated fines)		< 0.06 mm
WD	wood		
RC	concrete/ asphalt		
OT	other		

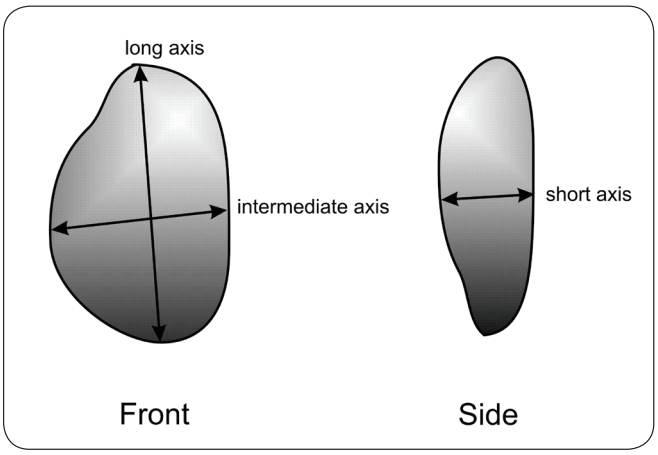

Figure 10. Diagram of three major perpendicular axes of substrate particles. The intermediate axis is recorded for pebble counts (reprinted from Ode 2007).

6.6 PARTICLE SIZE CLASS

Remove the particle from the streambed. Assign the particle to one of the size classes listed in Table 3 (these are also provided in a box on the transect form), based on its intermediate axis length (Figure 10). Record this information under Substrate size class.

Be sure to use measurements or the established codes for particle size class. If the latter, confirm the 2-letter codes for the particles as you call them out to your partner recording the data to ensure you are using the correct codes.

6.7 COBBLE EMBEDDEDNESS

It is generally agreed that the degree to which fine particles fill interstitial spaces has a significant impact on the ecology of benthic organisms and fish, but techniques for measuring this impact vary greatly. Here we define embeddedness as the volume of cobble-sized particles (64-250 mm) that is buried by fine and sand particles (< 2.0 mm diameter).

When a cobble-sized particle is encountered during the pebble count, visually estimate the percentage of the cobble's volume that has been buried by fine/sand particles (this will likely require removing the cobble from the streambed). Record, to the nearest 5%, the embeddedness of up to 25 cobble-sized particles within the sampling reach in the corresponding "% Cobble Embed" field for each cobble.

If 25 cobbles are not encountered during the pebble count, supplement the cobbles by conducting a "random walk" through the reach. Starting at a random point in the reach, follow a line from one bank to the other at a randomly chosen angle. Once at the other bank reverse the process with a new randomly chosen angle. Enter any of these additional embeddedness values at the bottom of the first page of the set of field forms, under "ADDITIONAL COBBLE EMBEDDEDNESS MEASURES".

If 25 cobble sized particles are not present in the entire reach, then record the values for however many cobbles are present.

6.8 CPOM

Record the presence or absence of Coarse Particulate Organic Matter (CPOM) that is > 1 mm diameter, and within 1 cm of the particle.

6.9 ALGAL COVER

Algal cover refers to the amount of algae in the stream reach, both in terms of 1) microalgal coatings ("slimy-ness") on stream substrates and 2) macroalgae (e.g., filaments, mats, globules). Algal cover is estimated by a point-intercept approach that entails collecting information about the presence/absence of both types of algae (as well as thickness, for the microalgae) at each of the points along the transects associated with the pebble count. If the imaginary point corresponding to each pebble in the pebble count intercepts algae, then algae is recorded as "present" at that point. The percentage of the points across the sampling reach that have algae present yields an estimate of the percent algal cover.

For each point along the pebble count, record information about algae as follows. For any film-like coating of algae (referred to as "Microalgae" on the datasheet) present on the surface of the substrate at that point, estimate the presence/thickness category according to the scheme in Table 4. For thicker microalgal layers, a small metal or plastic rod with demarcations at 1, 5, and 20 mm can be used for measurement. For layers too thin to measure, use the diagnostic criteria listed in the last column of Table 4. Note that these thickness codes refer only to microalgal coatings/films on substrate. They do not refer to thickness of macroalgal filaments/mats; macroalgal thickness is not assessed in this protocol. Be sure to collect microalgal thickness data from whatever substrate is topmost within the stream and therefore is most likely to be exposed to sunlight. Sometimes this substrate is not the actual pebble used in the pebble count, but rather a substrate type that occurs above the pebble, such as a thick mat of macroalgae that is above (and covering) the stream bottom. Microalgal species (which can include diatoms and unicellular soft-bodied algae) can grow as "epiphytes" upon macroalgal filaments and mats, coating them with a slimy, tinted film.

Table 4
Microalgal thickness codes and descriptions (adapted from Stevenson and Rollins 2006).

Code	Thickness	Diagnostics
0	No microalgae present	The surface of the substrate feels rough, not slimy.
1	Present, but not visible	The surface of the substrate feels slimy, but the microalgal layer is too thin to be visible.
2	<1mm	Rubbing fingers on the substrate surface produces a brownish tint on them, and scraping the substrate leaves a visible trail, but the microalgal layer is too thin to measure.
3	1-5mm	
4	5-20mm	
5	> 20mm	
UD	Cannot determine if a microalgal layer is present	
D	Dry point	

Note: Sometimes, due to the nature of the substrate, it can be difficult to discern whether a microalgal layer is present (particularly if it is very thin). For example, in the case of very fine sediments, the dark color of the silt can obscure the diagnostic color of a microalgal layer, and the inherent "sliminess" of very fine silt may make tactile determination of microalgae impossible. Therefore, when silt is the substrate, only relatively thick layers of microalgae might be easily discernible. If presence/absence of a microalgal layer cannot be determined with certainty, score microalgal thickness as "UD".

In addition to recording the presence and thickness of microalgae on the surfaces of substrates, record the presence/absence of attached macroalgae in the water column, as well as unattached, floating macroalgal mats on the water's surface, corresponding to each pebble count sampling point. Do this by envisioning an imaginary "line" extending from the water's surface down to the stream bottom where the target "pebble" lies (particularly in turbulent water, it may be helpful to use a viewing bucket (Appendix C) in order to see below the water's surface; the use of the viewing bucket is optional). If this line intercepts macroalgae, either floating on the water's surface, or somewhere within the water column, the appropriate algal class(es) should be recorded as "present". Attached macroalgal filaments have an obvious physical connection to something (like a cobble, boulder, or a gravel bed) lying on the bottom of the stream, whereas for unattached macroalgae, there is no obvious physical connection with the streambed, and the algae is just freely floating at or near the water's surface. For each class of macroalgae (Attached and Unattached), mark "P" (for "present") if intercepted by the sampling point and "A" (for "absent") if not intercepted.

Bear in mind that, because pebble counts span the "wetted width" of each transect, the expectation is that even the pebbles at the bank positions will generally be at least moist, and sometimes even submerged. As such, it is important to realize that algal cover can occur at the bank positions of the pebble count as well as intermediate positions across the stream. An exception to this is when the pebble surface is completely dry. Section 6.11 provides instructions for data collection in this situation.

6.10 MACROPHYTES

If a vascular plant (i.e., a macrophyte) is intercepted by the imaginary line associated with the pebble count point, mark "P" for "present" under Macrophytes. Otherwise, mark "A" for absent. Include only herbaceous plants that are rooted underwater. Examples of macrophytes include cattails, tules, rushes, sedges, monkeyflowers, speedwells, knotweeds, and watercress.

6.11 DRY SUBSTRATES

To determine how to collect data at dry sampling points, it is necessary to first establish whether the dry area in question lies within the stream's active channel (i.e., therefore regularly inundated during storms), or whether the point is on a stable island (i.e., therefore rarely, if ever, inundated). Stable islands are typically

vegetated, often with woody shrubs or trees, and have heights near or exceeding bankfull height. Pebble counts should not be conducted on stable islands. If the transect spans a portion of the study reach in which the channel is bifurcated such that there are two channels with an intervening island, the entire transect should be placed across the dominant channel, and all five pebble count points should be located on that side.

If the point falls on a dry surface that is within the usual active channel (i.e., subject to regular disturbance by flows), then pebble count/algal cover data from the dry point should be recorded as follows:

- score Depth as 0
- score particle Size Class and Embeddedness as described above for wet particles
- score all the algae variables (Microalgae, Macroalgae Attached, and Macroalgae Unattached) as "D" for "dry"
- leave CPOM and Macrophytes "blank" (i.e., do not circle anything). These parameters will register as NR (Not Recorded) in the database.

Ordinarily, the sampling transect would span the wetted width of the channel, but when no water is present at a given transect, evidence of the typical wetted extent of the active channel will need to be used to infer appropriate transect boundaries. Such indicators can include the transition from vegetated to unvegetated area (i.e., moving from banks to active channel), as well as the presence of dried algae, water stains, microtopographic transitions, changes in substrate composition, and others.

6.12 BANK STABILITY

The vulnerability of stream banks to erosion is often of interest in bioassessments because of its direct relationship with sedimentation.

For each transect, record a visual assessment of bank vulnerability in the region between the wetted width and bankfull width of the stream margins and between the upstream and downstream inter-transects. Choose one of three vulnerability states: eroded (evidence of mass wasting), vulnerable (obvious signs of bank erosion or unprotected banks), or stable.

6.13 HUMAN INFLUENCE

For the left and right banks, estimate a 10 x 10 m riparian area centered on the edges of the transect (see Figure 11). In the "Human Influence" section of the Transect data sheet, record the presence of 14 human influence categories in three spatial zones relative to this 10 x 10 m square (between the wetted edge and bankfull margin, between the bankfull margin and 10 m from the stream, and between 10 m and 50 m beyond the stream margins): 1) walls/rip-rap/dams, 2) buildings, 3) pavement/cleared lots, 4) roads/

railroads, 5) pipes (inlets or outlets), 6) landfills or trash, 7) parks or lawns (e.g., golf courses), 8) row crops, 9) pasture/ rangelands, 10) logging/ timber harvest activities, 11) mining activities, 12) vegetative management (herbicides, brush removal, mowing), 13) bridges/ abutments, 14) orchards or vineyards. Circle all combinations of impacts and locations that apply, but be careful to not double-count any human influence observations.

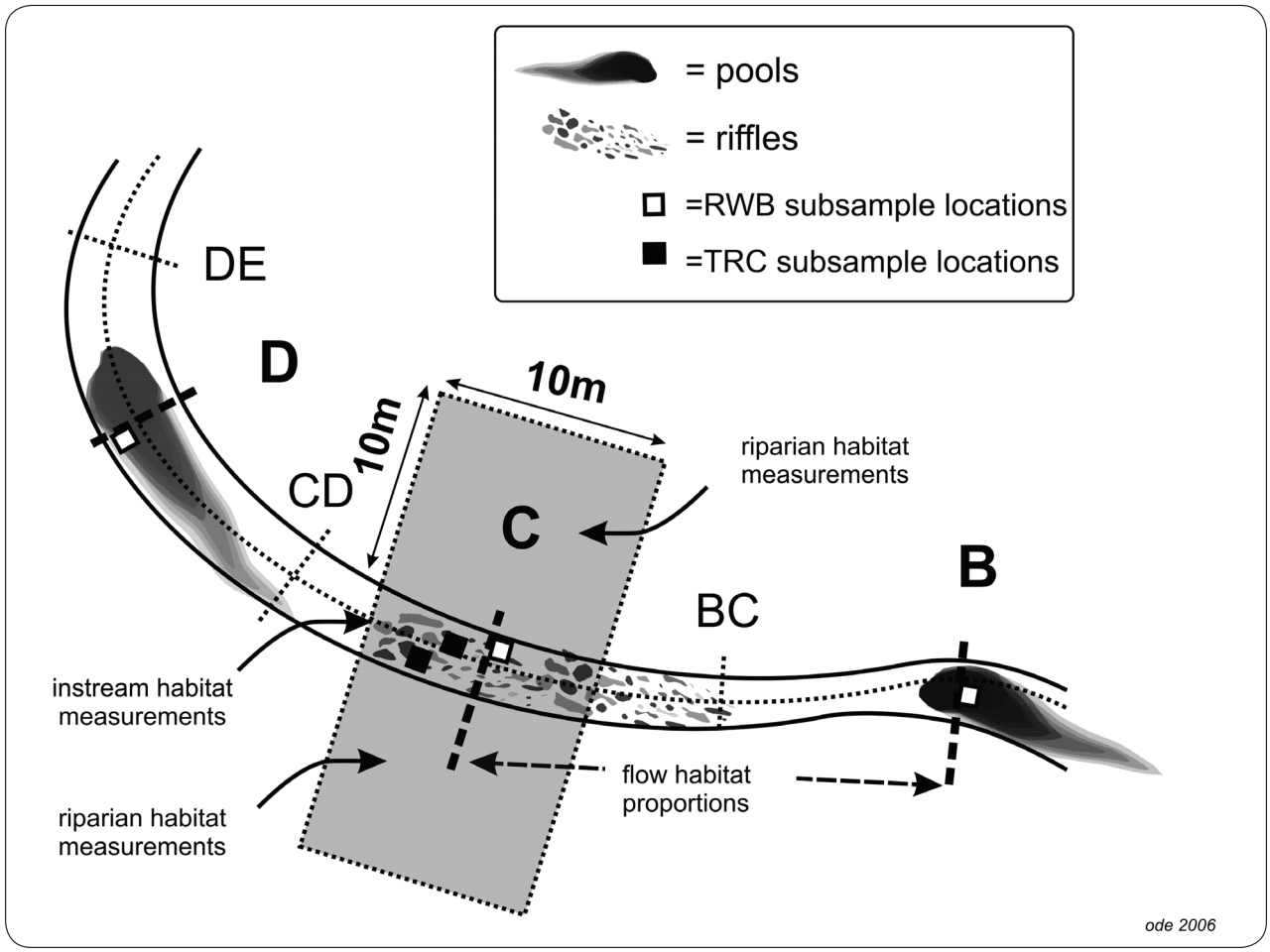

Figure 11. Section of the standard reach expanded from Figure 1 showing the appropriate positions for collecting algae samples (the white square, labeled "RWB" in the legend box) and flow habitat proportion measurements (reprinted from Ode 2007).

Record the presence of any of the 14 human influence categories in the stream channel within a zone 5 m upstream and 5 m downstream of the transect.

6.14 DENSIOMETER READINGS (CANOPY COVER)

The densiometer is read by counting the number of line intersections that are obscured by overhanging vegetation. Before using, the densiometer should be modified by taping off the lower left and right portions of the mirror in order to emphasize overhead vegetation over foreground vegetation (the main source of bias in canopy density measurements; see Figure 12.)

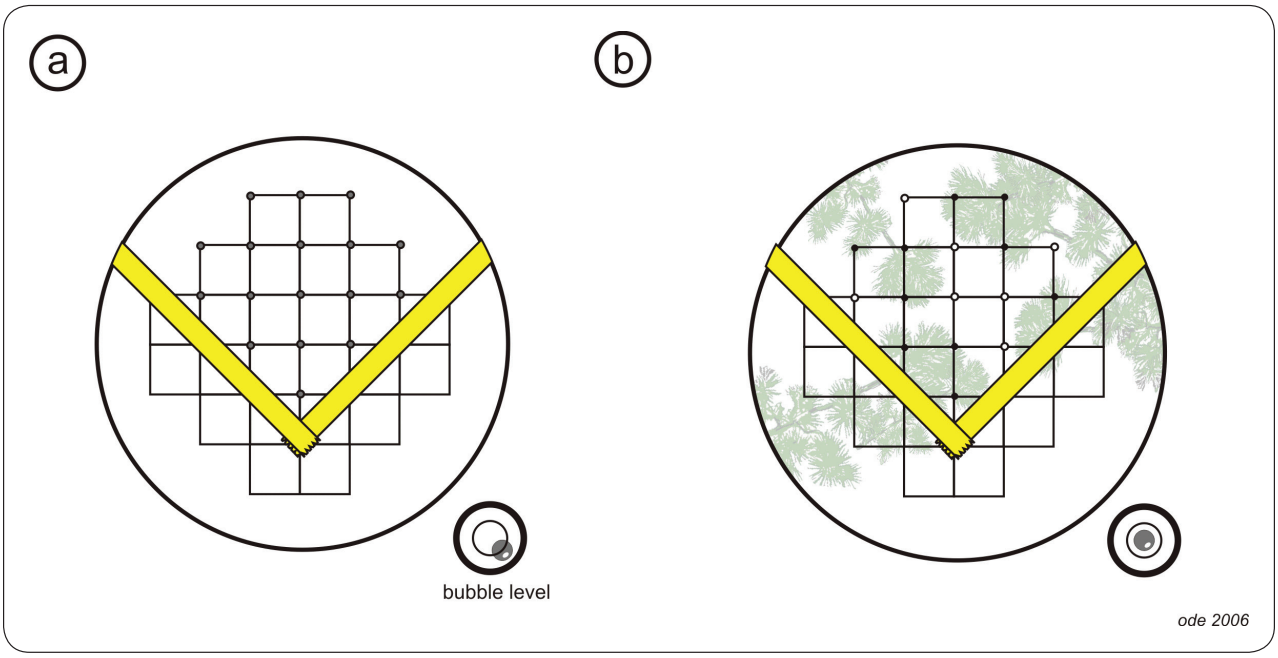

Figure 12. Representation of the mirrored surface of a convex spherical densiometer showing the position for taping the mirror and the intersection points used for the densiometer reading. The score for the hypothetical condition in (b) is 10 covered intersection points out of 17 possible. Note the position of the bubble level in (b) when the densiometer is leveled (reprinted from Ode 2007).

All densiometer readings should be taken with the bubble leveled, and 0.3 m (1 ft) above the water surface. The densiometer should be held just far enough from the squatting observer's body so that his/her forehead is just barely obscured by the intersection of the two pieces of tape.

Take and record four 17-point readings from the center of each transect: a) facing upstream, b) facing downstream, c) facing the left bank, d) facing the right bank. Optional readings can also be taken at the left and right banks (facing away from the stream, for these positions).

7 PHYSICAL HABITAT INTER-TRANSECT-BASED MEASUREMENTS

While most measures are taken at or relative to the main transects, a few measures are recorded at transects located at the midpoint between main transects. These are called "Inter-transects". The following measurements are taken relative to the Inter-transects: 1) Wetted Width, 2) Flow Habitats, and 3) "Pebble Count": Transect Substrates (including algal cover, as for the main transects).

7.1 INTER-TRANSECT WETTED WIDTH

Measure the same way that Transect wetted width was measured.

7.2 INTER-TRANSECT SUBSTRATES AND PERCENT ALGAL COVER

Collect these data the same way that Transect substrates and percent algal cover data were collected.

7.3 FLOW HABITATS

Because many benthic organisms prefer specific flow and substrate microhabitats, the proportional representation of these habitats in a reach is often of interest in bioassessments. There are many different ways to quantify the proportions of different flow habitats. This procedure produces a semi-quantitative measure consisting of 10 transect-based visual estimates.

At each Inter-transect, identify the percentage of six different habitat types in the region between the upstream Transect and downstream Transect: 1) cascades, 2) falls, 3) rapids, 4) riffles, 5) runs, 6) glides, 7) pools, and 8) dry areas. Record percentages to the nearest 5% — the total percentage of surface area for each section must equal 100%.

A description of each of these flow habitat types is provided below:

- cascades: short, high-gradient drops in stream bed elevation often accompanied by boulders and considerable turbulence
- falls: high-gradient drops in elevation of the stream bed associated with an abrupt change in the bedrock
- rapids: sections of stream with swiftly flowing water and considerable surface turbulence (rapids tend to have larger substrate sizes than riffles)
- riffles: "shallow/fast"; riffles are shallow sections where the water flows over coarse stream bed particles that create mild to moderate surface turbulence (< 0.5 m deep, > 0.3 m/s)
- runs: "deep/fast"; long, relatively straight, low-gradient sections without flow obstructions. The stream bed is typically even and the water flows faster than it does in a pool (> 0.5 m deep, > 0.3 m/s)
- glides: "shallow/slow"; sections of stream with little or no turbulence, but faster velocity than pools (< 0.5 m deep, < 0.3 m/s)
- pools: "deep/slow"; a reach of stream that is characterized by deep, low-velocity water and a smooth surface (> 0.5 m deep, < 0.3 m/s)
- dry: any surface area within the channel's wetted width that is above water

After you have collected all the above Transect-, and Inter-transect-, based measurements, collect data on Gradient. Also, if you have not already done so, take photographs at specific Transects, as indicated below. After you have collected Gradient data at each Transect, and have taken photographs where indicated, remove the corresponding flag from the stream bank.

7.4 PHOTOGRAPHS

Take a minimum of four (4) photographs of the reach at the following locations: a) Transect A facing upstream, b) Transect F facing upstream, c) Transect F facing downstream, and d) Transect K facing downstream. It is also desirable to take a photograph at Transect A facing downstream and Transect K facing upstream to document conditions immediately adjacent to the reach. Digital photographs should be used. Record the image numbers on the front page of the field form under "Photographs". *Note: An easy way to keep track of which site each series of photographs belongs to is to take a close-up of the front data sheet (containing legible site code and date) for that site prior to taking the series of photos.*

SECTION 8
REACHWIDE MEASUREMENTS

This last section describes PHab measurements of attributes specific to the stream reach as a whole. These include gradient of the reach and stream discharge.

8.1 GRADIENT

The gradient of a stream reach is one of the major stream classification variables, giving an indication of potential water velocities and stream power, which are in turn important controls on aquatic habitat and sediment transport within the reach. The data collected for gradient are recorded on the "Slope and Bearing" form.

Note: An autolevel should be used for reaches with a percent slope of less than or equal to 1%. Either a clinometer or an autolevel may be used for reaches with a percent slope of greater than 1%, and sometimes a clinometer is preferable in really steep areas that are also heavily vegetated. The following description is for clinometer-based slope measurements. In reaches that are close to 1%, you will not know whether you are above or below the 1% slope cutoff. In these cases, default to use of an autolevel, which is described further below.

Clinometer method:

Transect to transect measurements taken with a clinometer are used to calculate the average slope through a reach. This measurement works best with two people, one taking the readings at the upstream transect ("backsighting") and the other holding a stadia rod at the downstream transect. If you cannot see the mid point of the next transect from the starting point, use the supplemental sections (indicating the proportion of the total length represented by each section). Otherwise, leave these blank.

Beginning with the upper transect (Transect K), one person (the measurer) should stand at the water margin with a clinometer held at eye level. A second person should stand at the margin of the next downstream transect (Transect J) with a stadia rod flagged at the eye level of the person taking the clinometer readings. Be sure you mark your eye level while standing on level ground! Adjust for water depth by measuring from the same height above the water surface at both transects. This is most easily accomplished by holding the base of the stadia rod at water level. *Note: An alternative technique is to use two stadia rods pre-flagged at the eye-height of the person taking the readings.*

Use a clinometer to measure the percent slope of the water surface (not the streambed) between the upstream transect and the downstream transect by sighting to the flagged position on the stadia rod. The clinometer reads both percent slope and degree of the slope. Be careful to read and record percent slope

rather than degrees slope (the measurements differ by a factor of ~2.2). Percent slope is the scale on the right hand side as you look through most clinometers. *Note: If an autolevel or hand level is used, record the elevation difference (rise) between transects and the segment length (run) instead of the percent slope (autolevel instructions are provided in the following section).*

If the stream reach geometry makes it difficult to sight a line between transects, divide the distance into two sections and record the slope and the proportion of the total segment length between transects for each of these sections in the appropriate boxes on the slope form (supplemental segments). Do not measure slope across dry land (e.g., across a meander bend).

Proceed downstream to the next transect pair (I-J) and continue to record slope between each pair of transects until measurements have been recorded for all transects. If you have finished all the other transect and inter-transect based measurements for PHab, you may remove the transect flags as you go.

Autolevel method (preferred):

To measure gradient using an autolevel, identify a good spot to set up the autolevel, preferably somewhere around the center of the reach (if there is good visibility from this location to both the upstream and downstream ends of the reach.) Set up the autolevel on very stable, and preferably fairly flat, ground. Set the height of the autolevel to comfortable eye level for the operator. Level the plane of view of the autolevel by balancing it using the bubble. Start by adjusting the legs, and then fine-tune the adjustment using the knobs. Once balanced, begin "shooting" the change in the height of the water level of the stream from transect to transect. Try to start with one of the outer transects (like A). Have a field partner at Transect A hold the Stadia rod at water's edge and perpendicular to the ground. Viewing through the autolevel (and focusing as necessary), look at the Stadia rod and note to the smallest demarcation on the stadia rod the height at which the autolevel line of view (i.e., the middle line in the viewfinder) hits. Record this information, and then have the Stadia rod holder proceed to the next transect (e.g., Transect B), again holding the base of the Stadia rod at water's edge. Very carefully, rotate the head of the autolevel so that it points to the new Stadia rod location. *Note: Take care not to bump the autolevel out of its position, because if this happens, you will not be able to take a height measurement of Transect B's water surface relative to that of Transect A, to determine the slope between the two transects.*

If the autolevel is bumped out of position before all the measurements are done, or if there is a point along the reach at which there is no longer a clear line of sight from the autolevel to the Stadia rod positioned at the transect, at water's edge, a new location must be set up for the autolevel. In order to maintain a relationship between water heights of the various transects already measured, it will be necessary to "re-shoot" the height of the water at the last transect for which a valid measurement was attained. From there, assuming there is no more disturbance to the position of the autolevel, you can continue cycling through the remaining transects from the new position. On the Slope and Bearing Form corresponding to autolevel use, indicate when the autolevel's position has been changed. If it is necessary to move the autolevel at some point, the transect that was measured from the original and the new position will be listed twice on

the datasheet: once for the original position, and once for the new. Also indicate the distance between main transects (i.e., 15 m, 25 m or other). These pieces of information will later be used to determine the slopes between transects and for the reach as a whole.

8.2 STREAM DISCHARGE

Stream discharge is the volume of water that moves past a point in a given amount of time and is generally reported as cubic feet per second (cfs) or cubic meters per second (cms). Because discharge is directly related to water volume, discharge affects the concentration of nutrients, fine sediments and pollutants; and discharge measurements are critical for understanding impacts of disturbances such as impoundments, water withdrawals and water augmentation. Discharge is also closely related to many habitat characteristics including temperature regimes, physical habitat diversity, and habitat connectivity. As a direct result of these relationships, stream discharge is often also a strong predictor of biotic community composition. Since stream volume can vary significantly on many different temporal scales (diurnal, seasonal, inter-annually), it can also be very useful for understanding variation in stream condition.

It is preferable to take discharge measurements in sections where flow velocities are greater than 0.5 ft/s and most depths are greater than 15 cm, but slower velocities and shallower depths can be used. If flow volume is sufficient for a transect-based "velocity-area" discharge calculation, this is by far the preferred method. If flow volume is too low to permit this procedure or if your flow meter fails, use the "neutrally buoyant object/ timed flow" method.

8.2.1 Discharge: Velocity Area Method

The layout for discharge measurements under the velocity-area (VA) method is illustrated in Figure 13. Flow velocity should be measured with either a Swoffer Instruments propeller-type flow meter or a Marsh-McBirney inductive probe flow meter.

Select the best location in the reach for measuring discharge. To maximize the repeatability of the discharge measurement, choose a transect with the most uniform flow (select hydraulically smooth flow whenever possible) and simplest cross-sectional geometry. It is acceptable to move substrates or other obstacles to create a more uniform cross-section before beginning the discharge measurements.

Data for this parameter will be entered in the "Discharge Measurements" section of the datasheet with the basic site information at the top ("Reach Documentation"). Measure the wetted width of the discharge transect and divide this into 10 to 20 equal segments. The use of more segments gives a better discharge calculation, but is impractical in small channels. A minimum of 10 intervals should be used when stream width permits, but interval width should not be less than 15 cm.

At each interval, record the distance from the bank to the end of the interval. Using the top-setting rod that comes with the flow velocity meter, measure the median depth of the interval. Standing downstream of the

transect to avoid interfering with the flow, use the top-setting rod to set the probe of the flow meter at the midpoint of the interval, at 0.6 of the interval depth (this position generally approximates average velocity in the water column), and at right angles to the transect (facing upstream). See Figure 13 for positioning detail.

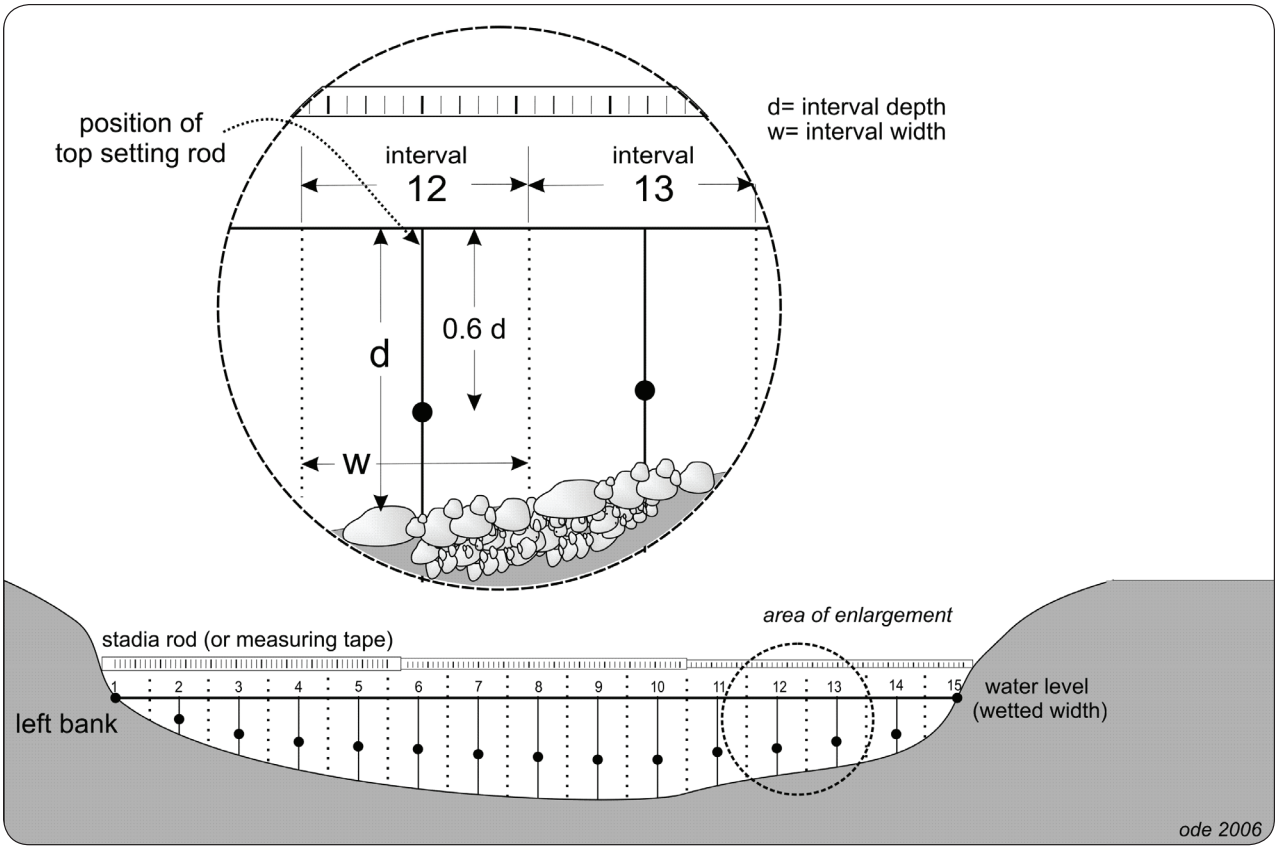

Figure 13. Diagram of layout for discharge measurements under the velocity-area method showing proper positions for velocity probe (black dots; reprinted from Ode 2007).

Allow the flow velocity meter to equilibrate for 10-20 seconds, then record velocity to the nearest ft/s. If the option is available, use the flow averaging setting on the flow meter. *Note 1: Under very low flow conditions, flow velocity meters may register readings of zero even when there is noticeable flow. In these situations, record a velocity of 0.5x the minimum flow detection capabilities of the instrument. Complete these steps on each of the intervals across the stream. Note 2: The first and last intervals usually have depths and velocities of zero.*

8.2.2 Discharge: Neutrally Buoyant Object Method

If streams are too shallow to use a flow velocity meter, the neutrally buoyant object (NBO) method should be used to measure flow velocity. However, since this method is less precise than the flow velocity meter

it should only be used if absolutely necessary. A neutrally buoyant object (one whose density allows it to just balance between sinking and floating) will act as if it were nearly weightless, thus its movement will approximate that of the water it floats in better than a light object. A piece of orange peel works well. To estimate the flow velocity through a reach, three transects are used to measure the cross-sectional areas within the test section sub-reach and three flow velocity estimates are used to measure average velocity through the test reach. To improve precision in velocity measurements, the reach segment should be long enough for the float time to last at least 10-15 seconds.

The position of the discharge sub-reach is not as critical as it is for the velocity-area method, but the same criteria for selection of a discharge reach apply to the neutrally buoyant object method. Identify a section that has relatively uniform flow and a uniform cross sectional shape.

The cross sectional area is estimated in a manner that is similar to, but less precise than, that used in the velocity area method. Measure the cross sectional area in one to three places in the section designated for the discharge measurement (three evenly-spaced cross sections are preferred, but one may be used if the cross section through the reach is very uniform). Record the width once for each cross section and measure depth at five equally-spaced positions along each transect.

Record the length of the discharge reach.

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GLOSSARY OF TERMS USED IN SOP G

Terms & Definitions	
TERM	**DEFINITION**
Aliquot	a measured portion of a sample, or subsample, or to measure a portion of a sample or subsample
Ash-free dry mass (AFDM)	the portion, by mass, of a dried sample that is represented by organic matter; the concentration of AFDM per stream surface area sampled can be used as a surrogate for algal biomass
Benthic algae	algae that are anchored to, or have at one point been anchored to, the stream bottom, in contrast to planktonic algae which are free-floating in the water column
Biofilm	a matrix/film adhering to stream substrata and consisting of microorganisms (e.g., algae, fungi, bacteria, protozoans) and detritus
Chlorophyll *a*	primary light receptor/photosynthetic pigment in algae and higher plants; the concentration of this pigment per stream surface area sampled provides an estimate of algal biomass
Composite sample	volume of all the liquid material amassed during sampling, including water used for rinsing substrate and sampling devices. Final composite volume should not exceed 400-500 ml.
Cyanobacteria	historically referred to as "blue-green" algae, but actually bacteria that are capable of photosynthesis and co-occur with true benthic algae in streams; useful as a bioindicator, and field-sampled and laboratory-processed concurrently with soft-bodied algae
Depositional	habitats in the stream that are dominated by slow-moving water, such as pools, where deposition of materials from the water column is more likely to occur than erosion (or (re)suspension) of loose bed materials; examples of "depositional" substrates include silt and sand
Diatom	a unicellular alga that possesses a rigid, silicified (silica-based) cell wall in the form of a "pill box"
Erosional	habitats in the stream that are dominated by fast-moving water, such as riffles, where stream power is more likely to facilitate erosion (suspension) of loose benthic material than deposition; examples of "erosional" substrates include cobbles and boulders
Homogenate	mixture of liquid composite sample and finely chopped fragments of macroalgae
Index of Biotic Integrity (IBI)	a quantitative assessment tool that uses information about the composition of one or more assemblages of organisms to make inferences about condition the environment they occupy (e.g., the assemblage of interest could be diatoms or benthic macroinvertebrates living in a stream)
Macroalgae	soft bodied algae that form macroscopically discernible filaments, mats, or globose structures
Microalgae	diatoms and microscopic soft-bodied algae, including unicellular forms; can co-occur with other microorganisms in a biofilm
Reachwide benthos (RWB)	method for biotic assemblage sample collection that does not target a specific substrate type, but rather objectively selects sampling locations across the reach, allowing for any of a number of substrate types to be represented in the resulting composite sample
Soft-bodied algae	non-diatom algal taxa; for the purposes of this SOP, cyanobacteria are subsumed under this assemblage
Wetted width	the distance between the sides of the channel at the point where substrates are no longer surrounded by surface water

List of Supplies for Stream Algae Sampling and Associated Data Collection A

Table 5.
General Supplies and Ambient Water Chemistry Collection

Item	Quantity / Site	Specifications
Sampling SOP (this document)	1/person	
Equipment decontamination supplies		See Appendix B
Hip or chest waders, or wading boots/shoes (not felt-soled)	at least 1 pair/ person	
Digital camera	1	
Full set of datasheets printed on waterproof paper (e.g., Rite-in-the-Rain™)	1 full set (and spare set recommended)	
Fine-tipped and thick-tipped waterproof/alcohol-proof pens and markers; pencils	2-3 each	
Clipboard	2-3	
Site dossier containing site maps, aerials, etc.	1	Add a 150 m scale line to aerials adjacent to stream
Thomas Guide and regional maps	as needed	
Centigrade thermometer	1	
pH meter	1	
DO meter and spare membrane	1	
Conductivity meter	1	
Turbidimeter and vial(s) (optional)	1	
Field alkalinity meter or test kit (e.g., Hach)	1	
Water chemistry containers	as needed	
Calibration standards	1	
Spare batteries for meters	as needed	
First aid kit	1	

Table 6.
Algal Taxonomic and Biomass Sample Collection

Needed for[1]:	Item	Quantity / Site	Specifications
D, S, C, A	White dish tub, rectangular, plastic, 11.5 qt	1	Use white, not colored
D, S, C, A	Scrubbing brush or scouring pad to clean dish tub, etc.	1	
D, S, C, A	Composite sample receiving bottle with cap, 1 L, plastic	1	Fisher 02-912-038
D, S, C, A	Graduated cylinder, 500 mL and 25 mL, plastic	1 each	Fisher 03-007-42 & 03-007-39
D, S, C, A	Bottle brush to clean graduated cylinders, etc.	1 sm, 1 lg	
D, S, C, A	PVC delimiter, 12.6 cm^2 area	1	See Appendix C
D, S, C, A	Spatula (> 12.6 cm^2 surface area)	1	
D, S, C, A	Rubber delimiter, 12.6 cm^2 area	1	See Appendix C
D, S, C, A	Toothbrush, firm-bristled	1	
D, S, C, A	Syringe scrubber, 60 mL syringe, 5.3 cm^2 area	1	See Appendix C
D, S, C, A	White (non-pigmented) scrubbing-pad circles	11 per replicate	See Appendix C
D, S, C, A	Tally meter (optional)	1	Ben Meadows 9JB-102385
D, S, C, A	Scissors	1	
D, S, C, A	Wash bottles	2	Label bottles with "stream water", and "DI water"
D, S, C, A	Razor blades or Swiss army knife	1	
D, S, C, A	Sample labels (printed on waterproof paper)	4 per replicate	See Figure 6
D, S, C, A	Clear plastic tape, 5 cm wide	Length of ~20cm per replicate	
D, S, C, A	Ice chest with wet ice	1 (2 preferred if multiple sites to be sampled)	
D, S, C, A	Fisherman's vest (optional)	1	
D, S	Centrifuge tubes, 50 mL, plastic	2 per replicate	Cole Parmer 06344-27
D, S	Rack for 50 mL centrifuge tubes	1	
D	10% formalin solution buffered with borax	10 mL per replicate	See Appendix C
D	Formalin-resistant gloves	1 pair	
D	Safety goggles or face shield	1	
D	Small syringe or bulb pipette	1	

1. "D" = diatom sample, "S" = soft-bodied algal sample, "C" = chlorophyll a sample, "A" = ash-free dry mass sample

Needed for[1]:	Item	Quantity / Site	Specifications
D	Vermiculite packing material	as needed	
S	Turkey baster	1	
S (see note)	25% glutaraldehyde solution (to be dispensed in a laboratory fume hood, wearing appropriate safety gear)	5 mL per replicate	*Note: could be added by taxonomy lab, with prior notification*
S	Calculator	1	
S	Small metric ruler (waterproof)	1	
S	Small Ziploc bag	1	
S, C, A	Whirl-pak bag, 100 mL	3 per replicate	Cole Parmer 06498-00
C, A	Filter forceps	1	Fisher 0975350
C, A	Filtering chamber/tower, 47 mm, plastic	1	Hach 2254400
C, A	Hand vacuum pump	1	Fisher 13-874-612B
C, A	Aluminum foil	~100 cm^2 per replicate	
C, A	Deionized water	500 mL	
C, A	Dry ice (if not returning to lab immediately following the day's fieldwork)	10 lbs	
C	Glass fiber filter, 47 mm, 0.7 µm pore size	1 per replicate	Fisher 09804142H
C	Snapping Petri dish, 47 µm	1 per replicate	Fisher 08-757-105
A	Glass fiber filter, 47 mm, 0.7 µm pore size; foil-wrapped and pre-combusted for ash-free dry mass (AFDM)	1 per replicate	

1. "D" = diatom sample, "S" = soft-bodied algal sample, "C" = chlorophyll a sample, "A" = ash-free dry mass sample

Table 7.
Physical Habitat Data Collection

Item	Quantity / Site	Specifications
GPS receiver	1	
Transect tape; 150 m	1	
Lengths of rope (7.5 m and 12.5 m)	1 each	
Small metric folding ruler (waterproof)	1	
Digital watch	1	
Stadia rod	1	
Clinometer	1	
Autolevel and tripod	1	
Current velocity meter and top-setting rod	1	
Convex spherical densiometer	1	Taped to expose only 17 intersections of the grid (see Figure 12)
Transect flags	21 total	Two colors; label with main transect (11 ct.) and inter-transect (10 ct.) names
Algae viewing bucket (optional)	1	See Appendix C
Small/slender rod with 1, 5, and 20 mm marks	1	For measuring microalgal thickness
Rangefinder (optional)	1	
Fresh orange peel	1	

B Information Resources for Avoiding Introduction of Invasive Species and Pathogens into Streams

The following is an adaptation of an excerpt taken from an EMAP-based Quality Assurance Project Plan developed by the California Department of Fish and Game Aquatic Bioassessment Laboratory (2008).

Organisms of concern in the U.S. include, but may not be limited to, Eurasian watermilfoil (*Myriophyllum spicatum*), New Zealand mud snail (*Potamopyrgus antipodarum*), zebra mussel (*Dreissena polymorpha*), *Myxobolus cerebralis* (the sporozoan parasite that causes salmonid whirling disease), and *Batrachochytrium dendrobatidis* (a chytrid fungus that threatens amphibian populations).

Field crews must be aware of regional species of concern, and take appropriate precautions to avoid transfer of these species. Crews should make every attempt to be apprised of the most up-to-date information regarding the emergence of new species of concern, as well as new advances in approaches to hygiene and decontamination to prevent the spread of all such organisms (e.g., Hosea and Finlayson, 2005; Schisler et al., 2008).

There are several online sources of information regarding invasive species, including information on cleaning and disinfecting gear:

Whirling Disease Foundation
www.whirling-disease.org

USDA Forest Service - Preventing Accidental Introductions of Freshwater Invasive Species
www.fs.fed.us/invasivespecies/documents/Aquatic_is_prevention.pdf

California Department of Fish and Game
www.dfg.ca.gov

U.S. Geological Survey Nonindigenous Aquatic Species: general information about freshwater invasive species
http://nas.er.usgs.gov

Protect Your Waters - Co-sponsored by the U.S. Fish and Wildlife Service
www.protectyourwaters.net/hitchhikers

The California State Water Resources Control Board Aquatic Invasive Species website

www.swrcb.ca.gov/water_issues/programs/swamp/ais

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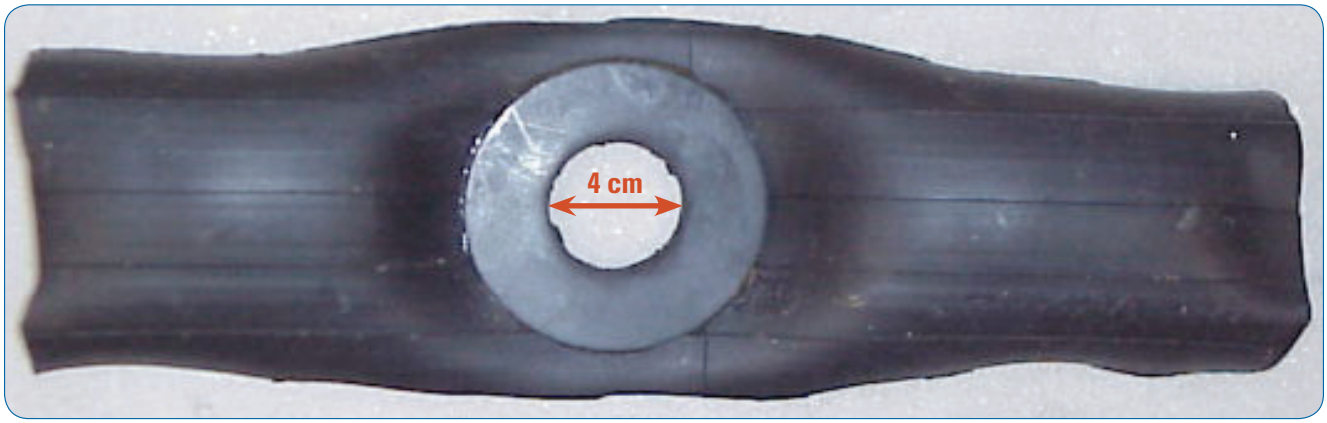
CONSTRUCTION OF ALGAE SAMPLING TOOLS C

This appendix provides step-by-step instructions for constructing the devices used for sampling algae. It also provides a recipe for the formalin fixative for diatoms.

1. RUBBER DELIMITER

The rubber delimiter for use on "erosional"/hard substrates like cobbles and wood is made from a sliced-open mountain bike inner tube that has a 4-cm diameter hole cut in the middle. The hole should be reinforced with a rubber gasket affixed to the tube with rubber cement.



2. PVC DELIMITER

The PVC delimiter for "depositional"/soft substrates like sand, small gravel, and silt is made from a 1½" sewer cleanout, which can be found at a home-improvement or plumbing supply store. The hole in the bottom of the cleanout is 4 cm in diameter. The bottom edge of the cleanout is filed to make it sharp, to ease insertion into silt/sand. To facilitate consistent sampling, it is useful to paint a bright line indicating a depth of 1 cm around the outer surface of the bottom of the sampling device. This indicates the depth to which to insert the delimiter when sampling.

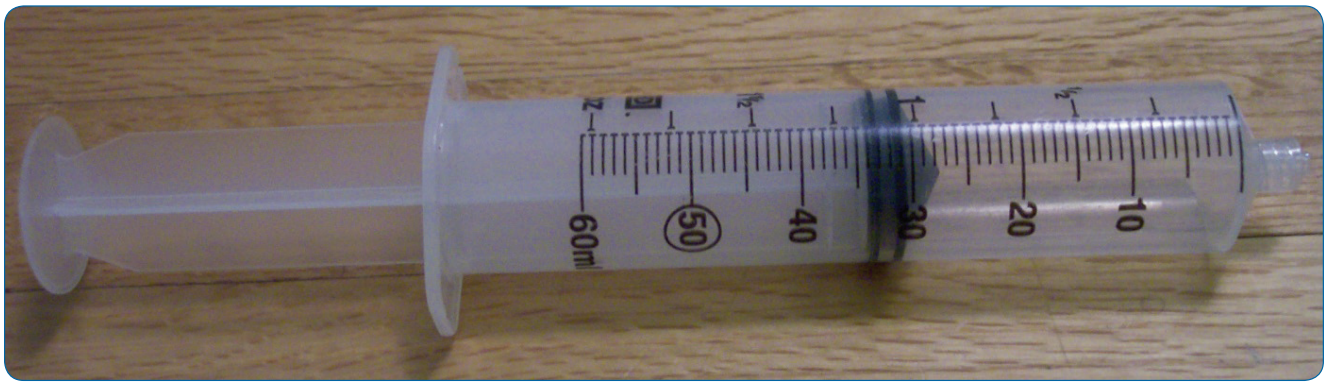






3. SYRINGE SCRUBBER

The syringe scrubber is for use on hard substrates that cannot be picked up out of the stream, like submerged bedrock and concrete channel bottoms. It is made from a 60 mL syringe barrel with the end cut off and its plunger fitted with Velcro-type material. Disposable, white (non-pigmented) scrubbing pads circles are then affixed to the end of the plunger and used to scrub the algae from the substrate.



You will need a 60-mL plastic syringe for each sampler you want to make. Remove the plunger and saw the conical end off the plastic syringe, then sand the bottom so it is flat all the way around and fits tightly against a flat surface.



Firmly affix the rubber end to the plastic plunger by removing the rubber tip, applying glue to the "naked" end of the plunger, and replacing the rubber cap. Allow glue to cure. Then cut the conical part off the plunger tip so that only a flat surface of rubber remains.



Cut a circle of Velcro®-style hook material to fit the size of the plunger. Use a waterproof adhesive to affix the "Velcro®" circle to the end of the plunger.

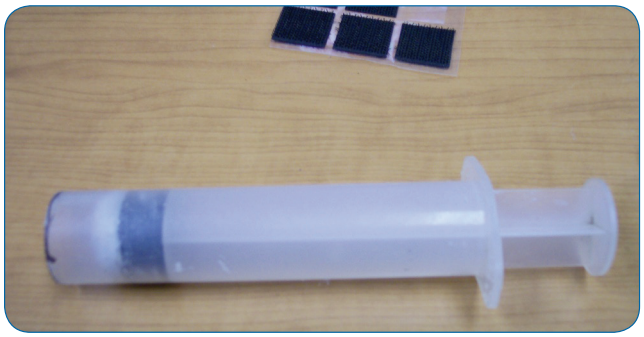




Obtain some white scrubbing pad material (make sure it is not pigmented so it will not end up interfering with eventual chlorophyll *a* analysis of the samples collected.) Cut a supply of circles to fit the size of the plunger.



Before each sampling event, attach a fresh circular scrubbing pad to the end of the plunger. This is a head-on view of the plunger, with the scrubbing pad circle attached.



This is what the syringe sampler looks like when it is ready to be used.

4. VIEWING BUCKET (OPTIONAL)

A viewing bucket can be useful for visualizing submerged algae, particularly in instances of a turbulent stream surface that obscures the stream bottom. A viewing bucket can be constructed from a narrow cylinder of clear Plexiglas (approximately 8 inches in diameter) whose bottom is fitted with a circle of thick glass, and secured in place with a silicone seal. If desired, one or two handles can also be fashioned out of Plexiglas and attached to the side(s) of the cylinder. The use of the viewing bucket is optional.



5. PREPARING A 1-L SOLUTION OF 10-PERCENT BUFFERED FORMALIN (MOULTON ET AL. 2002)

1. Add 100 mL of formaldehyde (37-40%) to 900 mL of water in a chemically resistant, non-breakable bottle.
2. Add about 3 g of borax to 10 mL of water and mix.
3. Add dissolved borax solute, to buffer formalin solution.
4. Tightly seal the bottle and mix by carefully inverting the bottle several times.
5. Label the outside of the bottle with "10-percent buffered formalin," the date of preparation, and related hazardous chemical stickers.

REFERENCE

Moulton II, S.R., J.G. Kennen, R.M. Goldstein, and J.A. Hambrook. 2002. Revised protocols for sampling algal, invertebrate, and fish communities as part of the National Water-Quality Assessment Program, Open-File Report 02-150.

STANDARD OPERATING PROCEDURES (SOP) FOR USING GLUTARALDEHYDE FOR THE PRESERVATION OF SOFT ALGAE

D

(adapted from the Aquatic Bioassessment Laboratory, California Department of Fish and Game)

Note: Glutaraldehyde must only be handled by trained individuals who understand the safe handling and use of this chemical

1. SCOPE AND APPLICATION

Glutaraldehyde is a colorless liquid with a pungent odor used as a preservative and sterilant. This SOP covers the use of Glutaraldehyde by Department of Fish and Game OSPR laboratories as a preservative for soft bodied algae.

2. PHYSICAL HAZARDS

The physical hazards associated with the use of Glutaraldehyde include:

- Incompatibility with strong oxidizing substances and bases
- Corrosive to metals
- Production of Carbon Monoxide and Carbon Dioxide during decomposition
- Discolors on exposure to air

3. HEALTH HAZARDS

The health hazards associated with the use of Glutaraldehyde include;

Inhalation

- Regulatory limit of 0.05 ppm as a ceiling level
- Chemical burns to the respiratory tract
- Asthma and shortness of breath
- Headache, dizziness, and nausea

Skin

- Sensitization or allergic reactions, hives
- Irritations and burns
- Staining of the hands (brownish or tan)

Eyes

- Irritation and burns. Eye contact causes moderate to severe irritation, experienced as discomfort or pain, excessive blinking and tear production
- May cause permanent visual impairment
- Conjunctivitis and corneal damage

Ingestion

- Gastrointestinal tract burns; Central nervous system depression, excitement
- Nausea, vomiting
- Unconsciousness, coma, respiratory failure, death

Note: Oral toxicity of Glutaraldehyde ***increases*** *with dilution*

4. ENGINEERING CONTROLS

Strict engineering controls will be followed when using Glutaraldehyde. This chemical and processes using this chemical will only be used under a laboratory fume hood meeting the requirements of Title 8, CCR Section 5154.1. At no time will containers of Glutaraldehyde be opened outside of an operating fume hood. Personnel using Glutaraldehyde will designate an area of the lab for its use. The area where it is used will be noticed with a sign reading:

CAUTION GLUTARALDEHYDE IN USE

Only trained personnel will be allowed to enter the designated area when using Glutaraldehyde.

5. PERSONAL PROTECTIVE EQUIPMENT

Personal Protective Equipment (PPE) is required to be worn at all times when working with Glutaraldehyde. This includes:

Eye Protection

- Chemical splash goggles; or
- Safety glasses with face shield

Hand Protection

- Nitrile or Polyvinyl Chloride (vinyl) gloves

Body Protection

- Lab coat with polypropylene splash apron that cover the arms

Any PPE with noticeable contamination will be immediately removed and the affected area washed with water. Gloves and apron will be removed before leaving the designated area. Disposable PPE (gloves and aprons) will not be re-worn. Disposable PPE will be disposed of in a sealed waste receptacle approved for hazardous waste. Any non-disposable PPE (lab coats, chemical goggles) with noticeable contamination will be rinsed or cleaned as soon as practical, and secured in a manner that does not allow contamination of laboratory personnel. Respiratory protection will not be required as long as strict engineering controls are followed.

6. SAFETY SHOWER AND EYEWASH

All employees using Glutaraldehyde must be aware of the location and use of the laboratory safety shower and eyewash, and must be able to reach it within 10 seconds from the time of contamination. At no time will processes using Glutaraldehyde be allowed that do not provide access to a safety shower and eyewash. Employees who have skin or eye contact with Glutaraldehyde will immediately stop all processes and proceed to the safety shower and eyewash station. The employee will rinse the affected area for a minimum of 15 minutes. If eye contact has occurred, the upper and lower eyelids must be lifted to allow adequate flushing of the eyes.

7. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Procedures will be followed that reduce exposure to Glutaraldehyde vapor to the lowest reasonable level. This includes:

- Ensure Glutaraldehyde is only used under a fume hood
- Use only enough Glutaraldehyde to perform the required procedure
- Every effort must be made to minimize splashing, spilling, and personnel exposure
- Once specimens are preserved, they will be capped or secured in a way that does not allow Glutaraldehyde vapor to escape into the lab
- At no time will open containers be removed from the fume hood
- All containers of Glutaraldehyde or solutions containing Glutaraldehyde will be appropriately marked with the chemical name, and hazard warning label at the end of the work day or whenever there is a personnel change
- Glutaraldehyde will be stored in tightly closed containers in a cool, secure, and properly marked location

8. WASTE DISPOSAL

Excess Glutaraldehyde and all waste material containing Glutaraldehyde must be placed in an unbreakable secondary container labeled with the following “HAZARDOUS WASTE GLUTARALDEHYDE.” Wastes will be disposed of through the laboratory hazardous waste contract.

9. SPILL AND ACCIDENT PROCEDURES

Drips and splashes will be wiped up immediately with a sponge, towel, or mop. Any material used to clean spills will be disposed of as hazardous waste. Large spills (Greater than 300 CC) require response by a local Hazmat team. The Hazmat team will be called by the laboratory supervisor. In the event of a large spill personnel will immediately leave the laboratory, and not re-enter until cleared by the laboratory supervisor.

10. TRAINING

All personnel engaged in the use of Glutaraldehyde will be trained on the hazards associated with this chemical, before use. The training will include;

- OSPR's Hazard Communication Program and information contained in the chemical's Material Safety Data Sheet (MSDS)
- Health hazards and routes of exposure
- Specific procedures and techniques for use and handling
- Use of PPE and engineering controls
- The contents and requirements of this Standard Operating Procedure.

STANDARD OPERATING PROCEDURES (SOP) FOR USING FORMALIN FOR THE PRESERVATION OF DIATOMS

E

(adapted from the US EPA EMAP program; Peck et al. 2006)

Note: Formalin must only be handled by trained individuals who understand the safe handling and use of this chemical. All personnel engaged in the use of formalin will be trained on the hazards associated with this chemical before use. The training will include the information contained in the chemical's Material Safety Data Sheet (MSDS).

Formaldehyde (or formalin) is highly allergenic, toxic, and dangerous to human health (potentially carcinogenic) if utilized improperly. Formalin vapors and solution are extremely caustic and may cause severe irritation on contact with skin, eyes, or mucous membranes. Formaldehyde is a potential carcinogen, and contact with it should be avoided. Wear gloves and safety glasses and always work in a well-ventilated area. In case of contact with skin or eyes, rinse immediate with large quantities of water. Store stock solution in sealed containers in a safety cabinet or cooler lined with vermiculite or other absorbent material. If possible, transport outside the passenger compartment of a vehicle.

During the course of field activities, a team may observe or be involved with an accidental spill or release of hazardous materials. In such cases, take the proper action and do not become exposed to something harmful. The following guidelines should be applied:

- First and foremost during any environmental incident, it is extremely important to protect the health and safety of all personnel. Take any necessary steps to avoid injury or exposure to hazardous materials. You should always err on the side of personal safety for yourself and your fellow field crew members.
- Never disturb, or even worse, retrieve improperly disposed hazardous materials from the field and bring them back to a facility for disposal. To do so may worsen the impact to the area of the incident, incur personal or organizational liability, cause personal injury, or cause unbudgeted expenditures of time and money for proper treatment and disposal of material. However, it is important not to ignore environmental incidents. You are required to notify the proper authorities of any incident of this type so they can take the necessary actions to respond properly to the incident.

Follow Department of Transportation (DOT) and the Occupational Safety and Health Administration (OSHA) regulations for handling, transporting, and shipping hazardous material such as formalin and ethanol. Regulations pertaining to formalin are in the Code of Federal Regulations (CFR, specifically 29 CFR 1910.1048).

These requirements should be summarized for all hazardous materials being used for the project and provided to field personnel. Transport formalin and ethanol in appropriate containers with absorbent material. Dispose of all wastes in accordance with approved procedures (e.g., National Institute for Occupational Safety and Health 1981, US EPA 1986).

To dispense formalin in the field, wear formalin-safe gloves and safety goggles. Use a small syringe or bulb pipette to add 10 mL of 10% buffered formalin solution to 40 mL of the diatom sample in a 50 mL centrifuge tube. Alternatively, in order to avoid dispensing formalin solution in the field, clean 50 mL centrifuge tubes that will hold the diatom samples can also be pre-loaded with 10 mL of 10% buffered formalin in a laboratory fume hood prior to going into the field.

The preparation of the 10% buffered formalin stock solution should always be done by trained personnel under a laboratory fume hood while wearing protective gloves, clothing, and goggles.

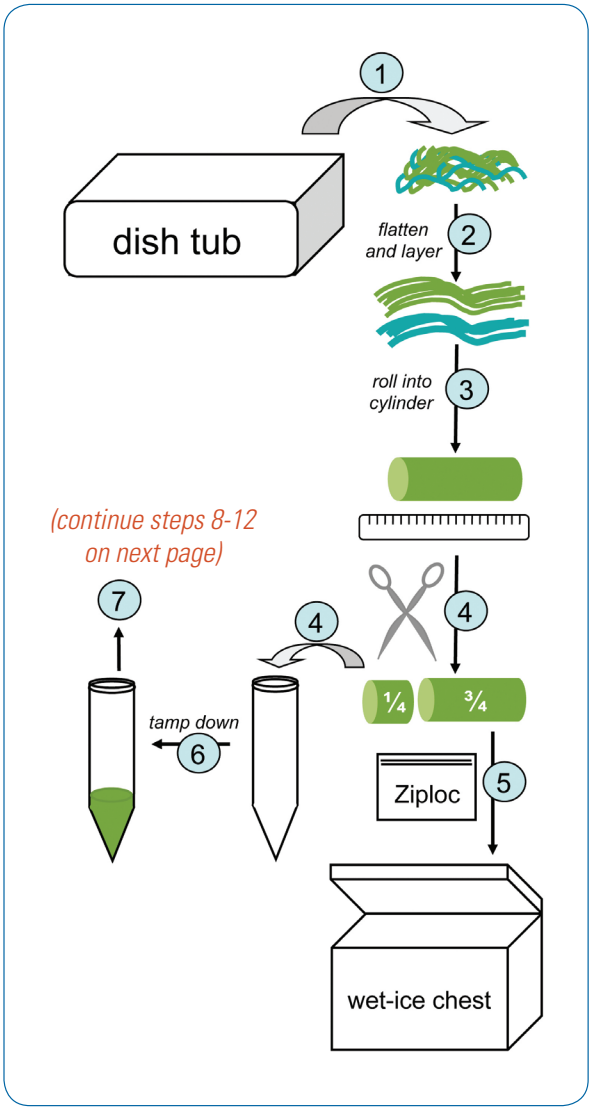
REFERENCE

Peck, D. V., A. T. Herlihy, B. H. Hill, R. M. Hughes, P. R. Kaufmann, D. Klemm, J. M. Lazorchak, F. H. McCormick, S. A. Peterson, P. L. Ringold, T. Magee, and M. Cappaert. 2006. Environmental Monitoring and Assessment Program-Surface Waters Western Pilot Study: Field operations manual for wadeable streams. U.S. Environmental Protection Agency, Washington, D.C. EPA/620/R-06/003.

PROCESSING SOFT-BODIED ALGAL AND DIATOM SAMPLES WHEN MACROALGAL CLUMPS ARE IN THE SAMPLE

F

The first step involves delivering a known quantity of macroalgae to the soft-bodied algae sample tube.



1) Gently wring excess water out of macroalgae and remove from dish tub.

2) Flatten each distinct taxon of macroalgae into even "sheets" and lay atop one another to distribute the volume of each as equally as possible.

3) Once the various layers of macroalgae are evenly spread upon one another, gently roll the stack into a cylinder shape that is roughly straight and even in thickness along its length.

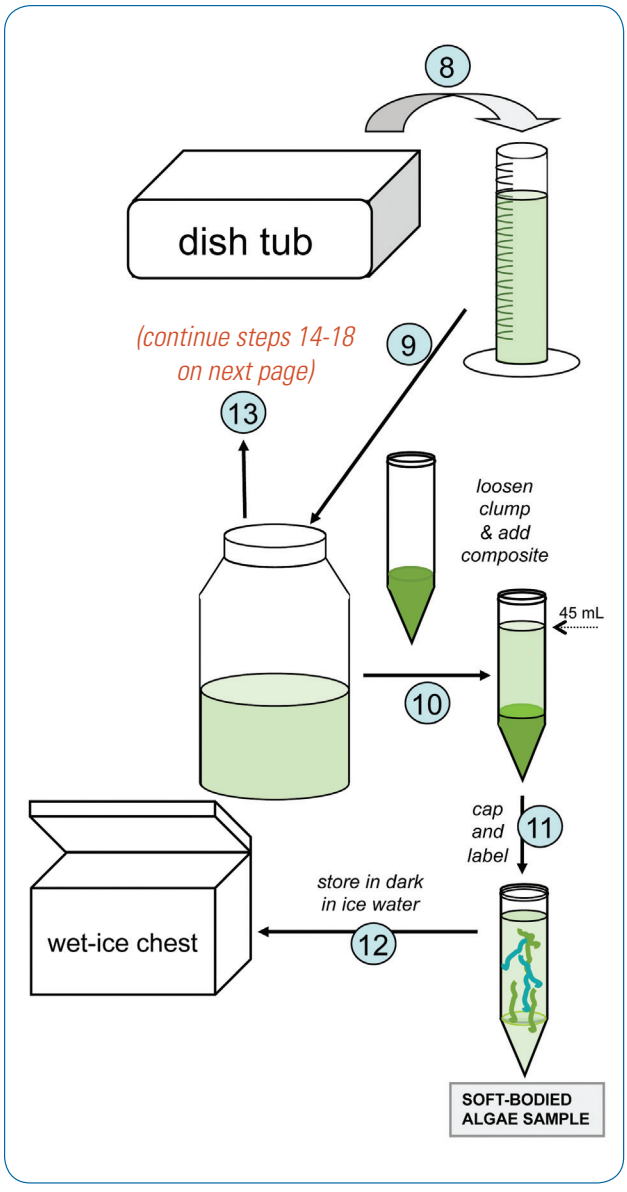
4) Measure and cut off ¼ of the cylinder and place that piece into the empty soft-bodied algae taxonomic ID sample tube.

5) Seal the remaining ¾ of the macroalgae in a clean plastic bag and place inside a cool, dark place such as the wet-ice chest.

6) Using a clean, blunt-ended object, tamp down the ¼ clump of macroalgae in the tube to make it dense and flatten the top surface. Estimate the volume of the macroalgal clump using the graduations on the tube and record this value on the Ratio Restoration worksheet (Figure 8).

7) Add composite sample solution to the tube according to directions on next page.

Some of the liquid composite sample is now added to the tube containing the macroalgae, but first the volume of the entire liquid composite collected must be measured.



8) Agitate the composite sample in the dish tub in order to suspend and mix the microalgae. Wait a few seconds to let the sand/silt settle. Quickly pour only the liquid (leaving silt/sand behind) into a graduated cylinder to measure its volume. Rinse substrate as necessary. Record TOTAL volume of the composite liquid (+ rinsate) on the datasheet, sample labels, and Ratio Restoration worksheet.

9) Pour the liquid composite sample into a clean, 1 L sample bottle

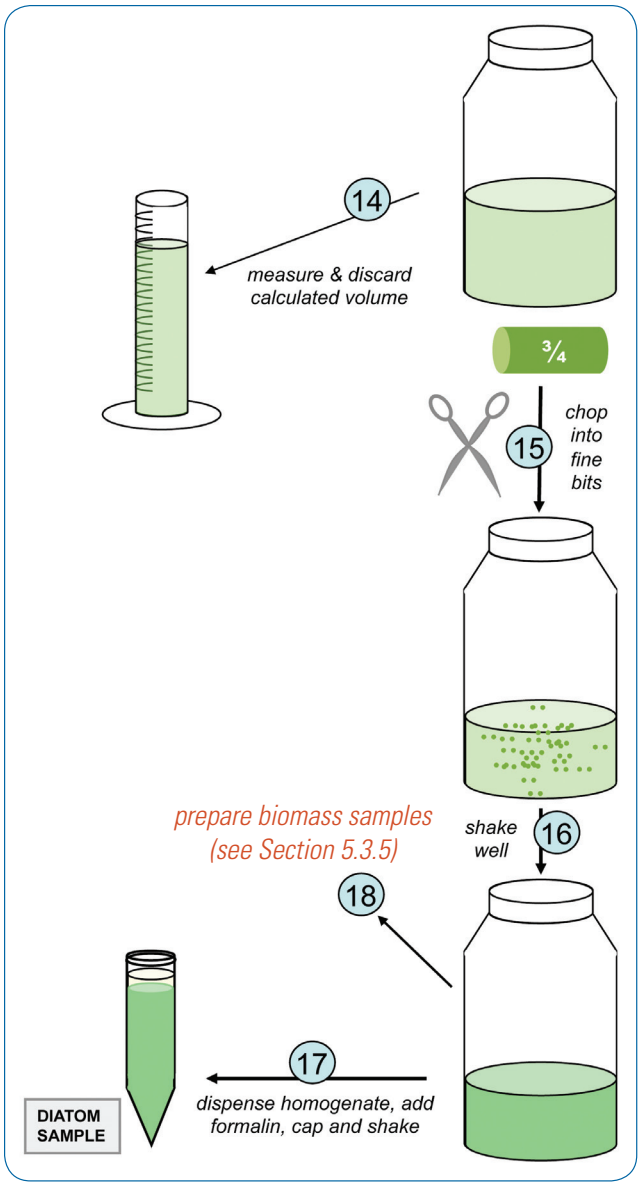
10) Loosen the macroalgae in the sample tube a little so it is no longer a dense clump lodged in the bottom and then pour freshly-agitated composite liquid into sample tube up to the 45 mL mark.

11) Cap the sample tube tightly. Affix a filled-out label to sample tube and cover with clear tape.

12) Place the tube in the dark in a wet-ice chest (not dry ice). Do not allow the algae to freeze. **Glutaraldehyde will need to be added to the tube within 4 days of sample collection, and preferably as soon as possible.**

13) According to directions on the next page, restore the original ratio of macroalgae to liquid composite in order to prepare the remainder of the samples.

The remainder of the macroalgae is now cut into tiny bits, which are added back to the liquid composite. **But the original ratio of macroalgae:liquid must first be restored.** The diatom and biomass samples are then prepared.



14) Use your Ratio Restoration worksheet to determine how much of the liquid composite to pour off. First shake the bottle vigorously, then measure and discard the appropriate volume.

15) Remove the macroalgal clump from the wet-ice chest. Chop the algae into **very fine** (eyelash length or smaller) pieces and add these to the liquid composite.

16) Cap and shake the bottle vigorously in order to homogenize the chopped algae into the liquid as thoroughly as possible.

17) Pour 40 mL of the freshly-agitated homogenate into the diatom sample tube. Add 10 mL 10% buffered formalin solution, observing all formalin safety precautions. Cap the tube, shake, and affix a sample label.

18) After both taxonomic ID samples have been prepared, the remainder of the homogenate is used for the biomass samples (chlorophyll *a* and ash-free dry mass). 25 mL of freshly shaken homogenate is filtered for each biomass sample. See Section 5.3.5.

SWAMP
Surface Water
Ambient Monitoring
Program

For more information, please contact:

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CALIFORNIA
Water Boards

www.waterboards.ca.gov/water_issues/programs/swamp/

APPENDIX H:

INSTRUMENT CALIBRATION AND MEASUREMENTS

This Appendix represents current equipment used by the District which may change as programmatic updates are implemented.

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Omega HHWT-11 Handheld Chlorine Photometer

For operational instructions with graphics, along with important notes, please refer to the **Operation Manual which can be found online at the following website**
http://www.omega.com/manuals/manualpdf/M5098.pdf

ISCO 3700 Portable Sampler

For operational instructions with graphics, along with important notes, please refer to the **Operation Manual which can be found online at the following website**
http://www.isco.com/pcfiles/PartPDF/SL000004/UP0019H4.pdf .

Hydrolab Quanta Multi-Parameter Water Quality Monitor

For detailed instructions with graphics, along with important notes, please refer to the **Operation Manual**.

A. Calibration
   1. Ensure that the sensor probe is connected.

   2. Wash the sensor in distilled water a few times and put some of the pH 4 standard solution into the calibration beaker to the marked line.

   3. Immerse the sensor in the calibration beaker.

   4. Press the **POWER** key.
      a. Use arrow keys to select 'CALIB' and press Enter
      b. Select parameter you wish to calibrate and press Enter
      c. Use arrow keys to adjust reading to standard solution press Enter

5. Fully rinse probe and calibration cup with DI water then dry before filling with next standard solution.
      a. When calibrating pH calibrate 7.0 first then 10.0 or 4.0. (NOTE Quanta only does 2 point pH calibration)
      b. When calibrating DO sensor fill cup with DI water to O-ring of membrane on DO probe. Use accurate mmHg to calibrate %DO this will calibrate mg/L DO at the same time.

B. Measurement
   1. Always attach the Guard to protect to the sensors before taking measurements.

   2. Slowly immerse the sensor in the sample.

   3. Turn the power on and allow measurements to stabilize.

   4. Record the measurements on the *Field Data Sheet* while out in the field. Select the SCREEN icon and use the **ENTER** key to switch measurement items.

   5. After taking the measurement:

      5.1 Turn the power off.

      5.2 Use DI water to completely wash off the sample on the sensor and then wipe water drops.

      5.3 Pour about 20 mL (about 2 cm from the bottom) of distilled water in the storage cup and install it on the sensor probe and store the instrument in the carrying case.

C. Specifications

Performance Specifications

	Range	Accuracy	Resolution
Temperature	-5°C to 50°C	±0.2°C	0.01°C
Dissolved Oxygen	0 to 50 mg/L	±0.2 mg/L ≤ 20 mg/L ±0.6 mg/L > 20 mg/L	0.01 mg/L
Specific Conductance	0 to 100 mS/cm	±1% of reading ±1 count	4 digits
pH	2 to 12 units	±0.2 units	0.01 units
ORP	-999 to 999 mV	±25 mV	1 mV
Vented Depth (10m)	0 to 10 m	±0.003 m (±0.01 ft)	0.001 m
Depth (25m)	0 to 25 m	±0.1 m	0.1 m
Depth (100m)	0 to 100 m	±0.3 m	0.1 m
Turbidity	0 to 1000 NTU	±5% of reading ±1 NTU	0.1 NTU < 100 NTU 1 NTU ≥ 100 NTU
Salinity	0 to 70 PSS	±1% of reading ±1 count	0.01 PSS

YSI 6920 V2 Multi-Parameter Water Quality Sonde

For detailed instructions with graphics, along with important notes, please refer to the **User Manual**.

A. Calibration

1. Ensure that the sensor probe is connected and sensor probe is fully immersed in standard solution.

2. Press the **POWER** key.
   d. Select Sonde Menu and press Enter
   e. Select Calibrate and press Enter
   f. Select parameter you wish to calibrate and press Enter
   g. Select 1-3 point calibration dependent on parameter and press Enter
   h. Type in standard solution value and press Enter
   i. Wait for readings to stabilize then press Enter to calibrate sensor

3. Fully rinse probe and calibration cup with DI water then dry before filling with next standard solution.
   a. When calibrating pH calibrate 7.0 first then 10.0 or 4.0.
   b. When calibrating optical sensors (DO or Turbidity clean optics before calibrating)
   c. When calibrating DO sensor allow atmosphere in calibration cup to stabilize for 15 mins with DI water before calibration.

B. Measurement

1. Always attach the flow-thru Guard to protect to the sensors before taking measurements.

2. Slowly immerse the sensor in the sample.

3. Turn the power on and allow measurements to stabilize.

4. Record the measurements on the *Field Data Sheet* while out in the field.

5. After taking the measurement:

   5.1 Turn the power off.

   5.2 Use DI water to completely wash off the sample on the sensor and then wipe water drops.

   5.3 Pour about 20 mL (about 2 cm from the bottom) of distilled water in the storage cup and install it on the sensor probe and store the instrument in the carrying case.

C. Specifications

6920V2-2 SONDE

Available Sensors	Temperature, Conductivity, pH, ORP, one ion selective electrode (ammonium, nitrate, or chloride), and Depth (shallow, medium, shallow vented). Two total optical sensors (ROX Optical DO, Turbidity, Chlorophyll, Rhodamine WT, BGA-PC, or BGA-PE).
Operating Environment	Medium: fresh, sea, or polluted water Temperature: -5 to +50 °C for most sensors Depth: 0 to 200 feet (61 meters)
Storage Temperature:	-40 to +60 °C for sonde and all sensors except pH , pH/ORP, ISE and optical sensors -10 to +60 °C for pH, pH/ORP, ISE, and optical sensors
Material:	Polyurethane, PVC, Stainless Steel
Diameter:	2.9 inches (7.4 cm)
Length:	Approximately 18.25 inches (46.4 cm) with no depth, 19.63 inches (49.9 cm) with depth
Weight:	Approximately 3.74 pounds (1.7 kg)
Computer Interface:	RS-232C, SDI-12
Internal logging memory size:	384 kilobytes (150,000 individual parameter readings)
Power:	8 AA-size Alkaline Batteries or External 12 VDC
Battery Life:	Approximately 32 days at 20 C at a 15 minute logging interval with ROX Optical DO, another optical sensor (turbidity, chlorophyll, Rhodamine WT, BGA-BC, or BGA-PE), temperature, conductivity, and pH active. Battery life is heavily dependent on sensor configuration and is given above for a typical sensor ensemble. If you have a different sensor configuration, set up your sonde for a deployment in the Run|Unattended menu and check the projected approximate battery life.

Temperature

Sensor Type.....Thermistor
Range.....-5 to 50 °C
Accuracy.....+/- 0.15 °C
Resolution.....0.01 °C
Depth.....200 meters

ROX Optical Dissolved Oxygen, mg/L (Calculated from % air saturation, temperature and salinity)
Sensor Type..... Optical, Luminescence Lifetime
Range.....0 to 50 mg/L
Accuracy.....0 to 20 mg/L, +/- 1 % of the reading or 0.1 mg/L, whichever is greater
20 to 50 mg/L, +/- 15 % of the reading; Relative to Calibration Gases.
Resolution.....0.01 mg/L
Temperature Range -5 to 50 C

pH
Sensor Type.....Glass combination electrode
Range.....0 to 14 units
Accuracy.....+/- 0.2 units
Resolution.....0.01 units
Temperature Range -5 to 50 C
Depth.....200 meters

Turbidity
Sensor type..... Optical, 90 ° scatter, with mechanical cleaning
Range..... 0 to 1000 NTU
Accuracy.....+/- 2% of the reading or 0.3 NTU (whichever is greater), in YSI AMCO-AEPA standards
Resolution.....0.1 NTU
Temperature Range -5 to 50 C
Depth..... 61 meters

Conductivity*
Sensor Type.....4 electrode cell with autoranging
Range.....0 to 100 mS/cm
Accuracy.....+/- 0.5% of reading + 0.001 mS/cm
Resolution.....0.001 mS/cm to 0.1 mS/cm (range dependent)
Temperature Range -5 to 60 C
Depth.....200 meters

Horiba U-22XD Multi-Parameter Water Quality Monitoring System

For detailed instructions with graphics, along with important notes, please refer to the **Operation Manual**.

A. Calibration
   1. Ensure that the sensor probe is connected.

   2. Press the **POWER** key.

   3. Wash the sensor in distilled water a few times and put some of the pH 4 standard solution into the calibration beaker to the marked line.

   4. Immerse the sensor in the calibration beaker.

   5. Press the CAL auto calibration mode key in one of the Measurement modes **pH**, **COND**, **TURB**, **DO**. **AUTO** and **CAL** appear and the instrument enters the **AUTO** calibration mode.

   6. Press the **ENT** key to start **AUTO** calibration. Upon completion of the **pH**, **COND**, **TURB**, **DO**, and **DEP** modes, "End" will be displayed on the screen.

   7. Press the **MEAS** key to return to the Measurement mode.

B. Measurement
   1. Slowly immerse the sensor in the sample.

   2. Select the measurement item. Use the **MEAS** key to switch measurement items in the following order: **pH**, **COND**, **TURB**, **DO**, **TEMP**, **DEP**, **SAL**, **TDS**, **σ**, **ORP**, **TIME**, then back to **pH**.

   3. After taking the measurement:

      3.1 Turn the power off.

      3.2 Use tap water to completely wash off the sample on the sensor and then wipe water drops.

      3.3 Pour about 20 mL (about 2 cm from the bottom) of distilled water in the probe cap and install it on the sensor probe. Place the rubber cap on the connector and store the instrument in the carrying case.

   4. Water quality data should always be recorded to the *Field Data Sheet* while out in the field. To additionally manually store the measurement data (up to 2880 sets) in the instrument for later download:
      4.1 Make sure that **MAN** is displayed as the Measurement mode.

      4.2 Press the **ENT** key. Data storage starts, **DATA IN** and the data set number is displayed on the screen, and the measured value to be stored and the measurement item are displayed in order at approximately 0.5 second intervals. After the data are stored to memory, the screen returns to the original Measurement mode. Note the data set number on the *Field Data Sheet*.

5. Viewing stored data on the Horiba (note that the data cannot be transferred to a PC, only to a Horiba printer):
   5.1 Press the **DATA** key in the Measurement mode. The instrument goes into **DATA** mode.

   5.2 Press the **DATA** key. The measurement data are displayed. Data you want to call can be displayed by selecting a measurement item and data number.

   5.3 Press the **UP/DOWN** keys to switch the measurement item or number that has been selected with the **DATA** key.

   5.4 Press the **DATA** key. Use the **UP/DOWN** keys to switch between "Year, Month, Day' and "Hour, Minute, Second".

C. Specifications

Measurement range

Measurement item		Measurement range		Measurement units
		Expanded	Standard	
pH		0.00 to 14.00	0.0 to 14.0	pH
		—	−1999 to 1999	mV in pH measurement
Conductivity (COND)	Range 1	0.90 to 9.99	0.9 to 9.9	S/m
		9.0 to 99.9	9 to 99	mS/cm
	Range 2	0.090 to 0.999	0.09 to 0.99	S/m
		0.90 to 9.99	0.9 to 9.9	mS/cm
	Range 3	0.0 to 99.9	0 to 99	mS/m
		0.000 to 0.999	0.00 to 0.99	mS/cm
Turbidity (TURB) *1		0.0 to 800.0	0 to 800	NTU (nephelometric turbidity units) or mg/L
Dissolved-oxygen (DO)		0.00 to 19.99	0.0 to 19.9	mg/L
		0.0 to 199.9	0 to 199	%
Temperature (TEMP)		0.00 to 55.00	0.0 to 55.0	°C
Water depth (DEP)		0.0 to 100.0	0 to 100	m
		0.0 to 330.0	0 to 330	ft
Salinity (SAL)		0.00 to 4.00	0.0 to 4.0	%
Total dissolved solids	Range 1	5.5 to 65.0	5 to 65	g/L
(TDS) *2	Range 2	0.55 to 6.50	0.5 to 6.5	g/L
	Range 3	0.000 to 0.650	0.00 to 0.65	g/L
Seawater specific gravity (σ_t)		0.0 to 50.0	0 to 50	–
Oxygen-reduction potential (ORP)		—	−1999 to 1999	mV

*1: Depending on the concentration range, the minimum turbidity is displayed as follows:
0 to 100 NTU ... 1 NTU for standard readout, 0.1 NTU for expanded readout.
100 to 800 NTU ... 10 NTU for standard readout, 1 NTU for expanded readout.
*2: The TDS range depends on the TDS factor settings. (Above ranges are given for a TDS coefficient of 0.65.)

Oakton Waterproof pHTestr 2

For detailed instructions with graphics, along with important notes, please refer to the **Operation Manual**.

A. Calibration
   1. Before you begin: Remove electrode cap. To condition electrode, immerse electrode in electrode storage solution, buffer, or tap water for at least 30 minutes. **DO NOT USE DE-IONIZED WATER.**

   2. Calibration: Calibration should be done regularly, typically every day that the *Testr* is used. Calibrate the *pHTestr 2* at three points (pH 4, 7, 10).

      2.1 Press **ON/OFF** button to switch unit on.

      2.2 Dip electrode 1/2" to 1" into chosen buffer (pH 4, 7, or 10).

      2.3 Press **CAL** button to enter Calibrate (CA) mode. 'CA' flashes on the display. Then, a pH value close to the pH buffer value will flash repeatedly.

      2.4 After at least 30 seconds (about 30 flashes) press the **HOLD/CON** button to confirm calibration. The display will show '**CO**' and then switch to the buffer value reading.

      2.5 Repeat with other buffers if necessary (*pHTestr 2* only). Rinse electrode in tap water before dipping into next buffer.

B. Measurement
   1. Remove cap from the electrode and press the **ON/OFF** button to switch *Testr* on.

   2. Dip the electrode 1/2" to 1" into the test solution. Stir once and let the reading stabilize.

   3. Note the pH or press **HOLD/CON** button to freeze the reading. Press **HOLD/CON** again to release the reading.

   4. Press **ON/OFF** to turn off *Testr*. If you do not press a button for 8.5 minutes, the *Testr* will automatically shut off to conserve batteries.

   5. If possible, keep a small piece of paper or sponge in the electrode cap – moistened with clean water or electrode storage solution (**NOT DE-IONIZED WATER**) – and close the cap over the electrode.

C. Specifications

Specifications

	WP pHTestr 1	WP pHTestr 2
Range	–1.0 to 15.0 pH	
Resolution	0.1 pH	
Accuracy	±0.2 pH	±0.1 pH
Calibration	1 point (pH 4.0; 7.0; or 10.0)	3 points (pH 4.0; 7.0 and 10.0)
ATC	No	Yes
Operating Temperature	0 to 50°C (32 to 122°F)	
Functions	ON/OFF; HOLD; CA (Calibrate); CO (Confirm display); auto buffer recognition; auto-shutoff after 8.5 min. of nonuse	
Power	Three 1.5 V batteries (included). 24 hours continuous use (approx. 720 tests per battery set)	
Dimensions	6.5"L x 1.5" dia. (165 x 38 mm dia.)	
Weight	3.25 oz (90 gms)	

Oakton TDSTestr 20

For detailed instructions with graphics, along with important notes, please refer to the **Operation Manual**.

A. Calibration

1. Before you Begin: Remove electrode cap. Switch unit on for 15 minutes to stabilize the batteries. Soak electrodes for a few minutes in alcohol to remove oils. **Caution: Never immerse the electrode above color band as it will damage the instrument electronics.**

2. Calibration: Your tester features push- button calibration at two points (one per range). Select a calibration standard appropriate for each range: low range, between 150 to 1999 µS; high range, between 2.0 to 19.99 mS. It is best to select a standard close to the test solution value, and one that has a similar chemical make-up to the test solution.

   2.1 Rinse the electrode in tap or deionized water, then in a known calibration standard.

   2.2 Switch unit on (ON/OFF button).

   2.3 Dip electrode into calibration standard. **DO NOT immerse above color band!**

   2.4 Press CAL/CON button to enter Calibrate mode. 'CA' flashes on the display. An uncalibrated conductivity value close to the calibration standard value will flash.

   2.5 Wait at least 30 seconds (about 30 flashes) for the reading to stabilize. Press the HOLD/INC button repeatedly to adjust reading to match value of the known calibration standard.

   2.6 Press CAL/CON button to confirm calibration. The display will show 'CO' and then switch to a calibrated conductivity reading.

   2.7 For second range, repeat steps 1-6.

B. Measurement

1. Remove cap from electrode. Switch unit on (ON/OFF button).

2. Rinse the electrode in tap or deionized water, then in a small portion of test solution.

3. Dip the electrode into the test solution. Stir once and let the reading stabilize. **DO NOT immerse electrode above color band!**

4. Allow time for the Automatic Temperature Compensation to correct the readings for solution temperature changes.

5. Note the reading once the display is stable. Press HOLD/CON button to freeze the reading. Press HOLD/CON again to release the reading.

6. Press ON/OFF to turn off Testr. If you do not press a button for 8.5 minutes, the Testr will automatically shut off to conserve batteries.

C. Specifications

Specifications

TDSTestr	10	20
Range	0 to 999 ppm/ 1.00 to 9.99 ppt	0 to 1999 µS/ 2.0 to 19.99 mS
Resolution	1 ppm/ 0.01 ppt	1 µS/ 0.01 mS
Accuracy	±2% full scale	
Calibration	two-point push button slope adjustments (one in each range)	
Calibration Standard	100 to 999 ppm 2.00 to 9.99 ppt	150 to 1999 µS/ 2.0 to 19.99 mS
Operating Temperature	32 to 122°F / 0 to 50°C	
ATC	32 to 122°F / 0 to 50°C (1.11% per °F / 2% per °C)	
Power	Four 1.5 V alkaline batteries (Eveready A76BP; supplied) 20 hrs. continuous use Alternate replacement Model Eveready 303 silver oxide, 70 hrs. continuous use.	
Dimensions	5.9" x 1.7" x 1" (151 x 42 x 24 mm)	
Weight	3.25 oz (90 gms)	

Hanna Instruments HI 98129 Waterproof pH, EC/TDS & Temperature Multimeter

For detailed instructions with graphics, along with important notes, please refer to the **Operation Manual**.

A. Calibration
   1. pH calibration:
      1.1 From measurement mode, press and hold the MODE button until CAL is displayed on the lower LCD. Release the button. The LCD will display pH 7.01 USE or pH 6.86 USE (if you have selected the NIST buffer set). The CAL tag blinks on the LCD.

      1.2 For a single-point pH calibration, place the electrode in any buffer from the selected buffer set (e.g. pH 7.01 or pH 4.01 or pH 10.01). The meter will recognize the buffer value automatically.
         1.2.1 If using pH 4.01 or pH 10.01, the meter will display OK for 1 second and then return to measurement mode.

         1.2.2 If using pH 7.01, after recognition of the buffer the meter will ask for pH 4.01 as second calibration point. Press the MODE button to return to measurement mode or, if desired, proceed with the 2-point calibration as explained below.

      1.3 A two-point pH calibration give better accuracy. For a two-point pH calibration, place the electrode in pH 7.01 (or 6.86 if you have selected the NIST buffer set). The meter will recognize the buffer value and then display pH 4.01 USE.
         1.3.1 Rinse the electrode thoroughly to eliminate cross-contamination.

         1.3.2 Place the electrode in the second buffer value (pH 4.01 or 10.01, or, if using NIST, pH 4.01 or 9.18). When the second buffer is recognized, the LCD will display OK for 1 second and the meter will return to normal measurement mode.

      1.4 The CAL symbol on the LCD means that the meter is calibrated.

   2. EC/TDS calibration:
      2.1 From measurement mode, press and hold the MODE button until CAL is displayed on the lower LCD.

      2.2 Release the button and immerse the probe in the proper calibration solution: HI7031 (1413 µS/cm) for HI98129 and HI7030 (12.88 mS/cm) for HI98130.

      2.3 Once the calibration has been automatically performed, the LCD will display OK for 1 second and the meter will return to normal measurement mode.

      2.4 Since there is a known relationship between EC and TDS readings, it is not necessary to calibrate the meter in TDS

      2.5 The CAL symbol on the LCD means that the meter is calibrated.

B. Measurement

1. pH measurement:

1.1 Select the pH mode with the SET/HOLD button.

1.2 Submerge the electrode in the solution to be tested.

1.3 The measurements should be taken when the stability symbol on the top left of the LCD disappears.

1.4 The pH value automatically compensated for temperature is shown on the primary LCD while the secondary LCD shows the temperature of the sample.

2. EC/TDS measurement:

2.1 Select either EC or TDS mode with the SET/HOLD button.

2.2 Submerge the probe in the solution to be tested. Use plastic beakers to minimize any electromagnetic interferences.

2.3 The measurements should be taken when the stability symbol on the top left of the LCD disappears.

2.4 The EC (or TDS) value automatically compensated for temperature is shown on the primary LCD while the secondary LCD shows the temperature of the sample.

C. Specifications

Range Temperature:	0.0 to 60.0°C or 32.0 to 140.0°F	
HI 98129	pH: 0.00 to 14.00	
	EC: 0 to 3999 µS/cm	
	TDS: 0 to 2000 ppm	
HI 98130	pH: 0.00 to 14.00	
	EC: 0.00 to 20.00 mS/cm	
	TDS: 0.00 to 10.00 ppt	
Resolution	0.1°C or 0.1°F	
HI 98129	0.01 pH; 1 µS/cm ; 1 ppm	
HI 98130	0.01 pH, 0.01 mS/cm ; 0.01 ppt	
Accuracy (@20°C/68°F)	Temperature	±0.5°C or ±1°F
	EC/TDS	±2% f.s.
	pH	±0.01
Typical EMC Deviation	Temperature	±0.5°C or ±1°F
	pH	±0.02 pH
	EC/TDS	±2% f.s.
Temp.Compensation	pH: Automatic	
	EC/TDS: with β=0.0 to 2.4%/°C	
Environment	0 to 50°C (32 to 122°F); RH 100%	
EC/TDS Conversion Factor	0.45 to 1.00 (CONV)	
Calibration	pH: at 1 or 2 points with 2 sets of memorized buffers (pH 4.01/7.01/10.01 or pH 4.01/6.86/9.18)	
	EC/TDS: automatic, at 1 point	
EC/TDS Calibration Solutions		
HI 98129	HI7031 (1413 µS/cm)	
	HI7032 (1382 ppm; CONV=0.5)	
	HI70442 (1500 ppm; CONV=0.7)	
HI 98130	HI7030 (12.88 mS/cm)	
	HI70038 (6.44 ppt; CONV=0.5 or 9.02 ppt; CONV=0.7)	
Electrode	HI 73127 pH electrode (**included**)	
Battery Type/Life	4 x 1.5V with BEPS / typical 100 hours	
Auto-off	After 8 min.	
Dimensions	163 x 40 x 26 mm (6.4 x 1.6 x 1.0")	
Weight	85 g (3.0 oz)	

APPENDIX I:

SWAMP DATA GUIDANCE MANUALS

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SWAMP
Surface Water Ambient Monitoring Program

SWAMP DATA MANAGEMENT PLAN

Chemistry Template

Surface Water Ambient Monitoring Program

April 13, 2009

CALIFORNIA Water Boards

www.waterboards.ca.gov/swamp

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A. Analytical Data

The typical method for submitting Laboratory Analytical Data to the SWAMP Database is electronically through the online data checker. This section will focus on the tools and steps involved in submitting these data.

The following information should be used in conjunction with the SWAMP QAPrP for complete compliance with the SWAMP program including measurement quality objectives and required quality assurance (QA) samples.

1. Analysis Authorization Forms

2. Water Quality (Chemistry and Bacteria) Data

The data for sediment chemistry, water column chemistry, and bacteria analyses are treated in a similar way in the SWAMP Database and for this reason will be treated together in this portion of the document.

a. Chemistry Data Template

The Chemistry Data Template is available online at http://swamp.mpsl.mlml.calstate.edu/resources-and-downloads/database-management-systems/swamp-25-database/templates-25/#Chem.

b. Formatting the Data

A Microsoft Excel template exists for laboratories to use to format the laboratory data in a manner that can be easily loaded into the SWAMP database. As previously discussed, for many labs working under the SWAMP master contract, the station collection information can be obtained from the Analysis Authorization form. This section will discuss each of the fields in the template and how to populate them.

i. Chemistry Results Worksheet

There are two worksheets that must travel with the data for the data package to be considered complete. The first holds all chemistry or bacteria results, including QA data, and should be named **Results** in a worksheet tab. Each record in this sheet represents a result from a specific analysis for a particular parameter at a single station or for a single QA sample. This worksheet will also contain all supporting QA sample results. If beginning with an Analysis Authorization form, the following fields will likely be pre-populated in the **Data** worksheet: *EventCode*, *ProtocolCode*, *StationCode*, *LocationCode*, *CollectionMethodCode*, *SampleTypeCode*, *Replicate*, *CollectionDepth*, *UnitCollectionDepth*, *ProjectCode*, and *AgencyCode*. Please note that all fields are required to have data except when otherwise noted below. Examples of special types of samples are listed in the Special Circumstances section.

All valid LookUp list values are available at http://ftp.mpsl.mlml.calstate.edu/LookUpLists.php. At any time, if the necessary field does not appear in the LookUp list, the SWAMP Data Management Team (DMT) must be contacted to have it added.

Template Field Name	LookUp List	Description & Business Rules
LabSampleID		The LabSampleID is a recommended field intended to provide lab specific identification for an analyzed sample. **BR:** The format and content is determined by the lab. It is preferable to add -Dup, -MS, -MSD to the end of the ID to help confirm the SampleType and the LabSampleID of the native sample.
StationCode	StationLookUp	StationCode represents a unique sampling site in a sampling design. A single waterbody may have multiple stations. **BR:** The format for the unique alphanumeric description of the station is ###ABC123, where ### is the Hydrologic Unit number and ABC123 is an alphanumeric description of the Station. An example is 111EELBRN which is Hydrologic Unit 111 and an abbreviated code to indicate “Eel River - South Fork near Branscomb”.

Template Field Name	LookUp List	Description & Business Rules
EventCode	EventLookUp	EventCode represents the initial intent of the sampling event at a particular station. **BR:** The EventCode will be in a hierarchical order as follows: BA – If the initial intent of sampling is for Bioassessment (Tissue and/or WaterQuality samples may or may not also be collected) TI – If the initial intent of sampling is for Tissue (WaterQuality samples may or may not also be collected; no associated Bioassessment samples collected) WQ – If the initial intent of sampling is for WaterQuality (no associated Bioassessment or Tissue samples collected) For example, if the initial intent of sampling on Day 1 was for Tissue and WaterQuality, the EventCode would be TI. If for some reason the WaterQuality had to be re-sampled the next day, on Day 2, the event for the re-sampling would still be TI because Tissue was the initial intent of sampling on Day 1 even though the WaterQuality was sampled on Day 2.
ProtocolCode	ProtocolLookUp	ProtocolCode represents the sampling protocol used, which includes the set of methods, methodology and/or specifications, such as MPSL-DFG_Field_v1.0. Established protocols may be used or Regions may document their own sampling protocols. **BR:** It is preferable to combine protocols per StationCode and date so that all WaterQuality, Bioassessment and Tissue data are combined under the same EventCode. For example, if Tissue and WaterQuality are sampled at a station, the EventCode would be TI. If the protocols are different for Tissue and WaterQuality, the Tissue protocol would be used and the WaterQuality protocol would be listed in the SampleComments. If that is not preferable, separate EventCodes may be used with each individual protocol. Default value is Not Recorded.

Template Field Name	LookUp List	Description & Business Rules
LocationCode (previously SampleLocation)	LocationLookUp	LocationCode describes the physical location in the waterbody where the sample was collected. One sampling event may have a single or multiple locations. **BR:** For a single point of sampling, the physical location in the waterbody can be used such as Bank, Thalweg, Midchannel, OpenWater. The LocationCode for field results should be the same as the location for the WaterQuality collection method. For TI EventType sampling, the physical location plus the CollectionMethod is used such as BankNet1, BankShock1, OpenWaterTrawl1, OpenWaterNet1. For resident mussel or clam collections, the LocationCode would be the physical location in the water body plus the generic CollectionMethod, e.g. BankTissue_Grab. OpenWater sampling with multiple sub-locations within a single water body or station could have locations of OpenWaterTrawl1, OpenWaterTrawl2 describing one large location with two smaller areas of sampling within the OpenWater Location. Multiple physical locations within a single station could consist of a LocationCode such as BankShock1, BankNet1, OpenWaterHook1. If recording specific locations within a station are necessary for the project, a LocationCode such as Location1Net1, Location1Net2, Location2Shock1 may be used.
SampleDate		SampleDate refers to the date the sample was collected in the field. **BR:** The format for date in the templates is dd/mmm/yyyy, such as 10/Nov/2007. For samples with collection times that last longer than one day, like autosamplers, the sample date is the date sampling began. When entering data using the forms, the format is mm/dd/yy. For transplanted bivalves, the SampleDate is the date when the bivalves were deployed in the field.

Template Field Name	LookUp List	Description & Business Rules
CollectionTime (previously SampleTime)		CollectionTime refers to the time when the first sample of a sampling event at a specific station was collected in the field. **BR:** If the sampling crew collects 18 bottles at a single station, the CollectionTime for each would be the time of the first bottle collected. By doing so, the samples can easily be linked and any holding time issues will be consistent, and conservative, for the laboratory work. The CollectionTime format should be expressed as xx:xx in 24 hour time, such as 13:30 for 1:30 pm.
CollectionMethodCode	CollectionMethodLookUp	CollectionMethodCode refers to the general method of collection such as Sed_Grab, Sed_Core, Water_Grab, Autosampler24h, Autosampler7d. **BR:** The SWAMP water default is Water_Grab and the sediment default is Sed_Grab.
SampleTypeCode	SampleTypeLookUp	SampleTypeCode refers to the type of sample collected or analyzed. **BR:** Some commonly used SampleTypeCode choices include Grab, Integrated, MS1, CRM, LCS, LabBlank, CNEG, Composite.
Replicate (previously SampleReplicate)		The Replicate number is used to distinguish between replicates created at a single collection in the field. **BR:** The default is 1. Field Duplicates will be identified by a Replicate of 2. Field Blind Duplicates will be identified with a different SampleTypeCode of FieldBLDup, not a Collection Replicate, because they are collected blind. Laboratory replicates will be identified by a replicate of 2 in the LabReplicate field, not a Collection Replicate. When field duplicates are collected, the samples are given a StationCode of FIELDQA and a SampleTypeCode of Grab or Integrated with a Replicate of 2. When the chemistry data are loaded into the database, the StationCode FIELDQA will be given the correct StationCode of the native sample and the Replicate will be used to distinguish the duplicate sample from the native sample. EventCode, ProtocolCode, LocationCode, SampleDate, CollectionTime, CollectionMethodCode, CollectionDepth, UnitCollectionDepth, ProjectCode and AgencyCode should be identical for both samples taken.

Template Field Name	LookUp List	Description & Business Rules
CollectionDepth (previously DepthSampleCollection)		CollectionDepth records the level, from the surface in the water or sediment column, at which the sample was collected. **BR:** This information should be listed on the Chain of Custody (COC) document that accompanies the samples from the field. CollectionDepth for water samples would be measured from the water surface and recorded in meters (m) while depth collected for sediment would be measured from the sediment surface and recorded in centimeters (cm). Since depths for ambient monitoring Grab samples are generally "subsurface", defaults have been established to indicate this. For water samples the default value is 0.1 m and for sediment samples the default value is 2 cm. For Integrated samples collected from the same depth at different points across a waterbody or for samples collected at multiple times, i.e. an autosampler, the actual sample depth should be recorded. This applies to both water and sediment samples. Integrated samples collected at multiple depths, i.e. samples integrated from the water column or sediment cores, should receive a depth of -88 and the actual depths of collection should be recorded in the CollectionComments field.
UnitCollectionDepth (previously DepthUnit)	VariableCodesLookUp	UnitCollectionDepth refers to the units used in the CollectionDepth including cm (centimeters) and m (meters). This information should be listed on the Chain of Custody (COC) document that accompanies the samples from the field.
ProjectCode (previously ParentProjectID)	ProjectLookUp	ProjectCode references the project that is associated with the sample. **BR:** The formatting for a ProjectCode is as follows Program_Project. For example, the format for a SWAMP Regional Board project is SWAMP_RBX where SWAMP is the program, RB indicates it is a Regional Board sample and X is the Regional Board number. The format for a SWAMP State Board project is SWAMP_SB_XXX where SWAMP is the program, SB indicates it is a State Board sample and XXX represents the State Board project. For example, the ProjectCode for the Bioaccumulation Oversight Group would be SWAMP_SB_BOG. For a project other than SWAMP such as the Friends of the Los Angeles River, the project is FLAR_XXX where FLAR indicates it is a Friends of the Los Angeles River program and XXX represents the Friends of the Los Angeles River project. In some cases, there may not be a specific project but only a program. In this case the ProjectCode would be just the program; e.g. UMD.

Template Field Name	LookUp List	Description & Business Rules
AgencyCode	AgencyLookUp	AgencyCode refers to the organization or agency that collected the sample. This should be listed on the Chain of Custody (COC) document that accompanies the samples from the field. **BR:** If an environmental sample is used to perform laboratory QC, i.e. a matrix spike or lab duplicate, the AgencyCode still refers to the agency that collected the native sample, not the agency that created the QC sample. See 'Special Circumstances' for LABQA business rules.
CollectionComments (Not Required)		CollectionComments records any comments relating to the collection of the field sample for laboratory analysis. **BR:** This field can also be used for laboratory QC samples, e.g. Matrix Spike was performed on a FieldBlank.
SampleID (Not Required)		SampleID is a unique identifier supplied by the organization directing the sampling or sampling agency and is used to track the sample throughout the sampling and analysis processes. This field can be used to tie a result to the sample. **BR:** This SampleID, which is different from the StationCode, will likely be on the sample container the laboratory receives from the field crew or on the COC. If there is no number, leave this field blank.
PreparationPreservation (previously Preparation)	PrepPreservationLookUp	PreparationPreservation references the preparation or preservation method performed on the samples prior to analysis. **BR:** If no preparation or preservation method was performed the default value is None.
PreparationPreservationDate		PreparationPreservationDate is the date and time the preparation or preservation was started. **BR:** The format is dd/mmm/yyyy hh:mm. If there is no preparation or preservation method performed (None) then the PreparationPreservationDate should be listed as 01/Jan/1950 00:00 (the SWAMP default date/time value for none).

Template Field Name	LookUp List	Description & Business Rules
DigestExtractMethod	DigestExtractLookUp	DigestExtractMethod references the digestion or extraction method performed on the sample prior to analysis. **BR:** If no digestion or extraction method was performed the default value is None.
DigestExtractDate		DigestExtractDate is the date and time the digestion or extraction was started. **BR:** The format is dd/mmm/yyyy hh:mm. If there is no digestion or extraction performed on the sample (None) then the DigestExtractDate should be listed as 01/Jan/1950 00:00 (the default value for none).
LabBatch		The LabBatch is a unique code, provided by the laboratory, that represents a group of samples processed together. It groups all environmental samples with their supporting QC samples and will be used to verify completeness based on the SWAMP QAPrP. **BR:** The LabBatch is assigned to and identifies all samples digested or extracted together in one batch. When a digestion or extraction is not performed as part of the method, the LabBatch represents all samples within a unique analysis run. Please see the File and Batch Naming Convention to correctly format the LabBatch name. All lab batches listed in the Results worksheet need to be listed one time only in the LabBatch worksheet.
AnalysisDate		AnalysisDate is the date and time the sample was processed on the analytical instrument. **BR:** This date/time should be expressed as dd/mmm/yyyy hh:mm.
LabReplicate		The LabReplicate number is used to distinguish between replicates created in the laboratory. It differentiates the original field sample that was analyzed from all subsequent laboratory duplicates. **BR:** The default is 1 for the first sample and increases by one for each successive replicate analyzed in the laboratory.

Template Field Name	LookUp List	Description & Business Rules
MatrixName	MatrixLookUp	MatrixName refers to the sample matrix. **BR:** Water - For field-generated water samples, the MatrixName is samplewater. For lab-generated QC samples, the matrix should be the type of water that was used for the analysis of the sample, either labwater or blankwater. Labwater is water coming either directly from the tap in the laboratory or purchased spring water. Blankwater is laboratory Type I or Type II water, purchased reagent water or water that is run through a filtration process in a laboratory, such as Deionized (DI) or Milli-Q (MQ) water. Sediment - For field-generated sediment samples, the MatrixName is sediment. For lab-generated QC samples, blankmatrix could be used as the MatrixName which is a matrix used to identify a commercial- or lab-produced medium in tissue or sediment QC samples. If this is not the case then the MatrixName for lab-generated QC samples would be sediment which would include samples where water, solvent or nothing was used as a matrix. Tissue - For field-generated tissue samples, the MatrixName is tissue. For lab-generated QC samples, blankmatrix could be used as the MatrixName which is a matrix used to identify a commercial- or lab-produced medium in tissue or sediment QC samples. If this is not the case then the MatrixName for lab-generated QC samples would be tissue which would include samples where water, solvent or nothing was used as a matrix.
MethodName	MethodLookUp	MethodName refers to the analysis method used by the laboratory to analyze the sample. **BR:** Methods are expressed with a MethodName such as SM 4500-NH3 C or EPA 600/R-99-064 and must be fully described in the Method Lookup list and in the laboratory records. If a laboratory has modified an EPA or Standard Method, the laboratory agency needs to add "M" to end of the MethodName. In such situations, the modification should be documented and communicated to the SWAMP DMT for notation in the database. For instance, a lab would report a modified EPA 600/R-99-064 as EPA 600/R-99-064M accompanied by a description of the modification made. Any method for the SWAMP Project which is not in the current SWAMP database lookup list must be approved by the SWAMP QA Team prior to being added to the database.

Template Field Name	LookUp List	Description & Business Rules
AnalyteName	AnalyteLookUp	The AnalyteName is the name of the analyte or parameter for which the analysis is conducted and result is reported. The lookup list includes the acceptable abbreviation or name of the variable used by the database, enabling consistency across reporting.
FractionName	FractionLookUp	FractionName is a specific descriptor of the Analyte. **BR:** For instance, metals are often expressed as Total or Dissolved, each of which would be expressed as the Fraction, distinguishing the appropriate Analyte. If there is no need for further description of the analyte, type 'None' in this field.
Unit	UnitLookUp	Unit refers to how the chemistry result is measured or expressed. **BR:** Each combination of Analyte and Matrix requires that a specific Unit be used in the SWAMP database to ensure comparability across data. This listing can be found in the SWAMP QAPrP, online at http://www.swrcb.ca.gov/swamp/qapp.html. ??? Water units are indicated by weight/volume, i.e. ng/L. Sediment and tissue units are indicated by weight/weight and includes whether the sample result is reported as wet weight (ww) or dry weight (dw). For example, ng/g ww for ng/g wet weight. Surrogates recovery results will use a unit of %.

Template Field Name	LookUp List	Description & Business Rules
DilFactor		DilutionFactor is the factor by which a sample was diluted and is reported as a whole number. It is equal to the final volume divided by the initial volume of solution, or DF = Vf ÷ Vi. ??? **BR:** Default value is 1. A dilution other than 1 is recorded when a sample requires an additional dilution to fit into the standard curve of the instrument. It does not apply to dilutions that are standard in the method being used for analysis. Final reported results must be corrected for dilution that was carried out during the process of analysis. 1 part sample plus 9 parts blank is a DilutionFactor of 10. A 50% dilution is equivalent to a DilutionFactor of 2. When a sample requires a dilution, the MDL and RL must also be raised by that DilutionFactor. A QACode of D is required when a dilution is performed on the sample.
Result		Final numeric result of a given analyte, stored as text to retain trailing zeros **BR:** The chemistry Result is expressed as a real number rather than a calculation. The result should be reported with appropriate number of significant figures. A result of 3.7266945 with 3 significant figures should be reported as 3.73. A result of 1.350 with 4 significant figures must display 1.350 in the Excel file. If you only see 1.35, that is the result that will be loaded to the database and the 4th significant figure will be dropped.

Template Field Name	LookUp List	Description & Business Rules
ResultQualCode (previously ResQualCode) (Not Required)	ResQualLookUp	The Result Qualifier Code or ResultQualCode qualifies the analytical result of the sample. **BR:** This field may be left blank for results that are considered detected. The database will be populated with an equal sign (=) when the data are loaded. When a result is Not Detected (ND) or Detected Not Quantified (DNQ) a ResultQualCode is required and the appropriate code would be applied. When the result is -88, a ResultQualCode is required. If the ResultQualCode value is NR for Not Recorded, then a reason for this code must be written into the LabResultComments field and/or an appropriate QACode would be applied.
MDL		Method Detection Limit (MDL) is the minimum concentration of an analyte that undergoes the entire measurement process and can be reported with a stated level of confidence that the analyte concentration is greater than zero. It is the detection limit associated with the method used to analyze the analyte, or parameter, in the sample. **BR:** If no MDL is used, enter -88. A value other than -88 must be used for either the MDL or the RL.
RL		Reporting Limit (RL) is the minimum value below which data are documented as nonquantifiable. It is the reporting limit for the sample analyzed, as determined by the laboratory. **BR:** If no RL is used, enter -88. A value other than -88 must be used for either the RL or the MDL.
QACode	QALookUp	QACode is applied to the result to describe any special conditions, situations or outliers that occurred during or prior to the analysis to achieve the result. **BR:** The default code, indicating no special conditions, is None. If more than one code should be applied to a record, the convention is to list them in alphabetical order separated by commas and no spaces; i.e. GB,SC

Template Field Name	LookUp List	Description & Business Rules
ExpectedValue (Not Required)		The ExpectedValue is the concentration of the analyte in a reference standard, laboratory control sample or matrix spike sample or the value expected to obtain from analysis of the QC Sample. This consists of the native sample result concentration plus the spike amount. **BR:** For surrogate samples, the expected value should be 100, representing 100%. This field is required for SampleTypeCodes of MS1, MS2, CRM and LCS.
LabResultComments (Not Required)		The LabResultComments field holds any comments related to the lab result or analysis of the sample. **BR:** These could be comments needed to clarify any portion of the analysis or a comment that is not accommodated by any other field, e.g. Percent Recovery or Relative Percent Difference. For reference standards, laboratory control samples and matrix spikes, it is recommended to include the Percent Recovery as PR xx and the Relative Percent Difference as RPD xx. When used in combination, as in Matrix Spike Duplicate samples, the convention would be PR xx, RPD xx.

ii. Chemistry LabBatch Worksheet

The second worksheet to travel with the data holds information specific to the laboratory batch in which data is analyzed. This worksheet should be named **LabBatch** (with no spaces) in a worksheet tab. The fields in this sheet are and should be completed as follows:

Template Field Name	LookUp List	Description & Business Rules
LabBatch		The LabBatch is a unique code, provided by the laboratory, that represents a group of samples processed together. It groups all environmental samples with their supporting QC samples and will be used to verify completeness based on the SWAMP QAPrP. **BR:** The LabBatch is assigned to and identifies all samples digested or extracted together in one batch. When a digestion or extraction is not performed as part of the method, the LabBatch represents all samples within a unique analysis run. Please see the File and Batch Naming Convention to correctly format the LabBatch name. All lab batches listed in the Results worksheet need to be listed one time only in the LabBatch worksheet.
LabAgencyCode	AgencyLookUp	LabAgencyCode refers to the organization, agency or laboratory that performed the analysis on the sample.
LabSubmissionCode (previously BatchQualifierCode)	LabSubmissionLookUp	The LabSubmissionCode is a unique batch qualifier code assigned to the LabBatch as a whole by the analyzing laboratory which references the quality of the data in the LabBatch. **BR:** If the LabSubmissionCode of A is used, meaning Acceptable, the laboratory is ensuring that all SWAMP QAQC protocols were met for the lab batch. If anything other than A is used, a LabBatchComment is required.
SubmittingAgencyCode	AgencyLookUp	SubmittingAgencyCode is the organization or agency that is responsible for submission of the data to the database. This agency may be different from LabAgencyCode if the analytical data were subcontracted to another agency.
LabBatchComm (Not Required)		LabBatchComments records any comments relating to the LabBatch as a whole. **BR:** If the LabSubmissionCode is anything other than "A", a LabBatchComment is required.

c. Special Circumstances

There are several types of special circumstances discussed in this section. One type includes samples that are generated or created by the laboratory (LABQA). Another type includes environmental samples that are modified by the laboratory. A third type includes samples that are created by the sampling agency that are not environmental samples and may or may not have been created in the field (FIELDQA).

For a list of QA sample types required for each type of chemical analysis, please see the SWAMP QAPrP.

i. Laboratory-generated QA samples (LABQA)

All samples generated from within the laboratory, such as LabBlank, LCS, CRM, etc. have specific business rules, which are as follows:

LabSampleID	Recommended - provide lab specific identification for an analyzed sample
StationCode	LABQA
EventCode	WQ for water and sediment chemistry
ProtocolCode	Not Applicable
LocationCode	Not Applicable
SampleDate	Date sample was digested/extracted, expressed as dd/mmm/yyyy. When no digestion/extraction was performed, *SampleDate* is equal to the analysis date.
CollectionTime	0:00 There are situations within a batch when two identical sample types are used for QA reasons and the only way to differentiate between them is to give them each a different *CollectionTime*. For example, when more than one LabBlank, CRM, or LCS is digested, extracted, or analyzed in the same batch on the same day but are not replicates of each other, one *CollectionTime* should be 0:00 and the other 0:15, increasing the time by 15 minutes for each additional sample.
CollectionMethodCode	Not Applicable
SampleTypeCode	Select from SampleTypeLookUp List
Replicate	1
CollectionDepth	-88
UnitCollectionDepth	m for water or cm for sediment
ProjectCode	Not Applicable
AgencyCode	Organization or agency that analyzed the sample
Matrix	Water samples - labwater or blankwater Sediment samples - blankmatrix (commercially generated product) or sediment (if laboratory is using solvent, water, or nothing)

ii. Laboratory-modified QA samples

There are several types of samples discussed in this section that are generated or modified within the laboratory. The first is a Matrix Spike, which is a modified or analyte-spiked field sample. The second is a laboratory-generated duplicate of a field sample. At times, laboratories use samples not generated through the SWAMP program to satisfy SWAMP batch QA requirements. This third type is a Non-Project sample.

(a) Matrix Spike and Laboratory Duplicate Samples

For these samples, all fields describing the sample (*StationCode*, *EventCode*, *ProtocolCode*, *LocationCode*, *SampleDate*, *CollectionTime*, *CollectionMethodCode*, *CollectionDepth*, *UnitCollectionDepth*, *ProjectCode*, *AgencyCode*) remain the same as the native sample. For Matrix Spike samples, the only fields that are different than the native field sample is the *SampleTypeCode*, which should be MS1, MS2, or MSBLDup, and potentially the *Replicate*. For laboratory-generated Duplicate samples, the only field that is different than the native field sample is the *LabReplicate*.

LabSampleID	Recommended - provide lab specific identification for an analyzed sample. It is preferable to add -Dup, -MS, -MSD to the end of the Lab ID to help confirm the *SampleTypeCode* and the *LabSampleID* of the native sample.
StationCode	Same as native field sample
EventCode	Same as native field sample
ProtocolCode	Same as native field sample
LocationCode	Same as native field sample
SampleDate	Same as native field sample
CollectionTime	Same as native field sample
CollectionMethodCode	Same as native field sample
SampleTypeCode	Same as native field sample - laboratory-generated Duplicates MS1 - Matrix Spike performed on a Grab or Integrated sample MS2 - Matrix Spike performed on a FieldDup (Grab or Integrated with a *Replicate* of 2) MSBLDup - Matrix Spike performed on a FieldBLDup There are situations when a Matrix Spike was unintentionally performed on a blank sample such as a FieldBlank, TravelBlank, EquipBlank, DIBlank or FilterBlank. A batch may include two or more of these types of native samples where the only difference between them is the *SampleTypeCode*. The only way to differentiate them is to give each a different *CollectionTime*. For example, when a batch contains both a DIBlank and an EquipBlank (both with an original time of 0:00) and a Matrix Spike was performed on the EquipBlank, one *CollectionTime* should be 0:00 and the other 0:15. Then the MS1 *CollectionTime* should correspond to the correct native sample time.
Replicate	1
CollectionDepth	Same as native field sample
UnitCollectionDepth	Same as native field sample

ProjectCode	Same as native field sample
AgencyCode	Same as native field sample
LabReplicate	2 - lab-generated Duplicates 1 - Matrix Spike 2 - Matrix Spike Duplicate
Matrix	Same as native field sample

(i) Matrix Spike Samples performed on Field Duplicates

Following is a table that describes the way to format matrix spike samples performed on field duplicates, field blind duplicates, and composite blind duplicates in both the v2.2 and v2.5 SWAMP databases. The *SampleTypeCode* MS represents an MS/MSD pair.

v2.2 SWAMP Database			**v2.5 SWAMP Database**	
SampleTypeCode	*Sample Replicate*		*SampleTypeCode*	*Replicate*
One sample - sampled or split in triplicate - blind				
Grab	1	=	Grab	1
FieldBLDup	1	=	FieldBLDup or CompBLDup	1
FieldBLTrip	1	=	FieldBLDup or CompBLDup	2
One sample - sampled or split in triplicate				
Grab	1	=	Grab	1
FieldDup	1	=	Grab	2
FieldTrip	1	=	Grab	3
One pair of MS/MSD associated to one grab				
Grab	1	=	Grab	1
MS	1	=	MS1	1
One pair of MS/MSD associated to one grab - FieldDup present				
Grab	1	=	Grab	1
FieldDup	1	=	Grab	2
MS	1	=	MS1	1
One pair of MS/MSD associated to one FieldDup				
Grab	1	=	Grab	1
FieldDup	1	=	Grab	2
MSFDup	1	=	MS2	1
One pair of MS/MSD associated to one FieldBLDup				
Grab	1	=	Grab	1
FieldBLDup	1	=	FieldBLDup or CompBLDup	1
MSFBLDup	1	=	MSBLDup	1
Two pairs of MS/MSD, one associated to the Grab and one associated to the FieldDup				
Grab	1	=	Grab	1
FieldDup	1	=	Grab	2
MS	1	=	MS1	1
MSFDup	1	=	MS2	1

(ii) Calculating Matrix Spike Percent Recovery

The reported lab *Result* is the number gathered from the instrument and is the net amount recovered from the sample including the spike concentration. For spiked samples, the *ExpectedValue* is the total concentration of the analyte in the native sample plus the spiked concentration. Matrix Spike Percent Recovery is calculated by subtracting the native result from both the MS lab *Result* and the MS *ExpectedValue*, then dividing the two by each other and multiplying by 100. To illustrate:

$$\frac{\text{MS Lab Result} - \text{Native}}{\text{MS Expected} - \text{Native}} \times 100 \quad \text{or} \quad \frac{5-1}{10-1} = \frac{4}{9} \times 100 = 44\%$$

If the sample being used for the matrix spike requires a dilution, the reported values for the MS and the native sample are the dilution corrected values, not the actual values from the instrument.

(b) Non-Project Matrix Spike and Duplicate Samples (000NONPJ)

At times, laboratories use samples not generated through the SWAMP program to satisfy SWAMP batch QA requirements. These samples have different formatting rules, as follows:

LabSampleID	Recommended - provide lab specific identification for an analyzed sample. It is preferable to add -Dup, -MS, -MSD to the end of the Lab ID to help confirm the *SampleTypeCode* and the *LabSampleID* of the native sample.
StationCode	000NONPJ
EventCode	WQ for water and sediment chemistry
ProtocolCode	Not Applicable
LocationCode	Not Recorded
SampleDate	Date sample was digested/extracted, expressed as dd/mmm/yyyy. When no digestion/extraction was performed, *SampleDate* is equal to the analysis date.
CollectionTime	0:00 There are situations within a batch when two identical sample types are used for QA reasons and the only way to differentiate between them is to give them each a different *CollectionTime*. For example, when more than one 000NONPJ sample with the same *SampleTypeCode* is digested, extracted or analyzed in the same batch on the same day but are not replicates of each other, one *CollectionTime* should be 0:00 and the other 0:15, increasing the time by 15 minutes for each additional sample.
CollectionMethodCode	Not Recorded
SampleTypeCode	Grab - lab-generated Duplicates MS1 - Matrix Spikes
Replicate	1
CollectionDepth	-88
UnitCollectionDepth	m for water or cm for sediment

ProjectCode	Not Applicable
AgencyCode	Organization or agency that analyzed the sample
SampleID	The *LabSampleID* or *Source ID* can be used here as the *SampleID* as an indicator to identify the native sample
PreparationPreservation	Actual preparation or preservation performed
PreparationPreservationDate	Actual preparation or preservation date and time expressed as dd/mmm/yyyy xx:xx
LabReplicate	2 - lab-generated Duplicates 1 - Matrix Spike 2 - Matrix Spike Duplicate
Matrix	samplewater or sediment
QACode	QAX, when the native sample is not included in the batch reported

iii. Field-generated QA samples (FIELDQA)

There are two types of samples discussed in this section that are generated in the field. The first is when a field-generated QA sample is created at a specific station and that station information is important to record. The second is when a field-generated QA sample is created for a sampling trip or if the station is not recorded.

(c) Station Specific

For analyses that require an EquipBlank, FieldBlank, or FilterBlank to accompany a sampling event and it is important to record the station information, the data is entered into the SWAMP database in the same manner as the samples in the same group. The specifics are as follows:

LabSampleID	Recommended - provide lab specific identification for an analyzed sample
EventCode	WQ for water and sediment chemistry
ProtocolCode	Protocol associated with the sample or Not Recorded
StationCode	Station where sample was created
LocationCode	Location where sample was created
SampleDate	Date sample was created
CollectionTime	Time sample was created or 00:00 There are situations within a batch when two identical sample types are used for QA reasons and the only way to differentiate between them is to give them each a different *CollectionTime*. For example, when more than one EquipBlank, FieldBlank, or FilterBlank is created on the same day but are not replicates of each other, one *CollectionTime* should be 00:00 and the other 00:15, increasing the time by 15 minutes for each additional sample.
CollectionMethodCode	Not Applicable
SampleTypeCode	EquipBlank, FieldBlank, or FilterBlank

Replicate	1
CollectionDepth	-88
UnitCollectionDepth	m for water or cm for sediment
ProjectCode	Project associated with the sample
AgencyCode	Organization or agency that created the sample
CollectionComment	EquipBlank - comment includes type of equipment cleaned and location (lab or field)
Matrix	labwater or blankwater

(d) Not Station-Specific (FIELDQA)

For analyses that require an EquipBlank, FieldBlank, FilterBlank, TravelBlank or DIBlank to accompany a sampling event and it is not important to record the station information, the data is entered into the SWAMP database in the same manner as the samples in the same group. The specifics are as follows:

LabSampleID	Recommended - provide lab specific identification for an analyzed sample
EventCode	WQ for water and sediment chemistry
ProtocolCode	Protocol used or Not Recorded
StationCode	FIELDQA
LocationCode	Not Applicable
SampleDate	Date sample was created TravelBlank should be entered as the date the TravelBlank becomes part of the sample group (i.e., leaves the lab for the sampling event).
CollectionTime	Time sample was created or 0:00 There are situations within a batch when two identical sample types are used for QA reasons and the only way to differentiate between them is to give them each a different *CollectionTime*. For example, when more than one EquipBlank, FieldBlank, FilterBlank, TravelBlank, or DIBlank is created on the same day but are not replicates of each other, one *CollectionTime* should be 00:00 and the other 00:15, increasing the time by 15 minutes for each additional sample.
CollectionMethodCode	Not Applicable
SampleTypeCode	EquipBlank, FieldBlank, FilterBlank, TravelBlank, or DIBlank
Replicate	1
CollectionDepth	-88
UnitCollectionDepth	m for water or cm for sediment

ProjectCode	Project associated with the sample
AgencyCode	Organization or agency that created the sample
CollectionComment	EquipBlank - comment includes type of equipment cleaned and location (lab or field)
Matrix	labwater or blankwater

iv. Other Types of Samples

There are two types of samples discussed in this section that have special circumstances. The first is a pore water matrix sample and the second is a sample where bacteria is analyzed.

(e) Interstitial Water (Pore Water)Analysis

Certain sampling events create a special set of rules that apply for a few of the entry fields in the SWAMP database. One of these would be the collection of sediment from which interstitial water is extracted and then analyzed. Below are the fields that differentiate these samples from the norm and how they should be completed.

CollectionMethodCode	Sed_Grab
SampleTypeCode	Integrated
UnitCollectionDepth	cm
PreparationPreservation	Centrifuged plus any additional preparation done at the lab (Centrifuged, X)
PreparationPreservationDate	If no preparation was performed at the analyzing lab, enter the centrifuge date for *PreparationPreservationDate*. If a preparation or preservation was performed at the analyzing laboratory, enter the preparation date and time and include the date of centrifuge in the *CollectionComments*.
Matrix	sediment, interstitialwater
Unit	water units

(f) Bacteria Samples

Bacteria/Pathogen samples are generally recorded in the same way as chemistry samples, except as follows:

AnalysisDate	Include the analysis time in the *AnalysisDate* field as dd/mmm/yyyy xx:xx
DilFactor	Dilution factor should be recorded
ResultQualCode	This field records the <, <= and >, >= as related to the results. Please note that if the result is less than the reporting limit and the lab is confident in reporting "Non Detect", this should be entered as ND in the *ResultQualCode* with a value of -MDL in *Result* field.



SWAMP
Surface Water Ambient Monitoring Program

SWAMP DATA MANAGEMENT PLAN

Toxicity Template

Surface Water Ambient Monitoring Program

April 15, 2009

California Water Boards

www.waterboards.ca.gov/swamp

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A. Analytical Data

The typical method for submitting Laboratory Analytical Data to the SWAMP Database is electronically through the online data checker. This section will focus on the tools and steps involved in submitting these data.

The following information should be used in conjunction with the SWAMP QAPrP for complete compliance with the SWAMP program including measurement quality objectives and required quality assurance (QA) samples.

1. Analysis Authorization Forms

2. Water Quality (Chemistry and Bacteria) Data

The Chemistry Data Template Documentation is available online at http://swamp.mpsl.mlml.calstate.edu/resources-and-downloads/database-management-systems/swamp-25-database/documentation-25/#Chemistry.

3. Toxicity Data

Toxicity Data consists of Toxicity Test, Point, and Results data along with Toxicity Summary data for each effort, which is based on the replicate data. The toxicity data is submitted to the SWAMP database in three worksheets; Results, Summary, and ToxBatch.

a. Toxicity Data Template

The Toxicity Data Template is available online at http://swamp.mpsl.mlml.calstate.edu/resources-and-downloads/database-management-systems/swamp-25-database/templates-25/#Tox.

b. Formatting the Data

A Microsoft Excel template exists for laboratories to use to format the toxicity laboratory data in a manner that can be easily loaded into the SWAMP database. As previously discussed, for many labs working under the SWAMP master contract, the station collection information can be obtained from the Analysis Authorization form. This section will discuss each of the fields in the template and how to populate them.

i. Tox Results Worksheet

There are three worksheets that must travel with the data for the toxicity data package to be considered complete. The first holds all toxicity results, including quality control (QC) data, and should be named **Results** in a Microsoft Excel worksheet tab. Each record in this sheet represents a result from a specific analysis for a particular parameter at a single station or for a single QC sample. This worksheet will also contain all supporting QC sample results. If beginning with an Analysis Authorization, the following fields will likely be pre-populated in the **Data** worksheet: *EventCode*, *ProtocolCode*, *StationCode*, *LocationCode*, *CollectionMethodCode*, *SampleTypeCode*, *Replicate*, *CollectionDepth*, *UnitCollectionDepth*, *ProjectCode*, and *Agency Code*. Please note that all fields are required to be populated except when otherwise noted below. Examples of special types of samples are listed in the Special Circumstances section.

All valid LookUp list values are available at http://ftp.mpsl.mlml.calstate.edu/LookUpLists.php. At any time, if the necessary field does not appear in the LookUp list, the SWAMP Data Management Team (DMT) must be contacted to have it added.

(*Note that the fields through Dilution are identical to those in the summary worksheet*)

Template Field Name	LookUp List	Description & Business Rules
LabSampleID		The LabSampleID is a recommended field intended to provide lab specific identification for an analyzed sample. BR: The format and content is determined by the lab. It is preferable to add -Dup, -MS, -MSD to the end of the ID to help confirm the SampleType and the LabSampleID of the native sample.
StationCode	StationLookUp	StationCode represents a unique sampling site in a sampling design. A single waterbody may have multiple stations. BR: The format for the unique alphanumeric description of the station is ###ABC123, where ### is the Hydrologic Unit number and ABC123 is an alphanumeric description of the Station. An example is 111EELBRN which is Hydrologic Unit 111 and an abbreviated code to indicate "Eel River - South Fork near Branscomb".

Template Field Name	LookUp List	Description & Business Rules
EventCode	EventLookUp	EventCode represents the initial intent of the sampling event at a particular station. BR: The EventCode will be in a hierarchical order as follows: BA – If the initial intent of sampling is for Bioassessment (Tissue and/or WaterQuality samples may or may not also be collected) TI – If the initial intent of sampling is for Tissue (WaterQuality samples may or may not also be collected; no associated Bioassessment samples collected) WQ – If the initial intent of sampling is for WaterQuality (no associated Bioassessment or Tissue samples collected) For example, if the initial intent of sampling on Day 1 was for Tissue and WaterQuality, the EventCode would be TI. If for some reason the WaterQuality had to be re-sampled the next day, on Day 2, the event for the re-sampling would still be TI because Tissue was the initial intent of sampling on Day 1 even though the WaterQuality was sampled on Day 2.
ProtocolCode	ProtocolLookUp	ProtocolCode represents the sampling protocol used, which includes the set of methods, methodology and/or specifications, such as MPSL-DFG_Field_v1.0. Established protocols may be used or Regions may document their own sampling protocols. BR: It is preferable to combine protocols per StationCode and date so that all WaterQuality, Bioassessment and Tissue data are combined under the same EventCode. For example, if Tissue and WaterQuality are sampled at a station, the EventCode would be TI. If the protocols are different for Tissue and WaterQuality, the Tissue protocol would be used and the WaterQuality protocol would be listed in the SampleComments. If that is not preferable, separate EventCodes may be used with each individual protocol. Default value is Not Recorded.

Template Field Name	LookUp List	Description & Business Rules
LocationCode (previously SampleLocation)	LocationLookUp	LocationCode describes the physical location in the waterbody where the sample was collected. One sampling event may have a single or multiple locations. BR: For a single point of sampling, the physical location in the waterbody can be used such as Bank, Thalweg, Midchannel, OpenWater. The LocationCode for field results should be the same as the location for the WaterQuality collection method. For TI EventType sampling, the physical location plus the CollectionMethod is used such as BankNet1, BankShock1, OpenWaterTrawl1, OpenWaterNet1. For resident mussel or clam collections, the LocationCode would be the physical location in the water body plus the generic CollectionMethod, e.g. BankTissue_Grab. OpenWater sampling with multiple sub-locations within a single water body or station could have locations of OpenWaterTrawl1, OpenWaterTrawl2 describing one large location with two smaller areas of sampling within the OpenWater Location. Multiple physical locations within a single station could consist of a LocationCode such as BankShock1, BankNet1, OpenWaterHook1. If recording specific locations within a station are necessary for the project, a LocationCode such as Location1Net1, Location1Net2, Location2Shock1 may be used.
SampleDate		SampleDate refers to the date the sample was collected in the field. BR: The format for date in the templates is dd/mmm/yyyy, such as 10/Nov/2007. For samples with collection times that last longer than one day, like autosamplers, the sample date is the date sampling began. When entering data using the forms, the format is mm/dd/yy. For transplanted bivalves, the SampleDate is the date when the bivalves were deployed in the field.

Template Field Name	LookUp List	Description & Business Rules
CollectionTime (previously SampleTime)		CollectionTime refers to the time when the first sample of a sampling event at a specific station was collected in the field. BR: If the sampling crew collects 18 bottles at a single station, the CollectionTime for each would be the time of the first bottle collected. By doing so, the samples can easily be linked and any holding time issues will be consistent, and conservative, for the laboratory work. The CollectionTime format should be expressed as xx:xx in 24 hour time, such as 13:30 for 1:30 pm.
CollectionMethodCode	CollectionMethodLookUp	CollectionMethodCode refers to the general method of collection such as Sed_Grab, Sed_Core, Water_Grab, Autosampler24h, Autosampler7d. BR: The SWAMP water default is Water_Grab and the sediment default is Sed_Grab.
SampleTypeCode	SampleTypeLookUp	SampleTypeCode refers to the type of sample collected or analyzed. BR: Some commonly used SampleTypeCode choices include Grab, Integrated, MS1, CRM, LCS, LabBlank, CNEG, Composite.
Replicate (previously SampleReplicate)		The Replicate number is used to distinguish between replicates created at a single collection in the field. BR: The default is 1. Field Duplicates will be identified by a Replicate of 2. Field Blind Duplicates will be identified with a different SampleTypeCode of FieldBLDup, not a collection Replicate, because they are collected blind. Laboratory replicates will be identified by a replicate of 2 in the LabReplicate field, not a collection Replicate. When field duplicates are collected, the samples are given a StationCode of FIELDQA and a SampleTypeCode of Grab or Integrated with a Replicate of 2. When the chemistry data are loaded into the database, the StationCode FIELDQA will be given the correct StationCode of the native sample and the Replicate will be used to distinguish the duplicate sample from the native sample. EventCode, ProtocolCode, LocationCode, SampleDate, CollectionTime, CollectionMethodCode, CollectionDepth, UnitCollectionDepth, ProjectCode and AgencyCode should be identical for both samples taken.

Template Field Name	LookUp List	Description & Business Rules
CollectionDepth (previously DepthSampleCollection)		CollectionDepth records the level, from the surface in the water or sediment column, at which the sample was collected. BR: This information should be listed on the Chain of Custody (COC) document that accompanies the samples from the field. CollectionDepth for water samples would be measured from the water surface and recorded in meters (m) while depth collected for sediment would be measured from the sediment surface and recorded in centimeters (cm). Since depths for ambient monitoring Grab samples are generally "subsurface", defaults have been established to indicate this. For water samples the default value is 0.1 m and for sediment samples the default value is 2 cm. For Integrated samples collected from the same depth at different points across a waterbody or for samples collected at multiple times, i.e. an autosampler, the actual sample depth should be recorded. This applies to both water and sediment samples. Integrated samples collected at multiple depths, i.e. samples integrated from the water column or sediment cores, should receive a depth of -88 and the actual depths of collection should be recorded in the CollectionComments field.
UnitCollectionDepth (previously DepthUnit)	VariableCodesLookUp	UnitCollectionDepth refers to the units used in the CollectionDepth including cm (centimeters) and m (meters). This information should be listed on the Chain of Custody (COC) document that accompanies the samples from the field.

Template Field Name	LookUp List	Description & Business Rules
ProjectCode (previously ParentProjectID)	ProjectLookUp	ProjectCode references the project that is associated with the sample. BR: The formatting for a ProjectCode is as follows Program_Project. For example, the format for a SWAMP Regional Board project is SWAMP_RBX where SWAMP is the program, RB indicates it is a Regional Board sample and X is the Regional Board number. The format for a SWAMP State Board project is SWAMP_SB_XXX where SWAMP is the program, SB indicates it is a State Board sample and XXX represents the State Board project. For example, the ProjectCode for the Bioaccumulation Oversight Group would be SWAMP_SB_BOG. For a project other than SWAMP such as the Friends of the Los Angeles River, the project is FLAR_XXX where FLAR indicates it is a Friends of the Los Angeles River program and XXX represents the Friends of the Los Angeles River project. In some cases, there may not be a specific project but only a program. In this case the ProjectCode would be just the program; e.g. UMD.
AgencyCode	AgencyLookUp	AgencyCode refers to the organization or agency that collected the sample. This should be listed on the Chain of Custody (COC) document that accompanies the samples from the field. BR: If an environmental sample is used to perform laboratory QC, i.e. a matrix spike or lab duplicate, the AgencyCode still refers to the agency that collected the native sample, not the agency that created the QC sample. See 'Special Circumstances' for LABQA business rules.
CollectionComments (previously SampleComments) (Not Required)		CollectionComments records any comments relating to the collection of the field sample for laboratory analysis. BR: This field can also be used for laboratory QC samples, e.g. Matrix Spike was performed on a FieldBlank.

Template Field Name	LookUp List	Description & Business Rules
SampleID (Not Required)		SampleID is a unique identifier supplied by the organization directing the sampling or sampling agency and is used to track the sample throughout the sampling and analysis processes. This field can be used to tie a result to the sample. BR: This SampleID, which is different from the StationCode, will likely be on the sample container the laboratory receives from the field crew or on the COC. If there is no number, leave this field blank.
MatrixName	MatrixLookUp	MatrixName refers to the sample matrix. BR: Water - For field-generated water samples, the MatrixName is samplewater. For lab-generated QC samples, the matrix should be the type of water that was used for the analysis of the sample, either labwater or blankwater. Labwater is water coming either directly from the tap in the laboratory or purchased spring water. Blankwater is laboratory Type I or Type II water, purchased reagent water or water that is run through a filtration process in a laboratory, such as Deionized (DI) or Milli-Q (MQ) water. Sediment - For field-generated sediment samples, the MatrixName is sediment. For lab-generated QC samples, blankmatrix could be used as the MatrixName which is a matrix used to identify a commercial- or lab-produced medium in tissue or sediment QC samples. If this is not the case then the MatrixName for lab-generated QC samples would be sediment which would include samples where water, solvent or nothing was used as a matrix. Tissue - For field-generated tissue samples, the MatrixName is tissue. For lab-generated QC samples, blankmatrix could be used as the MatrixName which is a matrix used to identify a commercial- or lab-produced medium in tissue or sediment QC samples. If this is not the case then the MatrixName for lab-generated QC samples would be tissue which would include samples where water, solvent or nothing was used as a matrix.

Template Field Name	LookUp List	Description & Business Rules
MethodName	MethodLookUp	MethodName refers to the analysis method used by the laboratory to analyze the sample. BR: Methods are expressed with a MethodName such as SM 4500-NH3 C or EPA 600/R-99-064 and must be fully described in the Method Lookup list and in the laboratory records. If a laboratory has modified an EPA or Standard Method, the laboratory agency needs to add "M" to end of the MethodName. In such situations, the modification should be documented and communicated to the SWAMP DMT for notation in the database. For instance, a lab would report a modified EPA 600/R-99-064 as EPA 600/R-99-064M accompanied by a description of the modification made. Any method for the SWAMP Project which is not in the current SWAMP database lookup list must be approved by the SWAMP QA Team prior to being added to the database.
TestDuration	ToxTestDurLookUp	ToxTestDurCode indicates the duration of the toxicity test as a number and includes the associated units. BR: Some methods allow for a test to be completed early if all the necessary data has been obtained. If this is the case, the ToxTestDurCode is recorded as the duration of the test initially indicated by the method. For example, a method indicates a 7 day test is to be performed but the laboratory ends the test one day early. The ToxTestDurCode would be 7 days, not 6 days.
OrganismName (previously ToxSpeciesName)	OrganismLookup	OrganismName refers to the scientific name of the species used in the toxicity test.
ToxBatch		The ToxBatch is assigned by the laboratory and groups all environmental samples and supporting QA samples within a unique analysis batch. It is used to compare field samples with their associated NegativeControls for statistical analysis and will be used to verify completeness based on the SWAMP QAPrP. BR: The ToxBatch should be listed only one time in the ToxBatch worksheet for each unique ToxBatch found in the Results and Summary worksheets. Follow the File and Batch Name Convention to correctly identify the batch. It is recommended to include the start date and an abbreviation of the OrganismName in the lab-specific portion of the ToxBatch.

Template Field Name	LookUp List	Description & Business Rules
ToxTestComments (Not Required)		Use the ToxTestComments field to note any comments necessary to describe special circumstances for the toxicity test for the specific record.
Treatment	AnalyteLookUp	Treatment refers to any treatment performed on the sample, such as a pH adjustment. BR: The default value is None.
Concentration		Concentration refers to the adjusted final concentration or value of the analyte applied to the toxicity sample, expressed as a number. BR: The default value is 0. ??? Or the adjusted concentration level of the analyte i.e. pH or temp adjustment to 7 or 15 degrees
UnitTreatment	UnitLookUp	UnitTreatment refers to the units used in the treatment. BR: If a Treatment did not occur, the default value is none.
Dilution		Dilution is recorded as a proportion of the original sample. A sample with 80% sample and 20% blankwater has a Dilution Value of 80. BR: If no dilution is performed, the default value of 100 is used.
LabReplicate (previously ToxReplicate)		The LabReplicate identifies the individual splits of the toxicity sample and is used to identify from which replicate a result originated. BR: For toxicity replicates, the default is 1 and increases by one for each successive replicate. If a water quality measurement record is associated with a single replicate, it should have the same value as the replicate it measures. If the water quality measurements are taken at the sample level, the LabReplicate should be recorded as replicate 0.
ToxPointMethod	MethodLookUp	ToxPointMethod refers to the general method used in obtaining or calculating the result. BR: Toxicity replicate and summary data have a default value of None unless a method other than the test MethodName is used for the calculations. Water quality measurement results have a default value of ToxWQMeasurement.

Template Field Name	LookUp List	Description & Business Rules
AnalyteName (previously EndPointCode)	AnalyteLookUp	AnalyteName refers to the parameter being measured. BR: Toxicity examples include Survival, Young/female, Biomass (weight/orig indiv). Water quality measurment examples include pH, Ammonia as NH3, Salinity. The recommendation is "Biomass" be calculated for all fish species (total weight of surviving individuals divided by the original number of organisms at the start of the test) and "Growth" be calculated for Hyalella growth weight (total weight of surviving individuals divided by the number of survivors at the end of the test). Toxicity endpoints in the database will change to represent this correction; the endpoints for all fish species will be expressed as biomass instead of growth weight. It is the recommendation of the panel that we do not go back and recalculate results in the database where growth was calculated instead of biomass. All previous measurements would be listed as growth or biomass according to analysis performed by the analyzing laboratory.
FractionName	FractionLookUp	FractionName is a specific descriptor of the Analyte. BR: Ammonia as NH3 is expressed as Total or Unionized, each of which would be expressed as the Fraction, distinguishing the appropriate Analyte. If there is no need for further description of the analyte the default value is None.
WQSource	MatrixLookUp	WQSource differentiates between water quality measurements taken in the overlying water as well as in the sediment or interstitialwater. BR: Overlyingwater is used for the overlying water measurements which is the default for all water quality measurements. Interstitialwater is used for the interstitial water measurements. NA is used for for all toxicity results.

Template Field Name	LookUp List	Description & Business Rules
TimePoint	TimePointLookUp	TimePoint refers to the point in time during the test at which the measurement was recorded for water quality measurements. BR: For water quality measurements, timepoints such as initial or final are used to indicate the measurments recorded at the beginning and end of the test. High and low are used to indicate the highest and lowest values recorded for a particular sample during the entire length of the test. Day 2 is used indicate a measurement taken on the 2nd day of the test. For toxicity measurements, the TimePoint should match the TestDuration value. So if a 7 day test is performed, the TimePoint for the toxicity results would be 7 Days.
UnitAnalyte (previously ToxResultsUnit)	UnitLookUp	UnitAnalyte indicates the units used in the measurment of the AnalyteName.
Result		Numeric result of test, stored as text to retain trailing zeros BR: The toxicity Result is expressed as a real number rather than a calculation. The result should be reported with the appropriate number of significant figures. A result of 3.7266945 with 3 significant figures should be reported as 3.73. A result of 1.350 with 4 significant figures must display 1.350 in the Excel file. If you only see 1.35, that is the result that will be loaded to the database and the 4th significant figure will be dropped.
ResultQualCode (Not Required)	ResQualLookUp	The Result Qualifier Code or ResultQualCode qualifies the analytical result of the sample. BR: This field may be left blank for results that are considered detected. The database will be populated with an equal sign (=) when the data are loaded. When a result is Not Detected a ResultQualCode of ND is required. When the result is -88, a ResultQualCode is required. If the ResultQualCode value is NR for Not Recorded or NS for No Survival, then a reason for this code must be written into the ToxResultComments field.

Template Field Name	LookUp List	Description & Business Rules
ToxResultQACode (Not Required)	ToxResultQALookUp	A ToxResultQACode is used to further qualify the analytical result of the sample. BR: When a test has a secondary toxpoint where young are measured and the first toxpoint is a Male instead of a female, the ToxResultQACode for the second toxpoint is MAL for male.
ToxResultComments (Not Required)		In the ToxResultsComments field note any comments necessary to describe special circumstances for the toxicity results data for the specific record. These could be comments needed to clarify any portion of the analysis which is not described in any other field. BR: When the ResultQualCode value is NR for Not Recorded or NS for No Survival, then a reason for this code must be written into the ToxResultsComments field.

ii. Toxicity Summary Worksheet

The second worksheet to travel with the data holds information specific to toxicity summary data. This worksheet should be named **Summary** in its worksheet tab. The fields in this sheet are and should be completed as follows. Examples of special types of samples are listed in the Special Circumstances section.

(*Note that the fields through Dilution are identical to those in the Results*)

Template Field Name	LookUp List	Description & Business Rules
LabSampleID		The LabSampleID is a recommended field intended to provide lab specific identification for an analyzed sample. BR: The format and content is determined by the lab. It is preferable to add -Dup, -MS, -MSD to the end of the ID to help confirm the SampleType and the LabSampleID of the native sample.
StationCode	StationLookUp	StationCode represents a unique sampling site in a sampling design. A single waterbody may have multiple stations. BR: The format for the unique alphanumeric description of the station is ###ABC123, where ### is the Hydrologic Unit number and ABC123 is an alphanumeric description of the Station. An example is 111EELBRN which is Hydrologic Unit 111 and an abbreviated code to indicate "Eel River - South Fork near Branscomb".

Template Field Name	LookUp List	Description & Business Rules
EventCode	EventLookUp	EventCode represents the initial intent of the sampling event at a particular station. BR: The EventCode will be in a hierarchical order as follows: BA – If the initial intent of sampling is for Bioassessment (Tissue and/or WaterQuality samples may or may not also be collected) TI – If the initial intent of sampling is for Tissue (WaterQuality samples may or may not also be collected; no associated Bioassessment samples collected) WQ – If the initial intent of sampling is for WaterQuality (no associated Bioassessment or Tissue samples collected) For example, if the initial intent of sampling on Day 1 was for Tissue and WaterQuality, the EventCode would be TI. If for some reason the WaterQuality had to be re-sampled the next day, on Day 2, the event for the re-sampling would still be TI because Tissue was the initial intent of sampling on Day 1 even though the WaterQuality was sampled on Day 2.
ProtocolCode	ProtocolLookUp	ProtocolCode represents the sampling protocol used, which includes the set of methods, methodology and/or specifications, such as MPSL-DFG_Field_v1.0. Established protocols may be used or Regions may document their own sampling protocols. BR: It is preferable to combine protocols per StationCode and date so that all WaterQuality, Bioassessment and Tissue data are combined under the same EventCode. For example, if Tissue and WaterQuality are sampled at a station, the EventCode would be TI. If the protocols are different for Tissue and WaterQuality, the Tissue protocol would be used and the WaterQuality protocol would be listed in the SampleComments. If that is not preferable, separate EventCodes may be used with each individual protocol. Default value is Not Recorded.

Template Field Name	LookUp List	Description & Business Rules
LocationCode (previously SampleLocation)	LocationLookUp	LocationCode describes the physical location in the waterbody where the sample was collected. One sampling event may have a single or multiple locations. BR: For a single point of sampling, the physical location in the waterbody can be used such as Bank, Thalweg, Midchannel, OpenWater. The LocationCode for field results should be the same as the location for the WaterQuality collection method. For TI EventType sampling, the physical location plus the CollectionMethod is used such as BankNet1, BankShock1, OpenWaterTrawl1, OpenWaterNet1. For resident mussel or clam collections, the LocationCode would be the physical location in the water body plus the generic CollectionMethod, e.g. BankTissue_Grab. OpenWater sampling with multiple sub-locations within a single water body or station could have locations of OpenWaterTrawl1, OpenWaterTrawl2 describing one large location with two smaller areas of sampling within the OpenWater Location. Multiple physical locations within a single station could consist of a LocationCode such as BankShock1, BankNet1, OpenWaterHook1. If recording specific locations within a station are necessary for the project, a LocationCode such as Location1Net1, Location1Net2, Location2Shock1 may be used.
SampleDate		SampleDate refers to the date the sample was collected in the field. BR: The format for date in the templates is dd/mmm/yyyy, such as 10/Nov/2007. For samples with collection times that last longer than one day, like autosamplers, the sample date is the date sampling began. When entering data using the forms, the format is mm/dd/yy. For transplanted bivalves, the SampleDate is the date when the bivalves were deployed in the field.

Template Field Name	LookUp List	Description & Business Rules
CollectionTime (previously SampleTime)		CollectionTime refers to the time when the first sample of a sampling event at a specific station was collected in the field. BR: If the sampling crew collects 18 bottles at a single station, the CollectionTime for each would be the time of the first bottle collected. By doing so, the samples can easily be linked and any holding time issues will be consistent, and conservative, for the laboratory work. The CollectionTime format should be expressed as xx:xx in 24 hour time, such as 13:30 for 1:30 pm.
CollectionMethodCode	CollectionMethodLookUp	CollectionMethodCode refers to the general method of collection such as Sed_Grab, Sed_Core, Water_Grab, Autosampler24h, Autosampler7d. BR: The SWAMP water default is Water_Grab and the sediment default is Sed_Grab.
SampleTypeCode	SampleTypeLookUp	SampleTypeCode refers to the type of sample collected or analyzed. BR: Some commonly used SampleTypeCode choices include Grab, Integrated, MS1, CRM, LCS, LabBlank, CNEG, Composite.
Replicate (previously SampleReplicate)		The Replicate number is used to distinguish between replicates created at a single collection in the field. BR: The default is 1. Field Duplicates will be identified by a Replicate of 2. Field Blind Duplicates will be identified with a different SampleTypeCode of FieldBLDup, not a collection Replicate, because they are collected blind. Laboratory replicates will be identified by a replicate of 2 in the LabReplicate field, not a collection Replicate. When field duplicates are collected, the samples are given a StationCode of FIELDQA and a SampleTypeCode of Grab or Integrated with a Replicate of 2. When the chemistry data are loaded into the database, the StationCode FIELDQA will be given the correct StationCode of the native sample and the Replicate will be used to distinguish the duplicate sample from the native sample. EventCode, ProtocolCode, LocationCode, SampleDate, CollectionTime, CollectionMethodCode, CollectionDepth, UnitCollectionDepth, ProjectCode and AgencyCode should be identical for both samples taken.

Template Field Name	LookUp List	Description & Business Rules
CollectionDepth (previously DepthSampleCollection)		CollectionDepth records the level, from the surface in the water or sediment column, at which the sample was collected. BR: This information should be listed on the Chain of Custody (COC) document that accompanies the samples from the field. CollectionDepth for water samples would be measured from the water surface and recorded in meters (m) while depth collected for sediment would be measured from the sediment surface and recorded in centimeters (cm). Since depths for ambient monitoring Grab samples are generally "subsurface", defaults have been established to indicate this. For water samples the default value is 0.1 m and for sediment samples the default value is 2 cm. For Integrated samples collected from the same depth at different points across a waterbody or for samples collected at multiple times, i.e. an autosampler, the actual sample depth should be recorded. This applies to both water and sediment samples. Integrated samples collected at multiple depths, i.e. samples integrated from the water column or sediment cores, should receive a depth of -88 and the actual depths of collection should be recorded in the CollectionComments field.
UnitCollectionDepth (previously DepthUnit)	VariableCodesLookUp	UnitCollectionDepth refers to the units used in the CollectionDepth including cm (centimeters) and m (meters). This information should be listed on the Chain of Custody (COC) document that accompanies the samples from the field.

Template Field Name	LookUp List	Description & Business Rules
ProjectCode (previously ParentProjectID)	ProjectLookUp	ProjectCode references the project that is associated with the sample. BR: The formatting for a ProjectCode is as follows Program_Project. For example, the format for a SWAMP Regional Board project is SWAMP_RBX where SWAMP is the program, RB indicates it is a Regional Board sample and X is the Regional Board number. The format for a SWAMP State Board project is SWAMP_SB_XXX where SWAMP is the program, SB indicates it is a State Board sample and XXX represents the State Board project. For example, the ProjectCode for the Bioaccumulation Oversight Group would be SWAMP_SB_BOG. For a project other than SWAMP such as the Friends of the Los Angeles River, the project is FLAR_XXX where FLAR indicates it is a Friends of the Los Angeles River program and XXX represents the Friends of the Los Angeles River project. In some cases, there may not be a specific project but only a program. In this case the ProjectCode would be just the program; e.g. UMD.
AgencyCode	AgencyLookUp	AgencyCode refers to the organization or agency that collected the sample. This should be listed on the Chain of Custody (COC) document that accompanies the samples from the field. BR: If an environmental sample is used to perform laboratory QC, i.e. a matrix spike or lab duplicate, the AgencyCode still refers to the agency that collected the native sample, not the agency that created the QC sample. See 'Special Circumstances' for LABQA business rules.
CollectionComments (previously SampleComments) (Not Required)		CollectionComments records any comments relating to the collection of the field sample for laboratory analysis. BR: This field can also be used for laboratory QC samples, e.g. Matrix Spike was performed on a FieldBlank.

Template Field Name	LookUp List	Description & Business Rules
SampleID (Not Required)		SampleID is a unique identifier supplied by the organization directing the sampling or sampling agency and is used to track the sample throughout the sampling and analysis processes. This field can be used to tie a result to the sample. BR: This SampleID, which is different from the StationCode, will likely be on the sample container the laboratory receives from the field crew or on the COC. If there is no number, leave this field blank.
MatrixName	MatrixLookUp	MatrixName refers to the sample matrix. BR: Water - For field-generated water samples, the MatrixName is samplewater. For lab-generated QC samples, the matrix should be the type of water that was used for the analysis of the sample, either labwater or blankwater. Labwater is water coming either directly from the tap in the laboratory or purchased spring water. Blankwater is laboratory Type I or Type II water, purchased reagent water or water that is run through a filtration process in a laboratory, such as Deionized (DI) or Milli-Q (MQ) water. Sediment - For field-generated sediment samples, the MatrixName is sediment. For lab-generated QC samples, blankmatrix could be used as the MatrixName which is a matrix used to identify a commercial- or lab-produced medium in tissue or sediment QC samples. If this is not the case then the MatrixName for lab-generated QC samples would be sediment which would include samples where water, solvent or nothing was used as a matrix. Tissue - For field-generated tissue samples, the MatrixName is tissue. For lab-generated QC samples, blankmatrix could be used as the MatrixName which is a matrix used to identify a commercial- or lab-produced medium in tissue or sediment QC samples. If this is not the case then the MatrixName for lab-generated QC samples would be tissue which would include samples where water, solvent or nothing was used as a matrix.

Template Field Name	LookUp List	Description & Business Rules
MethodName	MethodLookUp	MethodName refers to the analysis method used by the laboratory to analyze the sample. BR: Methods are expressed with a MethodName such as SM 4500-NH3 C or EPA 600/R-99-064 and must be fully described in the Method Lookup list and in the laboratory records. If a laboratory has modified an EPA or Standard Method, the laboratory agency needs to add "M" to end of the MethodName. In such situations, the modification should be documented and communicated to the SWAMP DMT for notation in the database. For instance, a lab would report a modified EPA 600/R-99-064 as EPA 600/R-99-064M accompanied by a description of the modification made. Any method for the SWAMP Project which is not in the current SWAMP database lookup list must be approved by the SWAMP QA Team prior to being added to the database.
TestDuration	ToxTestDurLookUp	ToxTestDurCode indicates the duration of the toxicity test as a number and includes the associated units. BR: Some methods allow for a test to be completed early if all the necessary data has been obtained. If this is the case, the ToxTestDurCode is recorded as the duration of the test initially indicated by the method. For example, a method indicates a 7 day test is to be performed but the laboratory ends the test one day early. The ToxTestDurCode would be 7 days, not 6 days.
OrganismName (previously ToxSpeciesName)	OrganismLookup	OrganismName refers to the scientific name of the species used in the toxicity test.
ToxBatch		The ToxBatch is assigned by the laboratory and groups all environmental samples and supporting QA samples within a unique analysis batch. It is used to compare field samples with their associated NegativeControls for statistical analysis and will be used to verify completeness based on the SWAMP QAPrP. BR: The ToxBatch should be listed only one time in the ToxBatch worksheet for each unique ToxBatch found in the Results and Summary worksheets. Follow the File and Batch Name Convention to correctly identify the batch. It is recommended to include the start date and an abbreviation of the OrganismName in the lab-specific portion of the ToxBatch.

Template Field Name	LookUp List	Description & Business Rules
ToxTestComments (Not Required)		Use the ToxTestComments field to note any comments necessary to describe special circumstances for the toxicity test for the specific record.
Treatment	AnalyteLookUp	Treatment refers to any treatment performed on the sample, such as a pH adjustment. BR: The default value is None.
Concentration		Concentration refers to the adjusted final concentration or value of the analyte applied to the toxicity sample, expressed as a number. BR: The default value is 0. ??? Or the adjusted concentration level of the analyte i.e. pH or temp adjustment to 7 or 15 degrees
UnitTreatment	UnitLookUp	UnitTreatment refers to the units used in the treatment. BR: If a Treatment did not occur, the default value is none.
Dilution		Dilution is recorded as a proportion of the original sample. A sample with 80% sample and 20% blankwater has a Dilution Value of 80. BR: If no dilution is performed, the default value of 100 is used.
ToxPointMethod	MethodLookUp	ToxPointMethod refers to the general method used in obtaining or calculating the result. BR: Toxicity replicate and summary data have a default value of None unless a method other than the test MethodName is used for the calculations. Water quality measurement results have a default value of ToxWQMeasurement.

Template Field Name	LookUp List	Description & Business Rules
AnalyteName (previously EndPointCode)	AnalyteLookUp	AnalyteName refers to the parameter being measured. BR: Toxicity examples include Survival, Young/female, Biomass (weight/orig indiv). Water quality measurment examples include pH, Ammonia as NH3, Salinity. The recommendation is "Biomass" be calculated for all fish species (total weight of surviving individuals divided by the original number of organisms at the start of the test) and "Growth" be calculated for Hyalella growth weight (total weight of surviving individuals divided by the number of survivors at the end of the test). Toxicity endpoints in the database will change to represent this correction; the endpoints for all fish species will be expressed as biomass instead of growth weight. It is the recommendation of the panel that we do not go back and recalculate results in the database where growth was calculated instead of biomass. All previous measurements would be listed as growth or biomass according to analysis performed by the analyzing laboratory.
FractionName	FractionLookUp	FractionName is a specific descriptor of the Analyte. BR: Ammonia as NH3 is expressed as Total or Unionized, each of which would be expressed as the Fraction, distinguishing the appropriate Analyte. If there is no need for further description of the analyte the default value is None.
WQSource	MatrixLookUp	WQSource differentiates between water quality measurements taken in the overlying water as well as in the sediment or interstitialwater. BR: Overlyingwater is used for the overlying water measurements which is the default for all water quality measurements. Interstitialwater is used for the interstitial water measurements. NA is used for for all toxicity results.

Template Field Name	LookUp List	Description & Business Rules
TimePoint	TimePointLookUp	TimePoint refers to the point in time during the test at which the measurement was recorded for water quality measurements. BR: For water quality measurements, timepoints such as initial or final are used to indicate the measurments recorded at the beginning and end of the test. High and low are used to indicate the highest and lowest values recorded for a particular sample during the entire length of the test. Day 2 is used indicate a measurement taken on the 2nd day of the test. For toxicity measurements, the TimePoint should match the TestDuration value. So if a 7 day test is performed, the TimePoint for the toxicity results would be 7 Days.
UnitAnalyte (previously ToxResultsUnit)	UnitLookUp	UnitAnalyte indicates the units used in the measurment of the AnalyteName.
RepCount		RepCount is the total number of sample replicates analyzed for the associated toxpoint in the toxicity test. BR: There are a few circumstances where a replicate should not be counted or used in the calculations. For all tests, if a replicate was spilled before a result could be recorded, the RepCount would decrease by one replicate. For all tests but primarily Ceriodaphnia dubia, if the first toxpoint had a single individual and it was a male, the second toxpoint of Young/female would not be possible so the RepCount for the second toxpoint would decrease by one. For Hyalella only, if the first toxpoint had a Survival of 0, the second toxpoint of Growth (weight/surv indiv) would not be included in the calculations so the RepCount would decrease by one replicate.
Mean		Mean is the average result calculated from all replicates of a single sample.
StdDev		StdDev or standard deviation is a statistic that indicates how tightly all the replicates are clustered around the mean in a set of data. This calculation includes all the applicable replicates from a single sample.
StatisticalMethod (previously Statistical Test Code)	VariableCodesLookUp	StatisticalMethod is the statistical test or method used to calculate the probability of whether a test is significant or not. Esentially, whether the sample replicates are significantly different from the control.

Template Field Name	LookUp List	Description & Business Rules
AlphaValue		AlphaValue is the predetermined statistical acceptance level that is not calculated, but is chosen by the laboratory. BR: The default value for SWAMP is 0.05.
Probability		Probability is the calculated probability using a standard statistical analysis between the replicates of the field samples and the control or reference sample within a ToxBatch. BR: Negative control samples (CNEG) probability is 0.5.
MSD		The minimum significant difference (MSD) is a measurement that can be produced for each statistical comparison performed between sample and control, or among multiple concentrations of a sample and control. It represents the smallest significant difference from the control and is unique for each statistical comparison. BR: A threshold is generated for each batch of samples associated with a single control. The sample response will be evaluated by a statistical comparison to the control response, and then comparing it to the generated threshold. This provides a two-tier system for designating a sample as toxic.
EvalThreshold		Evaluation threshold or EvalThreshold is the associated level that is used to identify that an environmental sample is significantly different from its associated control sample and is recorded as a percentage, e.g. 80%. EvalThreshold = Control % - MSD % BR: Control sample should be reported as 80 for the corresponding endpoint. Unless supplied, the default EvalThreshold will be 80.

Template Field Name	LookUp List	Description & Business Rules
SigEffect	SigEffectLookUp	The toxicity significant effect code or SigEffect indicates whether the sample result is significantly different from the control. BR: The code is based on two criteria used to determine significance. The first or first two letters of the code refers to the significance compared to the negative control, which is determined whether it is above or below the alpha value of 0.05. The last letter of the code refers to the whether the %control is above or below the evaluation threshold. For example NSG, is not significant compared to negative control based on statistical test, it was below the alpha of 5%, and above the evaluation threshold. For labs submitting only one criterion to determine significance, the SWAMP DMT will apply the last letter of the code based on an EvalThreshold of 80 unless the lab provides an alternate EvalThreshold value. The SigEffectCode will receive an NA code in this instance. Sediment and water samples must be compared to the negative control sample. Reference sediment or salinity controls may be reported in the database for informational purposes. While the ToxSigEffectCode will always reflect a combination of the probability and evaluation threshold, best professional judgment of the lab can be reflected in the sample comment.
TestQACode (previously TestQualCode)	QALookUp	TestQACode is applied to each sample's toxpoint and water quality measurements to describe any special conditions, situations or outliers that occurred during or prior to the analysis to achieve the result. BR: The default code, indicating no special conditions, is None. If more than one code should be applied to a record, the convention is to list them in alphabetical order separated by commas and no spaces; i.e. BY,TW
SummaryComments (Not Required)		In the SummaryComments field note any comments necessary to describe special circumstances for the toxicity summary data for the specific record.

iii. Tox Batch Worksheet

The third worksheet to travel with the data holds information specific to the laboratory batch in which data is analyzed. This worksheet should be named **ToxBatch** (with no spaces) in its worksheet tab. The fields in this sheet are and should be completed as follows:

Template Field Name	LookUp List	Description & Business Rules
ToxBatch		The ToxBatch is assigned by the laboratory and groups all environmental samples and supporting QA samples within a unique analysis batch. It is used to compare field samples with their associated NegativeControls for statistical analysis and will be used to verify completeness based on the SWAMP QAPrP. BR: The ToxBatch should be listed only one time in the ToxBatch worksheet for each unique ToxBatch found in the Results and Summary worksheets. Follow the File and Batch Name Convention to correctly identify the batch. It is recommended to include the start date and an abbreviation of the OrganismName in the lab-specific portion of the ToxBatch.
LabAgencyCode	AgencyLookUp	AgencyCode refers to the organization, agency or laboratory that performed the analysis of the sample.
StartDate		StartDate refers to the date the test began.
RefToxBatch		RefToxBatch lists the Reference Tox Batch ID run with this batch of samples.
OrganismSupplier (Not Required)		OrganismSupplier refers to the agency that supplied the test organisms.
OrganismAgeAtTestStart (Not Required)		OrganismAgeAtTestStart indicates the age or age range (e.g. 7 days or 7-10 days) of the test organisms at the beginning of the test. The age or range is usually recommended by the method.
LabSubmissionCode (previously BatchQualCode)	LabSubmissionLookUp	The LabSubmissionCode is a unique batch qualifier code assigned to the ToxBatch as a whole by the analyzing laboratory which references the quality of the data in the ToxBatch. BR: If the LabSubmissionCode of A is used, meaning Acceptable, the laboratory is ensuring that all SWAMP QAQC protocols were met for the toxicity batch. If anything other than A is used, a ToxBatchComment is required.

Template Field Name	LookUp List	Description & Business Rules
SubmittingAgencyCode	AgencyLookUp	SubmittingAgencyCode is the organization or agency that is responsible for submission of the data to the database. This agency may be different from LabAgencyCode if the analytical data were subcontracted to another agency.
ToxBatchComments (Not Required)		The ToxBatchComments field is intended to record any comments relating to the ToxBatch as a whole. BR: If the LabSubmissionCode is anything other than A, a ToxBatchComment is required

c. Special Circumstances

i. Laboratory-generated QA samples (LABQA)

All samples generated from within the laboratory, such as CNEG, CNSL, etc. have specific alternative rules, which are as follows:

LabSampleID	Recommended - provide lab specific identification for an analyzed sample
StationCode	LABQA
EventCode	WQ for water and sediment chemistry and toxicity results
ProtocolCode	Not Applicable
LocationCode	Not Applicable
SampleDate	Date test started, expressed as dd/mmm/yyyy
CollectionTime	0:00
CollectionMethodCode	Not Applicable
SampleTypeCode	Select from SampleTypeLookup List
Replicate	1
CollectionDepth	-88
UnitCollectionDepth	m for water or cm for sediment
ProjectCode	Not Applicable
AgencyCode	Organization or agency that analyzed the sample
Matrix	Water samples - labwater or blankwater Sediment samples - blankmatrix (commercially generated product) or sediment (if laboratories is using solvent, water or nothing)

ii. Interstitial Water (Pore Water) Analysis

Certain sampling events create a special set of rules that apply for a few of the entry fields in the SWAMP database. One of these would be the collection of sediment from which interstitial water is extracted and then analyzed. Below are the fields that differentiate these samples from the norm and how they should be completed.

CollectionMethodCode	Sed_Grab
SampleTypeCode	Integrated
UnitCollectionDepth	cm
PreparationPreservation	Centrifuged plus any additional preparation done at the lab (Centrifuged, X)
PreparationPreservationDate	If no preparation was performed at the analyzing lab, enter the centrifuge date for *PreparationPreservationDate*. If a preparation or preservation was

	performed at the analyzing laboratory, enter the preparation date and include the date of centrifuge in the *CollectionComments*.
Matrix	sediment, interstitialwater
Unit	Water units



SWAMP
Surface Water Ambient Monitoring Program

SWAMP DATA MANAGEMENT PLAN

Taxonomy Results Template

Surface Water Ambient Monitoring Program

October 20, 2010

California Water Boards

http://www.waterboards.ca.gov/water_issues/programs/swamp

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E. ANALYTICAL DATA

The typical method for submitting Laboratory Analytical Data to the SWAMP Database is electronically through the online data checker. This section will focus on the tools and steps involved in submitting these data.

The following information should be used in conjunction with the SWAMP QAPrP for complete compliance with the SWAMP program including measurement quality objectives and required QA samples.

2. TAXONOMY ANALYSIS AUTHORIZATION FORMS

Prior to a sampling event, it is helpful to organize and identify what taxonomic samples are to be analyzed. For those organizations contracting with the Department of Fish and Game (DFG) for sampling activity, the tool used for this expectation of work is called a Taxonomy Analysis Authorization Form. This AA form is a copy of the Taxonomy Results Template (also available online) with specific samples listed for analysis.

The Analysis Authorization (AA) form is an Excel workbook provided to the labs in an electronic format prior to sampling. It is used as a detailed supplement to the Chain of Custody (COC) documentation that travels with the samples from the field to the lab. Should any discrepancy between the two types of documentation occur, contact the provider of the Analysis Authorization for further clarification.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	EventCode	ProtocolCode	StationCode	SampleDate	AgencyCode	ProjectCode	UserName	SampleComments	LocationCode	GeometryShape	CollectionTime	CollectionMethodCode	SampleTypeCode	Replicate	CollectionDeviceName
2	EXAMPLE MARINE INVERTEBRATES														
11	WQ	MPSL-DFG_Field_v1.0	306MSLG22	04/Jun/2004	MPSL-MLML	SWAMP_RB3	msigala	Station in deep water	OpenWater	Point	10:00	Sed_Grab	Grab	1	MPSL-MLML Mod.VanV
12	WQ	MPSL-DFG_Field_v1.0	306MSLG22	04/Jun/2004	MPSL-MLML	SWAMP_RB3	msigala	Station in deep water	OpenWater	Point	10:00	Sed_Grab	Grab	1	MPSL-MLML Mod.VanV
13	WQ	MPSL-DFG_Field_v1.0	306MSLG22	04/Jun/2004	MPSL-MLML	SWAMP_RB3	msigala	Station in deep water	OpenWater	Point	10:00	Sed_Grab	Grab	2	MPSL-MLML Mod.VanV
14	WQ	MPSL-DFG_Field_v1.0	306MSLG22	04/Jun/2004	MPSL-MLML	SWAMP_RB3	msigala	Station in deep water	OpenWater	Point	10:00	Sed_Grab	Grab	2	MPSL-MLML Mod.VanV
15	WQ	MPSL-DFG_Field_v1.0	306MSLG22	04/Jun/2004	MPSL-MLML	SWAMP_RB3	msigala	Station in deep water	OpenWater	Point	10:00	Sed_Grab	Grab	2	MPSL-MLML Mod.VanV
16	WQ	MPSL-DFG_Field_v1.0	306MSLG22	04/Jun/2004	MPSL-MLML	SWAMP_RB3	msigala	Station in deep water	OpenWater	Point	10:00	Sed_Grab	Grab	1	MPSL-MLML Mod.VanV
17	WQ	MPSL-DFG_Field_v1.0	306MSLG22	04/Jun/2004	MPSL-MLML	SWAMP_RB3	msigala	Station in deep water	OpenWater	Point	10:00	Sed_Core	Grab	1	Core_0.0071m2
18	EXAMPLE BMI INVERTEBRATES														
19	BA	SWAMP_WS	401VCJVCL	05/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	BMI_TRC	Integrated	1	D-Frame Kick Net
20	BA	SWAMP_WS	401VCJVCL	05/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	BMI_RWB	Integrated	1	D-Frame Kick Net
21	BA	SWAMP_WS	401VCJVCL	05/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	BMI_RWB	Integrated	1	D-Frame Kick Net
22	BA	SWAMP_WS	401VCJVCL	05/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	BMI_RWB	Integrated	1	D-Frame Kick Net
23	BA	SWAMP_WS	401VCJVCL	05/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	BMI_RWB	Integrated	1	D-Frame Kick Net
24	BA	SWAMP_WS	401VCJVCL	05/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	BMI_RWB	Integrated	1	D-Frame Kick Net
25	BA	SWAMP_WS	401VCJVCL	05/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	BMI_RWB	Integrated	1	D-Frame Kick Net
26	BA	SWAMP_WS	401VCJVCL	05/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	BMI_RWB	Integrated	1	D-Frame Kick Net
27	BA	SWAMP_WS	401VCMADL	07/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	BMI_RWB	Integrated	1	D-Frame Kick Net
28	BA	SWAMP_WS	401VCMADL	07/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	BMI_RWB	Integrated	2	D-Frame Kick Net
29	EXAMPLE DIATOMS														
30	BA	SWAMP_WS	401VCMADL	07/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	Algae_SWAMP	Integrated	1	RubDelim & PVCDelim
31	BA	SWAMP_WS	401VCMADL	07/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	Algae_SWAMP	Integrated	1	RubDelim & PVCDelim
32	BA	SWAMP_WS	401VCMADL	07/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	Algae_SWAMP	Integrated	1	RubDelim & PVCDelim
33	BA	SWAMP_WS	401VCMADL	07/Jun/2006	MPSL-DFG	SWAMP_RB4	admin		X	Point	11:00	Algae_SWAMP	Integrated	1	RubDelim & PVCDelim

Notes_Information | BenthicCollectionResults | BenthicCollectionResultsEXAMPLE | AgencyLookUp | CollectionDevice_FieldResLookUp

- The **BenthicCollectionResults** worksheet provides the sample information in the correct template format for the laboratory to use in order to enter the analysis results.
- A **BenthicCollectionResults Example** worksheet is also listed which gives an example of the final formatting of the taxonomy template.

Regardless of whether an organization chooses to use these Analysis Authorization Forms or others like them that serve the same purpose, they are useful tools to help communicate and maintain consistency regarding samples collected and analyzed. If interested, contact the SWAMP DMT to receive an electronic version of an AA form template.

7. TAXONOMIC DATA

Data for marine benthic infauna, freshwater benthic macroinvertebrate (BMI), algae, and diatom taxonomic analyses are treated in a similar way in the SWAMP database and for this reason will be treated together in this portion of the document.

a. Taxonomy Results Template

The Taxonomy Results Template is available online at http://swamp.mpsl.mlml.calstate.edu/resources-and-downloads/database-management-systems/swamp-25-database/templates-25#Taxonomic.

b. Formatting the Data

A Microsoft Excel template exists for laboratories to use to format and submit taxonomy results in a manner that can be easily loaded into the SWAMP database. As previously discussed, for many labs working under the SWAMP master contract, the station collection information can be obtained from the Taxonomy Analysis Authorization form. This section will discuss each of the fields in the template and how to populate them.

All valid LookUp list values are available at http://ftp.mpsl.mlml.calstate.edu/LookUpLists.php. If the necessary field and/or values do not appear in the LookUp list, a request to have it added can be submitted to the SWAMP Data Management Team (DMT).

i. Benthic Collection Results Worksheet

There is one worksheet that must travel with the data for the data package to be considered complete. This worksheet holds all marine benthic infauna, freshwater benthic macroinvertebrate (BMI), algae, and diatom collection and result data, and should be named **BenthicCollectionResults** in a worksheet tab. Each record in this sheet represents a unique taxonomic identification from each sample and collection event. If beginning with a Taxonomy Analysis Authorization form, the following fields will likely be pre-populated in the **BenthicCollectionResults** worksheet: *EventCode*, *ProtocolCode*, *StationCode*, *SampleDate*, *AgencyCode*, *ProjectCode*, *LocationCode*, *CollectionTime*, *CollectionMethodCode*, *SampleTypeCode*, *Replicate*, *CollectionDeviceName*, *SieveSize*, *CollectionDepth*, and *UnitCollectionDepth*. Please note that all fields are required to have data except when otherwise noted below. Examples of special types of samples are listed in the Special Circumstances section.

Template Field Name	LookUp List	Description & Business Rules
StationCode	StationLookUp	StationCode represents a unique sampling site in a sampling design. A single waterbody may have multiple stations. BR: StationCode should represent a geographic location not a geographic location combined with a replicate reference. There cannot be multiple StationCodes in the StationLookUp with the same target latitute/longitude coordinates. The format for the unique alphanumeric description of the station is ###ABC123, where ### is the Hydrologic Unit number and ABC123 is an alphanumeric description of the Station. An example is 111EELBRN which is Hydrologic Unit 111 and an abbreviated code to indicate “Eel River - South Fork near Branscomb”. If the exact Hydrologic Unit is not known, populate the first number with the regional board number; i.e. the station is known to be in California Regional Water Board 3, the StationCode would be 300######. If the station is not in California, the Hydrologic Unit is 000.

Template Field Name	LookUp List	Description & Business Rules
SampleDate		SampleDate refers to the date the sample was collected in the field. BR: The format for date in the templates is dd/mmm/yyyy, such as 10/Nov/2007. For samples with collection times that last longer than one day, like autosamplers, the sample date is the date sampling began. When entering data using the forms, the format is mm/dd/yy. For transplanted bivalves, the SampleDate is the date the transplanted organisms were collected, removed, or retrieved from the field.
ProjectCode	ProjectLookUp	ProjectCode is a unique code referencing a project which includes data of a single study design; e.g. RWB5_StS_FY0708, RWB2_Status_YR1, RWB7_Trend_2003, SWB_RCMP_2008. BR: ProjectCodes with FY in the name indicate samples were collected in a fiscal year calendar cycle, e.g. FY0708 would indicate fiscal year 2007-2008 which is July 1, 2007 through June 30, 2008. ProjectCodes without FY indicate samples were collected in a calendar year, e.g. 2003 would indicate calendar year 2003 which is January 1, 2003 through December 31, 2003. Each Project must have an associated QAPrP or Project QAPP listed. SWAMP moves data to the permanent side of the database by ProjectCode.

Template Field Name	LookUp List	Description & Business Rules
EventCode	EventLookUp	EventCode represents the initial intent of the sampling event at a particular station. BR: The EventCode will be in a hierarchical order as follows: BA – If the initial intent of sampling is for Bioassessment (PHab, BMI [freshwater], and/or Algae) (Tissue and/or WaterQuality samples may or may not also be collected) TI – If the initial intent of sampling is for Tissue (WaterQuality samples may or may not also be collected; no associated Bioassessment samples collected) WQ – If the initial intent of sampling is for WaterQuality (Water, Sediment, Toxicity, and/or Marine Benthic Abundance) (no associated Bioassessment or Tissue samples collected) For example, if the initial intent of sampling on Day 1 was for Tissue and WaterQuality, the EventCode would be TI. If for some reason the WaterQuality had to be re-sampled the next day, on Day 2, the event for the re-sampling would still be TI because Tissue was the initial intent of sampling on Day 1 even though WaterQuality was sampled on Day 2.

Template Field Name	LookUp List	Description & Business Rules
ProtocolCode	ProtocolLookUp	ProtocolCode represents the sampling protocol used, which includes the set of methods, methodology, and/or specifications; e.g. MPSL-DFG_Field_v1.0 or SWAMP_WS_2007. Established protocols may be used or Regions may document their own sampling protocols. BR: It is preferable to combine protocols per StationCode and date so that all WaterQuality, Bioassessment, and Tissue data are combined under the same EventCode and Protocol. For example, if Tissue and WaterQuality are sampled at a station, the EventCode would be TI. If the protocols are different for Tissue and WaterQuality, the Tissue protocol would be used and the WaterQuality protocol would be listed in the SampleComments. If that is not preferable, separate EventCodes may be used with each individual protocol. Not Recorded is only used for historic data. All non-historic SWAMP projects require a true protocol reference. Not Applicable is used for LABQA and 000NONPJ samples only.
AgencyCode	AgencyLookUp	AgencyCode refers to the organization or agency that collected the sample. This should be listed on the Chain of Custody (COC) document that accompanies the samples from the field. BR: If an environmental sample is used to perform laboratory QC, i.e. a matrix spike or lab duplicate, the AgencyCode still refers to the agency that collected the native sample, not the agency that created the QC sample. See 'Special Circumstances' for LABQA business rules.
SampleComments (Not Required)		SampleComments records any comments related to the sampling event at a particular station. BR: When a PurposeFailureCode of Other is used, a SampleComment is required.

Template Field Name	LookUp List	Description & Business Rules
LocationCode	LocationLookUp	LocationCode describes the physical location in the waterbody where the sample was collected. One sampling event may have a single or multiple locations. BR: For a single point of sampling, the physical location in the waterbody can be used such as Bank, Thalweg, Midchannel, OpenWater, Transect 1, or X (general location for bioassessments). For field results, the LocationCode should be the same as the location for the WaterQuality collection method. For TI EventType sampling, the physical location plus the CollectionMethod is used such as BankNet1, BankShock1, OpenWaterTrawl1, OpenWaterNet1. For resident mussel or clam collections, the LocationCode would be the physical location in the water body plus the generic CollectionMethod, e.g. BankTissue_Grab1. OpenWater sampling with multiple sub-locations within a single water body or station could have locations of OpenWaterTrawl1, OpenWaterTrawl2 describing one large location with two smaller areas of sampling within the OpenWater Location. Multiple physical locations within a single station could consist of a LocationCode such as BankShock1, BankNet1, OpenWaterHook1. If recording specific locations within a station are necessary for the project, a LocationCode such as Location1Net1, Location1Net2, Location2Shock1 may be used.
GeometryShape (Not Required)	VariableCodesLookUp	GeometryShape is the physical shape of the location; e.g. Line, Point, Line Centroid, Polygon, Polygon Centroid.

Template Field Name	LookUp List	Description & Business Rules
CollectionTime		CollectionTime refers to the time when the first field measure of a sampling event at a specific station was recorded in the field. BR: If the sampling crew collects 18 field measurements at a single station, the CollectionTime for each would be the time of the first measurement recorded. By doing so, the samples can easily be linked and any holding time issues will be consistent, and conservative, for laboratory work. The CollectionTime format should be expressed as xx:xx in 24 hour time, such as 13:30 for 1:30 pm.
CollectionMethodCode	CollectionMethodLookUp	CollectionMethodCode refers to the general method of collection. BR: For BA EventCodes, use the appropriate CollectionMethodCode for BMIs (e.g., BMI_RWB, BMI_CSBP) and for Algae (e.g., Algae_SWAMP, Algae_EMAP) that follows the associated protocol. The SWAMP marine invertebrates default is Sed_Grab.
SampleTypeCode	SampleTypeLookUp	SampleTypeCode refers to the type of sample collected or analyzed. BR: Some commonly used SampleTypeCode choices include Grab, Integrated, Macroalgae, Microalgae, Epiphyte, Qualitative, etc. When laboratories report soft algae taxonomy data with multiple sample types (Epiphyte, Macroalgae, Microalgae, Integrated, Qualitative), a comment should be added to the BenthicCollectionComment identifying if no taxonomic results were found for any or all of the SampleTypeCodes. It is the data submitter's responsibility to update the BenthicCollectionComment for this particular SampleTypeCode where no results were found and to notify the data loader of the change. The submitting laboratory should not delete the SampleType row from the MS Excel file.

Template Field Name	LookUp List	Description & Business Rules
Replicate		Replicate is the collection replicate number used to distinguish between replicates created at collection. BR: If a replicate was performed in the lab, indicate replicate 2 and make a comment in the BenthicCollectionComments that it was a lab replicate.
CollectionDeviceName	CollectionDeviceLookUp	CollectionDeviceName refers to the specific device used in the collection of the sample such as MPSL-MLML Mod.VanVeen Grab-Dbl_0.05m2, 0.05m2 or Core_0.0071m2 for marine invertebrate collections, D-Frame Kick Net for BMI invertebrate collections, and RubDelim & PVCDelim or Individual Collection by Hand for algae and diatom collections.
SieveSize	VariableCodesLookUp	SieveSize is the size of the sieve the sample was passed through; e.g. 0.5mm, none
CollectionDepth		CollectionDepth records the level, from the surface in the water or sediment column, at which the field measurements were recorded. BR: This information should be listed on the field data sheet from the field crew. CollectionDepth for water samples would be measured from the water surface and recorded in meters (m). Since depths for ambient monitoring field measurements are generally "subsurface", defaults have been established to indicate this. For water samples, the default value is 0.1 m. For freshwater bioassessments, algae, and diatom samples where samples are composited, the default is -88 m. If samples were composited from multiple locations at different depths, CollectionDepth is -88.
UnitCollectionDepth	VariableCodesLookUp	UnitCollectionDepth refers to the units used in the CollectionDepth including cm (centimeters) and m (meters). This information should be listed on the Chain of Custody (COC) document that accompanies samples from the field.

Template Field Name	LookUp List	Description & Business Rules
SampleID (Not Required)		SampleID is a unique identifier supplied by the organization directing the sampling or sampling agency and is used to track the sample throughout the sampling and analysis processes. This field can be used to tie a result to the sample. BR: This SampleID, which is different from the StationCode, will likely be on the sample container the laboratory receives from the field crew or on the COC. If there is no number, leave this field blank.
BenthicCollectionComments (Not Required)		BenthicCollectionComments records any comments relating to the collection of the field sample for laboratory analysis. BR: If no results were found, enter a comment stating that no organisms were identified. If a sample collection is missing an expected bottle, or the bottle broke or was lost enroute to or at the laboratory, enter a comment here describing why results are not reported. The submitting laboratory should not delete the sample row from the MS Excel file in either situation.
GrabSize (Not Required)		GrabSize is the total area of substrate collected for the sample, regardless of CollectionDevice area size. This is determined by the sampling device area and, if applicable, the number of transects or grabs sampled.
UnitGrabSize (Not Required)	VariableCodesLookUp	UnitGrabSize refers to the units used for GrabSize; from UnitGrabSizeList in VariableCodesLookUp; e.g. m2 or cm2.
ReplicateName (Not Required)		ReplicateName is the name of the Replicate Number if applicable; e.g. Transect 1 or T-1. This field was used previously in the CalEDAS database to identify if replicate samples were collected.
ReplicateCollectionDate (Not Required)		ReplicateCollectionDate is the date of the ReplicateCollection; format as dd/mmm/yyyy
NumberJars (Not Required)		NumberJars is the number of jars into which the sample fit for transport to the analytical lab
BenthicCollectionDetailComments (Not Required)		BenthicCollectionDetailComments are comments related to the BenthicCollectionDetail

Template Field Name	LookUp List	Description & Business Rules
AgencyCode_LabEffort	AgencyLookUp	AgencyCode_LabEffort is the agency that sorted or processed the taxonomic sample
PersonnelCode_LabEffort	PersonnelLookUp	PersonnelCode_LabEffort refers to the Lab personnel (sorter or taxonomist) who processed the sample, performed the initial sorting of the sample, and was responsible for this entry.
PercentSampleCounted (Not Required)		PercentSampleCounted refers to the percent of the sample that was counted.
TotalGrids (Not Required)		TotalGrids is the total number of grids onto which the sample was spread for subsampling.
GridsAnalyzed (Not Required)		GridsAnalyzed is the number of grids (in integers) of material pulled from to achieve the TargetOrganismCount.
GridsVolumeAnalyzed (Not Required)		Volume of grids included in the analysis required to achieve the TargetOrganismCount; i.e. if 0.25 from each of 3 grids were analyzed, GridsVolumeAnalyzed would be 0.75. Units are in grids.
TargetOrganismCount (Not Required)		TargetOrganismCount is the number of organisms at which subsampling will cease.
ActualOrganismCount (Not Required)		ActualOrganismCount is the total number of organisms recovered by lab sorter in all grids analyzed, including the count above and beyond the target total for the subsample.
ExtraOrganismCount (Not Required)		ExtraOrganismCount is the number of organisms subsampled beyond the target count.
QCOrganismCount (Not Required)		QCOrganismCount refers to the number of organisms in the subsample counted during the quality control (QC) check. It refers to cases where a sample is re-sorted and more organisms are found. If the original sort found 500 organisms and then it was re-sorted by a different person who found 3 organisms, the QCOrganismCount would be 3 rather than 503.
DiscardedOrganismCount (Not Required)		DiscardedOrganismCount is the number of organisms in the subsample determined to be unsuitable for identification.

Template Field Name	LookUp List	Description & Business Rules
EffortQACode	EffortQALookUp	EffortQACode is a unique code applied to the result which describes any special conditions, situations or outliers occurring during or prior to lab sorting.
BenthicLabEffortComments (Not Required)		BenthicLabEffortComments are the comments related to lab sorting or sample processing.
FinalID	OrganismLookup	FinalID refers to the lowest taxon level identified for the organism.
LifeStageCode	LifeStageLookUp	LifeStageCode is a unique code referencing the stage of life of the organism; e.g. adult, juvenile, larvae.
Distinct		Distinct is an indicator of whether this is a distinct (>=1) or non-distinct (0) taxon.
BAResult		BAResult is the number of individuals of a given FinalID and stage that were identified within a sample replicate. This is for unadjusted (raw) counts and is to be used for cases where a TargetOrganismCount is used. Either BAResult or Result should be populated (unless QACodes and ResQualCodes other than the defaults are used), but NOT both fields.
Result		Result is the final numeric result of a given FinalID and stage scaled up to grab size. Result is for counts adjusted to the area sampled and for biovolumes and it may represent raw counts if the full sample is sorted. BR: Either BAResult or Result should be populated (unless QACodes and ResQualCodes other than the defaults are used), but NOT both fields.
UnitName	UnitLookUp	UnitName refers to how the taxonomic result is measured or expressed. BR: Taxonomic units are indicated by count or volume/area, e.g. um3/cm2

Template Field Name	LookUp List	Description & Business Rules
ResQualCode	ResQualLookUp	ResQualCode or Result Qualifier Code qualifies the analytical result of the sample. BR: This field should have an equal sign (=) for results that are recorded. When a result is Greater Than (>) or Less Than (<), a ResQualCode is required and the appropriate code would be applied. When both the BAResult and Result are blank, a ResQualCode is required. If the ResQualCode value is NR for Not Recorded, then a reason for this code must be written in the BenthicResultComments field and/or an appropriate QACode would be applied.
QACode	QALookUp	QACode is applied to the result to describe any special conditions, situations or outliers that occurred during or prior to the identification to achieve the result. BR: The default code, indicating no special conditions, is None. If more than one code should be applied to a record, the convention is to list them in alphabetical order separated by commas and no spaces; e.g. GB,SC.
ComplianceCode	ComplianceLookUp	ComplianceCode is a unique code referencing the Compliance with the associated QAPP.
BatchVerificationCode	BatchVerificationLookUp	BatchVerificationCode is a unique code referencing the Verification of a Batch.
TaxonomicQualifier (Not Required)	VariableCodesLookUp	TaxonomicQualifier is a code representing the taxonomist's justification for not identifying a specimen to standard effort; from TaxonomicQualifierList in VariableCodesLookUp.
ExcludedTaxa (Not Required)	VariableCodesLookUp	ExcludedTaxa is a code representing the taxonomist's justification for excluding a specimen from analysis; from ExcludedQualifierList in VariableCodesLookUp.
PersonnelCode_Result	PersonnelLookUp	PersonnelCode_Result is a unique code referencing the personnel or person who performed the taxonomy and produced the FinalID. In some cases, the PersonnelCode_LabEffort and PersonnelCode_Result are the same person. In other cases, the lab pays a student to do the initial sorting of pulling organisms out of the sample (PersonnelCode_Lab Effort) and then has a taxonomist do the actual identification (PersonnelCode_Results).

Template Field Name	LookUp List	Description & Business Rules
LabSampleID (Not Required)		LabSampleID is a recommended field intended to provide lab specific identification for an analyzed sample. The format and content is determined by the lab.
EnterDate (Not Required)		EnterDate is the date the data were entered into the template; formatted as dd/mmm/yyyy.
BenthicResultComments (Not Required)		BenthicResultComments are comments related to the BenthicResult or individual taxa count.

c. Special Circumstances

There are two types of special circumstances discussed in this section. SWAMP is currently developing QA/QC guidance for freshwater bioassessment taxonomy.

(a) Qualitative Organism Identifications

Qualitative organism identifications refer to samples where the field personnel note the presence of algae in the stream without noting the abundance of the taxon. The special circumstances for recording these types of results are as follows:

SampleTypeCode	Qualitative
Result	Leave null
ResQualCode	P (present)
Unit	count

(b) Colonial Organism Counts

Colonial organism counts refer to samples where the objective is to obtain a count for a taxon but a colonial organism is found. Laboratories should not provide a count in these cases due to the difficulty in obtaining a count for certain organism types (e.g. a sponge or hydroid). If a biovolume or biomass is the objective, then record the result and appropriate unit. The special circumstances for recording colonial organism counts are as follows:

SampleTypeCode	Epiphyte, Macroalgae, etc. (not Qualitative)
Result	Leave null
ResQualCode	COL (Colonial)
Unit	count

d. Procedure for Adding New Organisms to the Database

There are instances when new organisms will need to be added to the SWAMP database. Following is the procedure to add those organisms.

i. Adding a New Organism

The first step is to check the OrganismLookUp list online http://ftp.mpsl.mlml.calstate.edu/LookUpLists.php to determine if the organism already exists in the list. If the organism does not exist in SWAMP, the name and associated information must be submitted to the SWAMP DMT for consideration to be added to the database. Additional information may be found through SCAMIT for marine taxonomic references and SAFIT for freshwater taxonomic references.

ii. Organism_DetailLookUp Worksheet

Once it is determined that an organism is not in the current lookup list, complete the Organism_DetailLookUp worksheet in the SWAMP Taxonomy Results Template. Please note that all fields are required to have data except when otherwise noted below, but it is preferred to populate all fields if the information is known. In cases where an organism has multiple LifeStageCodes, a record consisting of each FinalID and LifeStageCode combination would be expected.

Template Field Name	LookUp List	Description & Business Rules
CommonName (Not Required)		CommonName refers to the common name of the organism collected.
FinalID		FinalID is the lowest taxon level identified for the organism. BR: Do not use sp. or spp. after the genus name as part of the FinalID if the organism can only be identified down to the genus and not the species. It is allowable if the organism is known as Genus sp A, where Species A is a known and documented species.
ParentFinalID (Not Required)		ParentFinalID is the FinalID of the parent Taxon ID.
Phylum		Phylum is the phylum of the organism; a taxonomic rank used in the classification of organisms.
Subphylum (Not Required)		Subphylum is the subphylum of the organism; a taxonomic rank used in the classification of organisms.
Superclass (Not Required)		Superclass is the superclass of the organism; a taxonomic rank used in the classification of organisms.
Class		Class is the class of the organism; a taxonomic rank used in the classification of organisms.
Subclass (Not Required)		Subclass is the subclass of the organism; a taxonomic rank used in the classification of organisms.
Superorder (Not Required)		Superorder is the superorder of the organism; a taxonomic rank used in the classification of organisms.
Order		Order is the order of the organism; a taxonomic rank used in the classification of organisms.

Template Field Name	LookUp List	Description & Business Rules
Suborder (Not Required)		Suborder is the suborder of the organism; a taxonomic rank used in the classification of organisms.
Superfamily (Not Required)		Superfamily is the superfamily of the organism; a taxonomic rank used in the classification of organisms.
Family		Family is the family of the organism; a taxonomic rank used in the classification of organisms.
Subfamily (Not Required)		Subfamily is the subfamily of the organism; a taxonomic rank used in the classification of organisms.
Tribe (Not Required)		Tribe is the tribe of the organism; a taxonomic rank used in the classification of organisms.
GenusComplex (Not Required)		GenusComplex is the genus complex of the organism; a taxonomic rank used in the classification of organisms.
Genus		Genus is the genus of the organism; a taxonomic rank used in the classification of organisms.
SpeciesComplex (Not Required)		SpeciesComplex is the species complex of the organism; a taxonomic rank used in the classification of organisms.
Species		Species is the species of the organism; a taxonomic rank used in the classification of organisms.
Subspecies		Subspecies is the subspecies of the organism; a taxonomic rank used in the classification of organisms.
Variety (Not Required)		Variety is the variety of the organism; a taxonomic rank used in the classification of organisms.
TaxonomicLevelCode	TaxonomicLevelLookup	TaxonomicLevelCode is a unique code referencing the level of the FinalID.
LifeStageDefault	LifeStageLookUp	LifeStageDefault is the default LifeStageCode of each organism or FinalID one expects to find and to be used in analyses. BR: Default value is NR.

Template Field Name	LookUp List	Description & Business Rules
TaxonomicAuthority (Not Required)		TaxonomicAuthority is the Taxonomist or reference (including year) used to identify the organism; e.g. Barnum 1905. BR: If the FinalID is defined to genus and species, a TaxonomicAuthority is required. If it is defined to the family level or higher, this field may be left blank if not applicable.
CaliforniaTaxon (Not Required)		CaliforniaTaxon is a yes/no field used to record if the organism is a CaliforniaTaxon, i.e. that it exists in California regardless if it exists in other states or not. BR: Limit values to TRUE or FALSE where TRUE identifies the FinalID as a California taxon.
DateFinalIDRevised (Not Required)		DateFinalIDRevised is the date the FinalID was revised. BR: Format is dd/mmm/yyyy.
FinalIDAuthority	AgencyLookUp	FinalIDAuthority represents the Agency that has the authority to change values for the FinalID; e.g. SAFIT, SCAMIT.
Source (Not Required)	AgencyLookUp	Source is the agency that introduced or added the organism to the database; e.g. MPSL-MLML, DFG-ABL, SFEI.
OrganismComments (Not Required)		OrganismComments are comments related to the organism.
LifeStageCode	LifeStageLookUp	LifeStageCode is a unique code referencing the stage of life of the organism; e.g. adult, larvae. Each FinalID can have multiple yet different LifeStageCodes to create unique records; i.e. one FinalID can have both an adult and larvae LifeStageCode but not two adult LifeStageCodes.

iii. Submit Data to SWAMP

Submit taxonomic results and new LookUp values to SWAMP by following the Submitting Data To SWAMP Data Management Team procedures and using the Online Data Checker.

iv. Authority Check

Proposed new organisms will be forwarded to SCCWRP who will then forward it to the appropriate authority (e.g. SAFIT or SCAMIT) for review and consideration to be added to the SWAMP database. Follow-up questions or comments may be needed before final resolution is completed.

v. Clarification of New Organisms

If the authority has questions about the new organism, SCCWRP will be contacted. SCCWRP will then contact the SWAMP DMT who will contact the submitting laboratory to obtain the answers. This information will be relayed back to the appropriate authority for final approval of the new organism.

vi. Addition of New Organisms

Once the authority approves the new organism for addition to the SWAMP database, SCCWRP will be notified. SCCWRP will then notify the SWAMP DMT. The SWAMP DMT will then add the new organism to the SWAMP database.

APPENDIX J:

HEALTH AND SAFETY PROCEDURES

It is the Policy of the District that the safety of its employees and the people it serves is of the highest priority. All District employees shall comply with all the of the safety directives outlined in the District's Safety and Operation Manual (SOM). Managers are responsible for ensuring that employees in their Divisions comply with all of the safety directives outlined in the Safety and Operations Manual (SOM1 thru SOM 30). Supervisors are directly responsible for the safety of their employees and must ensure that their staff is trained and in compliance with the procedures outlined in the SOM. Employees are to inform the District's Safety Consultant, their Supervisor or management of any perceived safety hazards. Suggestions for improving the Safety Program are encouraged and will be given full consideration.

SOM 30 specifically references the Watershed Protection Division Field Safety Manual. The Manual is a living document reviewed and updated as necessary. The purpose of this Manual is to assist District staff in identifying potential hazards associated with their unique field activities and to assist them in following the District's safety policies. It is also intended as a training tool for all new employees and a document to be reviewed by each employee before undertaking field assignments involving WPD tasks. It includes references to the District's SOMs that are standard and applicable to all field operations, such as communication, vehicle operation, and adequate preparation for anticipated weather conditions.
The guide is not intended to be a technical handbook outlining step-by-step procedures for performing specific tasks, or a comprehensive discussion of every possible activity that may be undertaken by an employee. Ultimately, each employee is personally responsible for knowing and learning the proper procedures to avoid injuries.

Safety of the sampling team is paramount. The field vehicle should start out with a full tank of gas and be in good repair. Extra care must be taken when driving at night or in the rain. If the sampling location is unsafe, make note of the unsafe situation and either do not collect a sample or come back after the hazardous situation has ceased.

Medical Referral for Treatment of Work-related Injuries or Illnesses

The treatment of work-related injuries or illnesses is handled through the County of Riverside Human Resources Department, Workers' Compensation Division.

The following website will locate the closest medical provider. The Medical Provider Network (MPN) includes the Kaiser Occupational Clinics in Riverside and Fontana. Upon clicking the link below, the MPN search page will load. Simply type in the name of the provider or choose a specialty option and click "Find Providers". An option to adjust the range of the search is also provided by utilizing the "within miles" tool.

http://www.compcaremed.com/riverside/

Questions regarding the MPN program may be answered by contacting the following:

CorVel Corporation, MPN Department	800-966-5307
Riverside County Workers' Compensation Division (HR Dept)	951-955-3530

APPENDIX K:

NPDES CONTACTS

NPDES Watershed Program Contacts

Riverside County Flood Control and Water Conservation District
1995 Market Street
Riverside, CA 92501

Watershed Protection Division
Chief
Edwin Quinonez
Ph: 951.955.1265
eequinon@ricvco.org

NPDES Program Manager
Richard Boon
1995 Market Street
Ph: 951.955.1330
rboon@rivco.org

Santa Margarita Region
Matt Yeager
Ph: 951.955.0843
myeager@rivco.org

Whitewater River Region
Aldo Licitra
Ph: 951.955.0842
alicitra@rivco.org

Santa Ana Region
Andrea Gonzalez
Ph: 951.955.1372
agonzale@rivco.org

Monitoring Program Manager

Rebekah Guill
Ph: 951.955.2901
Fax: 951.788.9965
rguil@rivco.org

Other County Contacts

Riverside County Executive Office

Scott Bruckner
4080 Lemon Street, 4th Floor
Riverside, CA 92501
Ph: 951.955.1110
Fax: 951.955.1105
sebruckner@rivco.org

Riverside County Department of Environmental Health

Keith Jones
3880 Lemon Street, 2nd Floor
Riverside, CA 92501
Ph: 951.358.5055
kjones@rivco.org

Riverside County Facilities Management

John Alfred or Cliff Smith
3403 10th Street, Suite 500
Riverside, CA 92501
Ph: 951.955.4884
Jalfred@rivcoeda.org or CliffSmith@rivcoeda.org

Riverside County Transportation Land and Management Agency (TMLA)

Jan Bulinski
4080 Lemon Street, 8th Floor
Riverside, CA 92501
Ph: 951.955.6859
Fax: 951.955.6721
jbulinki@rivco.org

Code Enforcement Contacts

Interim Code Enforcement Official

Hector Viray
Ph: 951.955.2004

Division Manager

District 1 – Mead Valley Area
Britt Starkweather
Ph: 951.776.3233
Cell: 951.906.9407
bstarkwe@rctlma.org

Division Manager

District 2-Riverside Area
Tracey Towner
Ph: 951.955.0295
Cell: 951.830.8576
ttowner@rctlma.org

Supervisor

District 3-French Valley Area
Mary Ortez
Ph: 951.600.6252

Supervisor

District 4-Palm Desert Area
Manny Acueto
Ph: 760.393.3344
Cell: 951.538.7975

Supervisor

District 5-San Jacinto Area
Brian Black
Ph: 951.791.3900
Cell: 951.791.3908
bblack@rctlma.org

NPDES Coordinators, Santa Ana Region

City of Beaumont
Amer Jaker
550 E. 6th Street
Beaumont, CA 92223
Ph: 951.572.3195
ajakher@ci.beaumont.ca.us

City of Calimesa
Lori Askew
908 Park Avenue
Calimesa, CA 92320
Ph: 909.795.9801
laskew@cityofcalimesa.net

City of Canyon Lake
Aaron Palmer
31516 Railroad Canyon Road
Canyon Lake, CA 92587
Ph: 951.246.2025
apalmer@cityofcanyonlake.com

City of Corona
Jeff Potts
400 S. Vicentia Ave.
Corona, CA 92882
Ph: 951.736.2442
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City of Eastvale
Joe Indrawan
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Eastvale. CA 91752
Ph: 951.361.0900
Jindrawan@eastvaleca.gov

City of Hemet
Daniel Cortese
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Ph: 951.765.3712
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City of San Jacinto
Rob Johnson
595 S. San Jacinto Avenue
San Jacinto, CA 92583
Ph: 951.654.4041
Fax: 951.487.6779
rjohnson@sanjacintoca.us

City of Jurupa Valley
Bob Makowski
8304 Limonite Ave., Suite M
City of Jurupa Valley
Ph: 951.332.6464 ext.248
bmakowski@jurupavalley.org

City of Lake Elsinore
Rita Thompson
130 S. Main Street
Lake Elsinore, CA 92530
Ph: 951.674.3124 x308
rthompson@lake-elsinore.org

City of Menifee
Jonathan Smith
29714 Haun Road
Menifee, CA 92586
Ph: 951.672.6777
jsmith@cityofmenifee.us

City of Moreno Valley
Michael Wolfe
14177 Frederick Street
Moreno Valley, CA 92552-0805
Ph: 951.413.3105
michaelw@moval.org

City of Norco
Dan Cuthbertson
2870 Clark Avenue
Norco, CA 92860
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dcuthbertson@ci.norco.ca.us

City of Perris
Maria Arreguin
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marreguin@cityofperris.org

City of Riverside
Michael Roberts
3900 Main Street
Riverside, CA 92522
Ph: 951.351.6310
Fax: 951.351.6267
mdroberts@riversideca.gov

NPDES Contacts, Santa Margarita Region

City of Murrieta
Mai Son
1 Town Square (mailing address)
24601 Jefferson Ave
Murrieta, CA 92562
Ph: 951.461.6085
Fax: 951.698.3416
maison@murrietaCA.gov

City of Temecula
Stuart Kuhn
41000 Main Street
Temecula, CA 92590
Ph: 951.308.6387
Fax: 951.694.6475
stuart.kuhn@temecula.org

City of Wildomar
Jason Farag
23873 Clinton Keith Rd, Suite 201
Wildomar, CA 92595
Ph: 951.677.7751 x219
Fax: 951.698.1463
jfarag@cityofwildomar.org

City of Menifee
Haile Ford
Ph: 951.723.3773
Fax: 951.679.3843
hford@cityofmenifee.us

City of Temecula
Mr. Aldo Licitra
P.O. Box 9033
Temecula, CA 92589-9033
951.308.6387 Fax 951.694.6475
Aldo.licitra@cityoftemecula.org

NPDES Contacts, Whitewater River Region

City of Banning
Ann Marie Loconte
99 E. Ramsey Street
Banning, CA 92220
Ph: 951.922.3130
Fax: 951.922.3141
amloconte@ci.banning.ca.us

City of Cathedral City
Vincent Lopez
68700 Avenida Lalo Guerrero
Cathedral City, CA 92234
Ph: 760.770.0349
Fax: 760.202.2518
bsimons@cathedralcity.gov

City of Desert Hot Springs
Daniel Porras
65950 Pierson Blvd.
Desert Hot Springs, CA 92240
Ph: 760.329.6411, ext. 216,
Fax: 760.288.0639
dporras@cityofdhs.org

City of Indio
Ms. Sara Toyoda
83-101 Avenue 45
Indio, CA 92201
Ph: 760.625.1815
stoyoda@indio.org

City of Palm Springs
Mr. Rick Minjares
3200 E. Tahquitz Canyon Way
Palm Springs, CA 92263-2743
Ph: 760.323.8253 ext. 8741
Fax: 760 323 8325
Rick.Minjares@palmspringsca.gov

City of Rancho Mirage
Mr. Leland Cole
69-825 Highway 111
Rancho Mirage, CA. 92270
760.770.3224 ext. 272, Fax 760.770.3261
lelandc@RanchoMirageCA.gov

Coachella Valley Water District (CVWD)
Vanessa Duong
P.O. Box 1058
Coachella, CA 92236
Ph: 760.398.2661
Fax 760.391.9637
vduong@cvwd.org

City of Coachella
Ms. Berlinda Blackburn
1515 6th Street
Coachella, CA 92236
Ph: 760.501.8114, Fax 760.398.1630
bblackburn@coachella.org

City of Indian Wells
Mr. Bondie Baker
44-950 Eldorado Drive
Indian Wells, CA 92210
760.776.0237, Fax 760.346.0407
Bbaker@cityofindianwells.org

City of La Quinta
Amy Yu
78495 Calle Tampico
La Quinta, CA. 92247
Ph: 760 777 7047
Fax: 760 777 7155
ayu@la-quinta.org

City of Palm Desert
Ms. Christina Canales
73-510 Fred Waring Drive
Palm Desert, CA 92260
Ph: 760.746.6450
Fax: 760.341.7098
ccanales@cityofpalmdesert.org

Fire Department Contacts

The County of Riverside contracts with the following cities for emergency response services. For hazardous materials incidents within these cities, or within unincorporated Riverside County, contact County Environmental Health at 951.358.5055

Banning	Beaumont	Calimesa	Canyon Lake
Cathedral City	Coachella	Desert Hot Springs	Indian Wells
Indio	La Quinta	Lake Elsinore	Moreno Valley
Murrieta	Norco	Palm Desert	Palm Springs
Perris	Rancho Mirage	Rubidoux	San Jacinto
Temecula			

The following cities have their own hazardous material management program:

City of Riverside
Fire Station No. 2
9449 Andrew St.
Riverside, CA 92503
Ph: 951.351.6102

City of Corona
Call 9-1-1

City of Hemet
Hemet Fire Department
510 E. Florida Ave.
Hemet, CA 92543
Ph: 951.765.2450 during business hours
Ph: 951.765.2400 outside of business hours

APPENDIX L:

CHARACTERISTICS OF CONTAMINANTS COMMONLY ASSOCIATED WITH VARIOUS FACILITIES AND ACTIVITIES

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Table 4.[1] Typical Chemical and Physical properties of Industrial Non-Stormwater Discharges.

Industrial Categories Major Classifications SIC Group Numbers	Odor	Color	Turbidity	Floatables	Debris and Stains	Structural Damage	Vegetation	pH	TDS
Primary Industries									
20 Food and Kindred Products									
201 Meat Products	Spoiled Meats, Rotten Eggs and Flesh	Brown to Reddish-Brown	High	Animal Fats, Byproducts, Pieces of Processed Meats	Brown to Black	High	Flourish	Normal	High
202 Dairy Products	Spoiled Milk, Rancid Butter	Grey to White	High	Animal Fats, Spoiled Milk Products	Grey to Light Brown	High	Flourish	Acidic	High
203 Canned and Preserved Fruits and Vegetables	Decaying Products Compost Pile	Various	High	Seeds, Skins, Cores, Leaves	Brown	Low	Normal	Wide Range	High
204 Grain Mill Products	Slightly Sweet & Musty, Grainy	Brown to Reddish Brown	High	Grain Hulls and Skins, Straw & Plant Fragments	Light Brown	Low	Normal	Normal	High
205 Bakery Products	Sweet and/or Spoiled	Brown to Black	High	Cooking Oils, Lard, Flour, Sugar	Grey to Light Brown	Low	Normal	Normal	High
206 Sugar and Confectionary Products	NA	NA	Low	Low Potential	White Crystals	Low	Normal	Normal	High
207 Fats and Oils	Spoiled Meats, Lard or Grease	Brown to Black	High	Animal Fats, Lard	Grey to Light Brown	Low	Normal	Normal	High
208 Beverages	Flat Soda, Beer or Wine, Alcohol, Yeast	Various	Moderate	Grains & Hops, Broken Glass, Discarded Canning Items	Light Brown	High	Inhibited	Wide Range	High
21 Tobacco Manufactures	Dried Tobacco, Cigars, Cigarettes	Brown to Black	Low	Leaves, Papers and Fillers	Brown	Low	Normal	Normal	Low
22 Textile Mill Products	Wet Burlap, Bleach, Soap, Detergents	Various	High	Fibers, Oils, Grease	Grey to Black	Low	Inhibited	Basic	High
23 Apparel and Other Finished Products	NA	Various	Low	Some Fabric Particles	NA	Low	Normal	Normal	Low

[1] Dr. Robert Pitt of the University of Alabama developed a table of chemical and physical properties of Industrial Non-Stormwater Discharges. This provides an aid to identifying potential sources of illicit discharges when no other evidence is available.

Table 4.[1] Typical Chemical and Physical properties of Industrial Non-Stormwater Discharges.

Industrial Categories Major Classifications SIC Group Numbers	Odor	Color	Turbidity	Floatables	Debris and Stains	Structural Damage	Vegetation	pH	TDS
Material Manufacture									
24 Lumber & Wood Products	NA	NA	Low	Some Sawdust	Light Brown	Low	Normal	Normal	Low
25 Furniture & Fixtures	Various	Various	Low	Some Sawdust,Solvents	Light Brown	Low	Normal	Normal	Low
26 Paper & Allied Products	Bleach, Various Chemicals	Various	Moderate	Sawdust, Pulp Paper, Waxes, Oils	Light Brown	Low	Normal	Wide Range	Low
27 Printing, Publishing, and Allied Industries	Ink, Solvents	Brown to Black	Moderate	Paper Dust, Solvents	Grey to Light Brown	Low	Inhibited	Normal	High
31 Leather & Leather Products	Leather, Bleach, Rotten Eggs or Flesh	Various	High	Animal Flesh & Hair, Oils, Grease	Grey to Black, Salt Crystals	High	Highly Inhibited	Wide Range	High
33 Primary Metal Industries	Various	Brown to Black	Moderate	Ore, Coke, Oils, Limestone, Millscale	Grey to Black	High	Inhibited	Acidic	High
34 Fabricated Metal Products	Detergents, Rotten Eggs	Brown to Black	High	Dirt, Grease, Oils, Sand, Clay Dust	Grey to Black	Low	Inhibited	Wide Range	High
32 Stone, Clay, Glass, and Concrete Products	Wet Clay, Mud, Detergents	Brown to Reddish-Brown	Moderate	Glass Particles Dust from Clay or Stone	Grey to Light Brown	Low	Normal	Basic	Low
Chemical Manufacture									
28 Chemicals & Allied Products									
2812 Alkalies and Chlorine	Strong Halogen or Chlorine, Pungent, Burning	Alkalies - NA Chlorine - Yellow to Green	Low	NA	Alkalies – White Carbonate Scale Chlorine - NA	High	Highly Inhibited	Basic	High
2816 Inorganic Pigments	NA	Various	High	Low Potential	Various	Low	Highly Inhibited	Wide Range	High
282 Plastic Materials and Synthetics	Pungent, Fishy	Various	High	Plastic Fragments, Pieces of Synthetic Products	Various	Low	Inhibited	Wide Range	High

Table 4.[1] Typical Chemical and Physical properties of Industrial Non-Stormwater Discharges.

Industrial Categories Major Classifications SIC Group Numbers	Odor	Color	Turbidity	Floatables	Debris and Stains	Structural Damage	Vegetation	pH	TDS
283 Drugs	NA	Various	High	Gelatin Byproducts for Capsulating Drugs	Various	Low	Highly Inhibited	Normal	High
284 Soap, Detergents & Cleaning Preparations	Sweet or Flowery	Various	High	Oils, Grease	Grey to Black	Low	Inhibited	Basic	High
285 Paints, Varnishes, Lacquers, Enamels and Allied Products (SB - Solvent Base)	Latex - Ammonia SB – Dependent Upon Solvent (Paint Thinner, Mineral Spirits)	Various	High	Latex - NA SB - All Solvents	Grey to Black	Low	Inhibited	Latex-Basic SB-Normal	High
286 Indust. Organic Chemicals									
2861 Gum and Wood Chemicals	Pine Spirits	Brown to Black	High	Rosins and Pine Tars	Grey to Black	Low	Inhibited	Acidic	High
2865 Cyclic Crudes, & Cyclic Intermediates Dyes, & Organic Pigments	Sweet Organic Smell	NA	Low	Translucent Sheen	NA	Low	Highly Inhibited	Normal	Low
287 Agricultural Chemicals									
2873 Nitrogenous Fertilizers	NA	NA	Low	NA	White Crystalline Powder	High	Inhibited	Acidic	High
2874 Phosphatic Fertilizers	Pungent Sweet	Milky White	High	NA	White Amorphous Powder	High	Inhibited	Acidic	High
2875 Fertilizers, Mixing Only	Various	Brown to Black	High	Pelletized Fertilizers	Brown Amorphous Powder	Low	Normal	Normal	High
29 Petroleum Refining and Related Industries									
291 Petroleum Refining	Rotten Eggs, Kerosene, Gasoline	Brown to Black	High	Any Crude or Processed Fuel	Black Salt Crystals	Low	Inhibited	Wide Range	High

Table 4.[1] Typical Chemical and Physical properties of Industrial Non-Stormwater Discharges.

Industrial Categories Major Classifications SIC Group Numbers	Odor	Color	Turbidity	Floatables	Debris and Stains	Structural Damage	Vegetation	pH	TDS
30 Rubber & Miscellaneous Plastic Products	Rotten Eggs, Chlorine, Peroxide	Brown to Black	Moderate	Shredded Rubber Pieces of Fabric or Metal	Grey to Black	Low	Inhibited	Wide Range	High
Transportation & Construction									
15 Building Construction	Various	Brown to Black	High	Oils, Grease, Fuels	Grey to Black	Low	Normal	Normal	High
16 Heavy Construction	Various	Brown to Black	High	Oils, Grease, Fuels, Diluted Asphalt or Cement	Grey to Black	Low	Normal	Normal	High
Retail									
52 Building Materials, Hardware, Garden Supply, and Mobil Home Dealers	NA	Brown to Black	Low	Some Seeds, Plant Parts, Dirt, Sawdust, or Oil	Light Brown	Low	Normal	Normal	Low
53 Gen. Merchandise Stores	NA	NA	NA	NA	NA	Low	Normal	Normal	Low
54 Food Stores	Spoiled Produce, Rancid, Sour	Various	Low	Fragments of Food, Decaying Produce	Light Brown	Low	Flourish	Normal	Low
55 Automotive Dealers & Gasoline Service Stations	Oil or Gasoline	Brown to Black	Moderate	Oil or Gasoline	Brown	Low	Inhibited	Normal	Low
56 Apparel & Accessory Stores	NA	NA	Low	NA	NA	Low	Normal	Normal	Low
57 Home Furniture, Furnishings, & Equip. Stores	NA	NA	Low	NA	NA	Low	Normal	Normal	Low
58 Eating & Drinking Places	Spoiled Foods Oil & Grease	Brown to Black	Low	Spoiled or Leftover Foods	Brown	Low	Normal	Normal	Low
Miscellaneous									
Coal Steam Electric Power	NA	Brown to Black	High	Coal Dust	Black Amorphous Powder	Low	Normal	Slightly Acidic	Low
Nuclear Steam Electric Power	NA	Light Brown	Low	Oils, Lubricants	Light Brown	Low	Normal	Normal	Low

Table 5.[2] Contaminants Commonly Associated With Selected Facilities and Activities.

POTENTIAL SOURCE	CONTAMINANT
Commercial / Industrial	
Above-ground storage tanks	Arsenic, Barium, Benzene, Cadmium, 1,4-Dichlorobenzene or P-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Trichloroethylene (TCE), Tetrachloroethylene or Perchlorethylene (Perc)
Automobile, Body Shops/Repair Shops	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, 1,4-Dichlorobenzene or P-Dichlorobenzene, Lead, Fluoride, 1,1,1-Trichloroethane or Methyl Chloroform, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Xylene (Mixed Isomers)
Boat Repair/Refinishing/Marinas	Benzene, Cadmium, cis 1,2-Dichloroethylene, Coliform, Cryptosporidium, Dichloromethane or Methylene Chloride, Giardia Lambia, Lead, Mercury, Nitrate, Nitrite, trans 1,2-Dichloroethylene, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Vinyl Chloride, Viruses
Cement/Concrete Plants	Barium, Benzene, Dichloromethane or Methylene Chloride, Ethylbenzene, Lead, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, Xylene (Mixed Isomers)
Chemical/Petroleum Processing	Acrylamide, Arsenic, Atrazine, Alachlor, Aluminum (Fume or Dust), Barium, Benzene, Cadmium, Carbofuran, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 2,4-D, 1,2-Dibromoethane or Ethylene Dibromide (EDB), 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2 Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthlate, 1,2-Dichloroethane or Ethylene Dichloride, Dioxin, Endrin, Epichlorohydrin, Ethylbenzene, Hexachlorobenzene, Hexachlorocyclopentadiene, Lead, Mercury, Methoxychlor,Polychlorinated Biphenyls, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,2,4-Trichlorobenzene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Construction/Demolition	Arsenic, Asbestos, Benzene, Cadmium, Chloride, Copper,Cyanide, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Fluorides, Lead, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Turbidity, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Dry Cleaners/Dry Cleaning	Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane

[2] EPA maintains a chart that lists some potential facilities and activities where one might find the contaminants referred to as primary and secondary drinking water standards. The listing of a contaminant does not mean that it will always occur at the associated source, nor does it encompass all contaminants that may be present. This list is intended as a resource guide for creating an inventory list. A state or local community may have different sources of concern from the list below, based on local variability such as existing industrial activity, and known contaminant occurrence information.

Table 5.[2] Contaminants Commonly Associated With Selected Facilities and Activities.

POTENTIAL SOURCE	CONTAMINANT
Dry Goods Manufacturing	Barium, Benzene, Cadmium, Copper, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Lead, 1,1,1-Trichloroethane or Methyl Chloroform, Polychlorinated Biphenyls, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, Trichloroethylene (TCE), Xylene (Mixed Isomers)
Electrical/Electronic Manufacturing	Aluminum (Fume or Dust), Antimony, Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, Cyanide, Carbon Tetrachloride, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Ethylbenzene, Lead, Mercury, Polychlorinated Biphenyls, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane, Trichloroethylene (TCE), Thallium, Toluene, Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Fleet/Trucking/ Bus Terminals	Arsenic, Acrylamide, Barium, Benzene, Benzo(a)pyrene, Cadmium, Chlorobenzene, Cyanide, Carbon Tetrachloride, 2,4-D, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Epichlorohydrin, Heptachlor (and Epoxide), Lead, Mercury, Methoxychlor, Pentachlorophenol, Propylene Dichloride or 1,2-Dichloropropane, Selenium, Styrene, Toxaphene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
Food Processing	Arsenic, Benzene, Cadmium, Copper, Carbon Tetrachloride, Dichloromethane or Methylene Chloride, Lead, Mercury, Picloram, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Xylene (Mixed Isomers)
Funeral Services/Taxidermy	Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Total Coliforms, Viruses
Furniture Repair/Manufacturing	Barium, 1,2-Dichloroethane or Ethylene Dichloride, Dichloromethane or Methylene Chloride, Ethylbenzene, Lead, Mercury, Selenium, Trichloroethylene (TCE)
Gas Stations (see also above ground/underground storage tanks, motor-vehicle drainage wells)	cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE)
Graveyards/Cemetaries	Dalapon, Lindane, Nitrate, Nitrite, Total Coliforms, Viruses.
Hardware/Lumber/Parts Stores	Aluminum (Fume or Dust), Barium, Benzene, Cadmium, Chlorobenzene, Copper, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl)adipate, Di(2-ethylhexyl) phthlate, 1,4-Dichlorobenzene or P-Dichlorobenzene, Ethylbenzene, Lead, Mercury, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Toluene, Xylene (Mixed Isomers)
Historic Waste Dumps/Landfills	Atrazine, Alachlor, Carbofuran, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Diquat, Dalapon, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Oxamyl (Vydate), Sulfate, Simazine, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene(TCE)

Table 5.[2] Contaminants Commonly Associated With Selected Facilities and Activities.

POTENTIAL SOURCE	CONTAMINANT
Home Manufacturing	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, Carbon Tetrachloride, 1,2-Dichlorobenzene or O-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Ethylbenzene, Lead, Mercury, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Toluene, Turbidity, Xylene (Mixed Isomers)
Industrial Waste Disposal Wells (see UIC for more information on concerns, and locations)	Acrylamide, Arsenic, Atrazine, Alachlor, Aluminum (Fume or Dust), Ammonia, Barium, Benzene, Cadmium, Carbofuran, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 2,4-D, 1,2-Dibromoethane or Ethylene Dibromide (EDB), 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or p-Dichlorobenzene, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2 Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthlate, 1,2-Dichloroethane or Ethylene Dichloride, Dioxin, Endrin, Epichlorohydrin, Hexachlorobenzene, Hexachlorocyclopentadiene, Lead, Mercury, Methoxychlor, Oxamyl (Vydate), Polychlorinated Biphenyls, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,2,4-Trichlorobenzene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Junk/Scrap/Salvage Yards	Barium, Benzene, Copper, Dalapon, cis 1,2-Dichloroethylene, Diquat, Glyphosate, Lead, Polychlorinated Biphenyls, Sulfate, Simazine, Trichloroethylene (TCE), Tetrachloroethylene or Perchlorethylene (Perc)
Machine Shops	Arsenic, Aluminum (Fume or Dust), Barium, Benzene, Boric Acid, Cadmium, Chlorobenzene, Copper, Cyanide, Carbon Tetrachloride 2,4-D, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, Ethylbenzene, Fluoride, Hexachlorobenzene, Lead, Mercury, Polychlorinated Biphenyls, Pentachlorophenol, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane, Trichloroethylene (TCE), Xylene (Mixed Isomers), Zinc (Fume or Dust)
Medical/Vet Offices	Arsenic, Acrylamide, Barium, Benzene, Cadmium, Copper, Cyanide, Carbon Tetrachloride, Dichloromethane or Methylene Chloride, 1,2-Dichloroethane or Ethylene Dichloride, Lead, Mercury, Methoxychlor, 1,1,1-Trichloroethane or Methyl Chloroform, Radionuclides, Selenium, Silver, Tetrachloroethylene or Perchlorethylene (Perc), 2,4,5-TP (Silvex), Thallium, Xylene (Mixed Isomers)
Metal Plating/Finishing/Fabricating	Antimony, Aluminum (Fume or Dust), Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Chlorobenzene, Chromium, Copper, Cyanide, 1,4-Dichlorobenzene or P-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Ethylbenzene,Lead, Mercury, Polychlorinated Biphenyls, Pentachlorophenol, Selenium, Styrene, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), , Thallium, Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, 1,1,2-Trichloroethane, Trichloroethylene(TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Military Installations	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Hexachlorobenzene, Lead, Mercury, Methoxychlor, 1,1,1-Trichloroethane or Methyl Chloroform, Radionuclides, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), , Toluene, Trichloroethylene (TCE)

Table 5.[2] Contaminants Commonly Associated With Selected Facilities and Activities.

POTENTIAL SOURCE	CONTAMINANT
Mines/Gravel Pits	Lead, Selenium, Sulfate, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Turbidity
Motor Pools	cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride,
Motor Vehicle Waste Disposal Wells (gas stations, repair shops) See UIC for more on concerns for these sources http://www.epa.gov/safewater/uic/cv-fs.html	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Copper, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, 1,4-Dichlorobenzene or P-Dichlorobenzene, Lead, Fluoride, 1,1,1-Trichloroethane or Methyl Chloroform, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Xylene (Mixed Isomers)
Office Building/Complex	Barium, Benzene, Cadmium, Copper, 2,4-D, Diazinon, 1,2-Dichlorobenzene or O-Dichlorobenzene, Dichloromethane or Methylene Chloride, Diquat, 1,2-Dichloroethane or Ethylene Dichloride, Ethylbenzene, Glyphosate, Lead, Mercury, Selenium, Simazine, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
Photo Processing/Printing	Acrylamide, Aluminum (Fume or Dust), Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, 1,2-Dibromoethane or Ethylene Dibromide (EDB), Heptachlor epoxide, Hexachlorobenzene, Lead, Lindane, Mercury, Methoxychlor, Propylene Dichloride or 1,2-Dichloropropane, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Toluene, 1,1,2-Trichloroethane, Trichloroethylene(TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
Synthetic / Plastics Production	Antimony, Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Chlorobenzene, Copper, Cyanide, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) adipate, Di(2-ethylhexyl) phthlate, Ethylbenzene, Hexachlorobenzene, Lead, Mercury, Methyl Chloroform or 1,1,1-Trichloroethane, Pentachlorophenol, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perk), Toluene, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers), Zinc (Fume or Dust)
RV/Mini Storage	Arsenic, Barium, Cyanide, 2,4-D, Endrin, Lead, Methoxychlor
Railroad Yards/Maintenance/Fueling Areas	Atrazine, Barium, Benzene, Cadmium, Dalapon, 1,4-Dichlorobenzene or P-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Mercury, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE).
Research Laboratories	Arsenic, Barium, Benzene, Beryllium Powder, Cadmium, Carbon Tetrachloride, Chlorobenzene, Cyanide, 1,2-Dichloroethane or Ethylene Dichloride, 1,1-Dichloroethylene or Vinylidene Chloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Endrin, Lead, Mercury, Polychlorinated Biphenyls, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), Thallium, Thiosulfates, Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)
Retail Operations	Arsenic, Barium, Benzene, Cadmium, 2,4-D, 1,2-Dichloroethane or Ethylene Dichloride, Lead, Mercury, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Toluene, 1,1,1-Trichloroethane, Vinyl Chloride

Table 5.[2] Contaminants Commonly Associated With Selected Facilities and Activities.

POTENTIAL SOURCE	CONTAMINANT
Underground Storage Tanks	Arsenic, Barium, Benzene, Cadmium, 1,4-Dichlorobenzene or P-Dichlorobenzene, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE).
Wood Preserving/Treating	cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Lead, Sulfate
Wood/Pulp/Paper Processing	Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, Copper, Dichloromethane or Methylene Chloride, Dioxin, 1,2-Dichloroethane or Ethylene Dichloride, Ethylbenzene, Lead, Mercury, Polychlorinated Biphenyls, Selenium, Styrene, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Xylene (Mixed Isomers)
Residential / Municipal	
Airports (Maintenance/Fueling Areas)	Arsenic, Barium, Benzene, Cadmium, Carbon Tetrachloride, cis 1,2- Dichloroethylene, Dichloromethane or Methylene Chloride, Ethylbenzene, Lead, Mercury, Selenium, Tetrachloroethylene or Perchlorethylene (Perc), 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Xylene (Mixed Isomers)
Apartments and Condominiums	Atrazine, Alachlor, Coliform, Cryptosporidium, Dalapon, Diquat, Giardia Lambia, Glyphosate, Nitrate, Nitrite, Picloram,Sulfate,Simazine, Vinyl Chloride, Viruses
Camp Grounds/RV Parks	Benomyl, Coliform, Cryptosporidium, Diquat, Dalapon, Giardia Lambia, Glyphosate, Isopropanol, Nitrate, Nitrite, Picloram,Sulfate,Simazine, Turbidity, Vinyl Chloride, Viruses
Cesspools - Large Capacity (see UIC for more information)	Atrazine, Alachlor, Carbofuran, Coliform, Cryptosporidium, Diquat, Dalapon, Giardia Lambia, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram,Sulfate,Simazine, Vinyl Chloride, Viruses
Drinking Water Treatment Facilities	Atrazine, Benzene, Cadmium, Cyanide, Fluoride, Lead, Polychlorinated Biphenyls, Toluene, Total Trihalomethanes, 1,1,1-Trichloroethane or Methyl Chloroform
Gas Pipelines	cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene or TCE
Golf Courses and Urban Parks	Arsenic, Atrazine, Benzene, Chlorobenzene, Carbofuran, 2,4-D, Diquat, Dalapon, Glyphosate, Lead, Methoxychlor, Nitrate, Nitrite, Picloram, Simazine, Turbidity
Housing developments	Atrazine, Alachlor, Coliform, Cryptosporidium, Carbofuran, Diquat, Dalapon, Giardia Lambia, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Picloram, Simazine, Trichloroethylene (TCE), Turbidity, Vinyl Chloride, Viruses
Landfills/Dumps	Arsenic, Atrazine, Alachlor, Barium, Benzene, Cadmium, Carbofuran, cis 1,2 Dichloroethylene, Diquat, Glyphosate, Lead, Lindane, Mercury, 1,1,1-Trichloroethane or Methyl Chloroform, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Picloram, Selenium, Simazine, Trichloroethylene (TCE)
Public Buildings (e.g., schools, town halls, fire stations, police stations) and Civic Organizations	Arsenic, Acrylamide, Barium, Benzene, Beryllium Powder, Cadmium, Carbon Tetrachloride, Chlorobenzene, Cyanide, 2,4-D, 1,2-Dichlorobenzene or O-Dichlorobenzene, 1,4-Dichlorobenzene or P-Dichlorobenzene, Dichloromethane or Methylene Chloride, Di(2-ethylhexyl) phthlate, 1,2-Dichloroethane or Ethylene Dichloride, Endothall, Endrin, 1,2-Dibromoethane or Ethylene Dibromide (EDB), Lead, Lindane, Mercury, Methoxychlor, Selenium, Toluene, 1,1,1-Trichloroethane or Methyl Chloroform, Trichloroethylene (TCE), Vinyl Chloride, Xylene (Mixed Isomers)

Table 5.[2] Contaminants Commonly Associated With Selected Facilities and Activities.

POTENTIAL SOURCE	CONTAMINANT
Septic Systems	Atrazine, Alachlor, Carbofuran, Coliform, Cryptosporidium, Diquat, Dalapon, Giardia Lambia, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses
Sewer Lines	Coliform, Cryptosporidium, Diquat, Dalapon, Giardia Lambia, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram,Sulfate,Simazine, Vinyl Chloride, Viruses
Stormwater infiltration basins/injection into wells (UIC Class V), runoff zones	Atrazine, Alachlor, Coliform, Cryptosporidium, Carbofuran, Chlorine, Diquat, Dalapon, Giardia Lambia, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Nitrosamine, Oxamyl (Vydate), Phosphates, Picloram, Simazine, Trichloroethylene(TCE), Turbidity, Vinyl Chloride, Viruses
Transportation Corridors (e.g., Roads, railroads)	Dalapon, Picloram, Simazine, Sodium, Sodium Chloride, Turbidity
Utility Stations	Arsenic, Barium, Benzene, Cadmium, Chlorobenzene, Cyanide, 2,4-D, 1,4-Dichlorobenzene or P-Dichlorobenzene, 1,2-Dichloroethane or Ethylene Dichloride, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Lead, Mercury, Picloram, Toluene, 1,1,2,2- Tetrachloroethane, Tetrachloroethylene or Perchlorethylene (Perc), Trichloroethylene (TCE), Xylene (Mixed Isomers)
Waste Transfer /Recycling	Coliform, Cryptosporidium, Giardia Lambia, Nitrate, Nitrite, Vinyl Chloride, Viruses
Wastewater Treatment Facilities/Discharge locations (incl. land disposal and underground injection of sludge)	Cadmium, Coliform, Cryptosporidium, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Dichloromethane or Methylene Chloride, Fluoride, Giardia Lambia, Lead, Mercury, Nitrate, Nitrite, Tetrachloroethylene or Perchlorethylene (Perc) Selenium, sulfate,Trichloroethylene (TCE), Vinyl Chloride, Viruses
Agricultural / Rural	
Auction Lots/Boarding Stables	Coliform, Cryptosporidium, Giardia Lambia, Nitrate, Nitrite,Sulfate,Viruses
Animal Feeding Operations/ Confined Animal Feeding Operations	Coliform, Cryptosporidium, Giardia Lambia, Nitrate, Nitrite, Sulfate, Turbidity, Viruses
Bird Rookeries/Wildlife feeding /migration zones	Coliform, Cryptosporidium, Giardia Lambia, Nitrate , Nitrite , Sulfate, Turbidity, Viruses
Crops - Irrigated + Non-irrigated	Benzene, 2,4-D, Dalapon, Dinoseb, Diquat, Glyphosate, Lindane, Lead, Nitrate, Nitrite , Picloram, Simazine, Turbidity
Dairy operations	Coliform, Cryptosporidium, Giardia Lambia, Nitrate , Nitrite,Sulfate,Turbidity, Viruses
Drainage Wells, Lagoons and Liquid Waste Disposal - Agricultural	Atrazine, Alachlor, Coliform, Cryptosporidium, Carbofuran, Diquat, Dalapon, Giardia Lambia, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram,Sulfate,Simazine, Vinyl Chloride, Viruses
Managed Forests/Grass Lands	Atrazine, Diquat, Glyphosate, Picloram, Simazine, Turbidity
Pesticide/Fertilizer Storage Facilities	Atrazine, Alachlor, Carbofuran, Chlordane, 2,4-D, Diquat, Dalapon, 1,2-Dibromo-3-Chloropropane or DBCP, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Simazine, 2,4,5-TP (Silvex)
Rangeland/Grazing lands	Coliform, Cryptosporidium, Giardia Lambia, Nitrate, Nitrite, Sulfate, Turbidity, Viruses
Residential Wastewater lagoons	Atrazine, Alachlor, Carbofuran, Coliform, Cryptosporidium, Diquat, Dalapon, Giardia Lambia, Glyphosate, Nitrate, Nitrite, Oxamyl (Vydate), Picloram,Sulfate,Simazine, Vinyl Chloride, Viruses

Table 5.[2] Contaminants Commonly Associated With Selected Facilities and Activities.

POTENTIAL SOURCE	CONTAMINANT
Rural Homesteads	Atrazine, Alachlor, Carbofuran, Coliform, Cryptosporidium, cis 1,2-Dichloroethylene, trans 1,2-Dichloroethylene, Diquat, Dalapon, Giardia Lambia, Glyphosate, Nitrate, Nitrite,Oxamyl (Vydate), Picloram, Sulfate, Simazine, Vinyl Chloride, Viruses

MISCELLANEOUS SOURCES	
Abandoned drinking water wells (conduits for contamination)	Atrazine, Alachlor, Coliform, Cryptosporidium, Carbofuran, Diquat, Dalapon, Giardia Lambia, Glyphosate, Dichloromethane or Methylene Chloride, Nitrate, Nitrite, Oxamyl (Vydate), Picloram, Simazine, Trichloroethylene (TCE), Turbidity, Vinyl Chloride, Viruses
Naturally Occurring	Arsenic, Asbestos, Barium, Cadmium, Chromium, Coliform, Copper, Cryptosporidium, Fluoride, Giardia Lambia, Iron, Lead, Manganese, Mercury, Nitrate, Nitrite, Radionuclides, Selenium, Silver, Sulfate, Viruses, Zinc (Fume or Dust)
Underground Injection Control (UIC) Wells CLASS I - deep injection of hazardous and non-hazardous wastes into aquifers separated from underground sources of drinking water	see UIC
UIC Wells CLASS II deep injection wells of fluids associated with oil/gas production (for more detailed list of sites click here)	see UIC
UIC Wells CLASS III re-injection of water/steam into mineral formations for mineral extraction	see UIC
UIC Wells CLASS IV - officially banned. Inject hazardous or radioactive waste into or above underground sources of drinking water	see UIC

Table 6.[3] Possible Contaminating Activities (PCAs).

Risk	Activities			
	Commercial/Industrial	**Residential/Municipal**	**Agricultural/Rural**	**Other**
Very High (VH)	-Gas stations -Chemical/petroleum processing/storage -Dry cleaners -Metal plating/ finishing/fabricating -Plastics/synthetics producers	-Airports – maintenance/fueling areas -Landfills/dumps -*Septic systems - High density (>1/acre) (for groundwater sources otherwise M) -*Wastewater Treatment Plants	-* Animal Feeding Operations -* Concentrated Aquatic Animal Production Facilities -* Managed Forests (VH for surface water otherwise H)	-Underground injection of commercial/ industrial discharges -Historic gas stations -Historic waste dumps/landfills -Injection wells/dry wells/ sumps -Known contaminant plumes -Military installations -Historic Mining operations -Active Mining operations -Confirmed leaking underground storage tanks
High (H)	-Auto Body shops -Auto Repair shops -Boat services/repair/ refinishing -Chemical/petroleum pipelines -Electrical/electronic manufacturing -Fleet/trucking/bus terminals -Furniture repair/ manufacturing -Home manufacturing -Junk/scrap/salvage yards -Machine shops -Photo processing/ printing -Research laboratories -Wood preserving/ treating -Lumber processing and manufacturing -Wood/pulp/paper processing and mills -*Sewer collection systems	-Railroad yards/ maintenance/fueling areas -*Sewer collection systems -Utility stations - maintenance areas -*Wastewater Treatment Plants	-* Grazing (> 5 animals/ acre) -* Animal Feeding Operations -* Other animal operations -Concentrated Aquatic Animal Production Facilities -Other aquatic animal operations -Farm chemical distributor/ application service -Farm machinery repair -*Septic systems- low density (<1/acre) -*Lagoons/liquid wastes -Machine shops -Pesticide/fertilizer/ petroleum storage and transfer areas -Managed Forests (VH for surface water otherwise H) -Agricultural Drainage and Irrigation Wells	-Industrial discharges -Illegal activities/unauthorized dumping -Mining - Sand/Gravel -Wells- Oil, Gas, Geothermal -Salt water intrusion -*Recreational area - surface water source -Non-regulated Underground storage tanks (tanks smaller than regulatory limit) -Not yet upgraded or registered Underground storage tanks -Snow Ski Areas -Recent (< 10 years) Burn Areas -Dredging

[3] The Navy Environmental Health Center (NEHC) has prepared tables based on EPA's State Source Water Assessment And Protection Programs Guidance, identifying Possible Contaminating Activities (PCAs) associated with various potential risks for drinking water contamination. The concept is largely applicable to stormwater, as activities with the runoff potential to contaminate drinking water are also likely to impact stormwater. In addition, rising contaminated groundwater could enter an MS4. This table is taken from the NEHC's efforts. It identifies PCAs divided by land use type and risk to drinking/receiving water. The risk rankings are based on the general nature of activities and the contaminants associated with them. An asterisk (*) indicates PCAs that may be associated with microbiological contamination.

Table 6.[3] Possible Contaminating Activities (PCAs).

Risk	Activities			
	Commercial/Industrial	**Residential/Municipal**	**Agricultural/Rural**	**Other**
Moderate (M)	-Car washes -Parking lots/malls (>50 spaces) -Cement/concrete plants -*Food processing -Funeral services/ graveyards -Hardware/lumber/parts stores	-*Septic systems - High density (>1/acre) -Drinking water treatment plants -Golf courses -Housing – High density (>1 house/0.5 acres) -Motor pools -Parks -Waste transfer/ recycling stations	-* Other animal operations -Other aquatic animal operations (H in Zones for surface water, otherwise M) -Crops, irrigated (berries, hops, mint, orchards, sod, greenhouses, vineyards, nurseries, vegetables) NOTE: Drip-irrigated crops are considered Low risks. -*Sewage sludge (biosolids) land application -Fertilizer, pesticide/ herbicide application -Managed Forests (M for ground water) -Agricultural Drainage	-Above ground storage tanks -Wells - water supply -Construction/demolition staging areas -Contractor or government agency equipment storage yards -Managed forests -Freeways/state highways -Railroads -Historic railroad right-of-ways -Road right-of-ways (herbicide use areas) -Hospitals -Storm drain discharge points -Storm water detention facilities -Artificial recharge projects – nonpotable water (includes recycled, storm, and untreated imported water) -Injection wells -Spreading basins -Snow Ski Areas (H in Zones for surface water, otherwise M) -Recent (< 10 years) Burn Areas (H in Zones for surface water, otherwise M) -Dredging (H in Zones for surface water, otherwise M)
Low (L)	-*Sewer collection systems -Appliance/Electronic repair -Office buildings/ complexes -Rental yards -RV/mini storage	-*Sewer collection systems -Apartments and condominiums -Campgrounds/ Recreational areas -Fire stations -RV parks -Schools -Hotels, Motels	-Crops, non-irrigated (e.g. Christmas trees, grains, grass seeds, hay) (or drip-irrigated crops) -* Septic systems - low density (<1/acre)	-Decommissioned underground storage tanks – inactive -Upgraded and/or registered underground storage tanks – active -Roads/Streets -Artificial recharge projects – potable water-Injection wells -Artificial recharge projects – potable water -Spreading basins -Medical/dental offices/clinics -Veterinary offices/clinics -*Surface water - streams/lakes/ rivers -Wells - Monitoring, test holes, borings

APPENDIX M:

KISTERS DATA ENTRY PROCEDURES

KiWQM Data Entry Procedures

In 2017 the District updating the Districts water quality database with newer technology that will allow staff to be more efficient and create better products in house. The prior database technology was Kisters Hydstra Water Quality Module purchased in the early 1990's. This database will remain at the District to maintain the Hydrologic data (rainfall, stage, flow) within it's Time Series Module. The Water Quality Module has become outdated with limitations on the amount of parameters certain fields can hold. This module also requires more support from the company to write individual computer programs to make any customizations. This module is being replaced by Kisters Water Quality Module (KiWQM). The migration of all historical data, import and Q/C procedures are being developed at the time of this CMP update. The following is a general procedure for importing data which may be further refined as this database becomes fully integrated.

1. Receive Analytical Data from Laboratory

2. Import Laboratory and Field Data Into Hydstra
   E.S. Babcock Lab will send "edds" – electronic data excel files, periodically via email. The excel files will be attachments to the email.
   - 2.1 Within KiWQM Explorer mode, select File, Import, Others, Samplings
   - 2.2 Within Configuration tab select correct importer for type of data (**Survey 123 data must be imported first as sampling event will be created from this**.)
   - 2.3 Click on Import tab and select data file to be uploaded by selecting the box with '…'
   - 2.4 Click 'Read file' button
   - 2.5 Address any errors identified by importer
   - 2.6 Click 'Import data' button to import into KiWQM
3. Run report to check reporting limits and parameter lists.
4. If report identified any errors, send back to Babcock Labs for correction.
5. Input any toxicity data manually to appropriate Sampling event.
6. Run plausibility checks to change status of data to 'Confirmed'.

Hydstra WQ Module Data Entry Procedures

1. Receive Analytical Data from Laboratory

2. Import Laboratory and Field Data Into Hydstra
   E.S. Babcock Lab will send "edds" – electronic data text files, periodically via email. The text files will be attachments to the email. A sample data file name is given for this example and will be different for each file sent by the lab.

   2.1 Match the paper copy of the lab results with the text file from the email. The paper copy of the lab results will accompany the invoices from the lab.
   2.2 Open up the text file and review its format. It should read similar to:

"A5D1827-01 813 BacT Sampling 04/22/2005 14:30 David Ortega 04/22/2005 16:35 Fecal Streptococcus 40 MPN/100 mL 20 SM 9230B 04/22/2005 SAMP"

   2.2.1 The first item (**A5D1827-01**) is the lab number.
   2.2.2 The Hydstra station number (**813**) is next. This number should match the Sample ID on the *Chain of Custody* form.
   2.2.3 The project name (**BACTEE Sampling**) should match the Project Name on the *Chain of Custody* form**.**
   2.2.4 The date (**4/22/05**) should match the sample date on the *Chain of Custody* form.
   2.2.5 The time (**14:30**) should match the sample time on the *Chain of Custody* form.
   2.2.6 The name (**David Ortega**) should match the name under Sampler Information on the *Chain of Custody* form.
   2.2.7 The next date (**4/22/05**) is the date that the samples were received by the lab, and should match the *Chain of Custody* form.
   2.2.8 The next time (**16:35**) is the time that the lab received the samples, and should match the *Chain of Custody* form.
   2.2.9 **Fecal Streptococcus** refers to the type of lab analysis performed by the lab.
   2.2.10 **MPN/100 mL** refers to the reporting units of the lab results.
   2.2.11 **SM 9230B** refers to the analytical method use by the lab.

   2.3 If there is a discrepancy or difference between the paper copy of the lab report and the electronic lab data, please contact Rebekah Guill (951-955-2901) and/or Abigail Suter ~~Penny Nanney~~ (951-955-1734 ~~1325~~) at the District and Kayelani Deener (951-653-3351) at the lab.
   2.4 Open **Q:\NPDES\LABORATORY REPORTS\Babcock Data 04-05** (the reporting year at the end of the filename may be different).
   2.5 If there are no discrepancies between the paper copy of the lab report and the electronic lab data, then copy the text file and paste to the file **Babcock Data 04-05** in **Q:\NPDES\LABORATORY REPORTS.** Make a note of the entire text file name, *e.g.*: **A5D1827 FINAL SIMPLE 27 Apr 05 10481.txt**
   2.6 Log on to the Hydstra database, double click on file: **"Programs by Function"**, double click on file: **"Hydstra/WQ – Water Quality"**, double click on **"RFCWQIN – Import WQ Samples from lab"**. Wait for Window labeled **"RFCWQIN – Import WQ Samples from lab"** appears. Click **"Program"** tab, click **"Previous run F8"**. Insert Data File Name: **Q:\NPDES\LABORATORY REPORTS\Babcock Data 04-05\.: A5D1827 FINAL SIMPLE 27 Apr 05 10481.txt**, Insert Work file name: **A5D1827**, Insert Date Format: **B** (for Babcock), click **RUN**.

2.7 Successful import will produce a page on the HYEXPLORE window. The page will read: **Perl – opening input file [Q:\NPDES\LABORATORY REPORTS\Babcock Data 04-05\.: A5D1827]**. The next line will read: **Perl – Preprocessor read** a number **lines, wrote** same number **lines**. The following line will read: **Summary for Samples**.
2.8 Double click on **WQWRK – WQ Samples and Results Management**.
2.9 Click on work file: **A5D1827** to highlight it, then click on **OK**.
2.10 Click on the **Toggle browse/form view** tab for each site number listed in the work file. Check the site number, sample number, collection date and time. Match this information to the *Chain of Custody* form, *Field Data Sheet* and the lab results. Perform a check off procedure as you match the information.
2.11 The Lab Sample number should match the Sample number on this page for Dry Weather or Wet Weather sampling (WWR, SMR and SAR). For TMDL samples, the sample number will begin with an S (example: S010205O5A).
2.12 To manually enter in the Field Data, click on **RESULTS – Water Quality Results (work area)** while in WQWRK Manage.
2.13 Click on the green plus symbol button at the top left to **"Add a New Record"**.
2.14 Enter in a three or four digit numerical variable from *Field Data Sheet*:
- 2.14.1 **262: CFS, Discharge (Flow) Q**
- 2.14.2 **1690: Turbidity (NTU)**
- 2.14.3 **1200: Conductivity (µS/cm or mS/cm)**
- 2.14.4 **1435: Dissolved Oxygen, Field Concentration (mg/L)**
- 2.14.5 **1515: ORP (Redox Potential) Field (mV)**
- 2.14.6 **1655: Temperature Field (ºC)**
- 2.14.7 **1660: Temperature Field (ºF)**
- 2.14.8 **1705: pH, Field**
- 2.14.9 **8998: IC/ID sample; Value: 1 = Yes; 0 = No**
- 2.14.10 **8999: Visited not Sampled; Value: 1 = Yes; 0 = No**
- 2.14.11 **9000: Visited (Sampled); Value: 1 = Wet weather; 0 = Dry weather**

2.15 Enter in value and enter in a comment (if needed).
2.16 Double click on **WQ Manage – WQ Archive Management**
2.17 Highlight a site number that matches with the work file, then click **SAMPLES – Water Quality Samples**.
2.18 Click the **Options** button at the top.
2.19 Click on **Import a WQ workfile**.
2.20 Click on the Workfile number to import into **Archive**.
2.21 Successful Archiving will allow you to go to the site number(s) and check the sample number and results as a double check against the *Chain of Custody* form, *Field Data Sheets* and the paper copy of the lab results.

APPENDIX N:

IC/ID AND IDDE FORMS

The following forms and instruction are provided for reference purposes. In general, Permittees shall follow the procedures and documentation specific to thier local implemenation plans as appropriate.

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IC/ID Incident Reporting Form

Riverside County Flood Control & Water Conservation District

Illicit Connection / Illegal Discharge Incident Reporting Form

Received by: _____
Date: _____ Time Received: _____
Complaint Routed to: _____

Reporting Party

Name: _____ ☐Anon. Agency: _____
Address: _____ City: _____ Zip Code: _____
Phone: _____ Ext.: _____ Pager/Cell: _____ e-mail: _____

Incident Location

Incident Address: _____ City: _____ Zip Code: _____
Incident Location or Business Name: _____ Thos. Bros. Page _____ Zone: ____
Incident Date: _____ Time (24-hr clock): _____ Discharge Currently Occurring: ☐Yes ☐No
Incident Description (attach add'l sheets as needed): _____
_____
_____
_____
_____ Photos Available: ☐Yes ☐No

Substance Involved

Substance Description/Chemical Name: _____
Quantity: ☐Less than ☐Greater than Amount: _____ Units: _____
Color: _____ Odor: _____ Duration of Discharge: _____
Other Details: _____
_____
Special Precautions Needed: ☐No ☐Yes _____
Other parties contacted: ☐HazMat Team ☐County Env. Health ☐County Exec. ☐City of _____
by Reporting Party ☐RWQCB ____ ☐OES – Control #_____ ☐Other _____

Containment

_____% Contained Containment Measure Used: _____
Waterbody or MS4 Involved: _____
Cleaned Up: ☐No ☐Yes, by whom _____ on Date _____ Time (24-hr) _____

Alleged Responsibility Party/Parties (If Known)

Name: _____ Business: _____
Address: _____ City: _____ Zip Code: _____
Phone: _____ Vehicle License No.: _____ Make: _____ Model: _____
Precautions Needed: ☐No ☐Yes _____

Action Needed

Investigation Required: ☐No ☐Yes Details: _____
_____
Investigation Team: Name: _____ Agency: _____ Phone No. _____
Name: _____ Agency: _____ Phone No. _____
Name: _____ Agency: _____ Phone No. _____
Name: _____ Agency: _____ Phone No. _____
Copy sent to: ☐City of _____ via ☐Mail ☐Fax ☐e-mail ☐_____

IC/ID Incident Reporting Form Instructions

A. Reporting Party
   1. *Self-explanatory.*
   2. *If the person does not want to give out their name, try to get at least their last name. If the caller hesitates in giving out a phone number, ask for a callback number. Be sure to also fill in the "Received by" information in the box above.*

B. Incident Location
   1. *Mostly self-explanatory.*
   2. *Get detailed directions to the incident location, including cross streets and Thomas Bros. map page, especially if it is in an out-of-the-way location.*
   3. *Ask the complainant if evidence of the incident is still present. If the incident occurred more than two days prior to the complaint, inform the caller that if there is no evidence of the incident nothing may be able to be done this time and request that the caller call sooner next time.*
   4. *Get as detailed a description of the incident as possible, including whether the complainant has taken photos or video. This information may be needed if formal enforcement actions will be taken.*
   5. *Let the caller know that if a District facility is not involved, you will be referring their complaint to the local jurisdiction. Thank the person for the call and tell him/her that you appreciate their helping to prevent pollution.*

C. Substance Involved
   1. *Mostly self-explanatory.*
   2. *Find out if the substance discharged has any known risks, such as toxic, respiratory irritant, etc.*
   3. *Get the names and agencies of other people the complainant contacted, if available.*
      a. *The complainant may have already notified several other people, and may feel they are getting the runaround or that their complaint is not being taken seriously. If you have to refer the complainant to another person, let the complainant know and try to get them a specific person to call.*
      b. *If another County or City employee referred the complainant to you and the referral was not appropriate, help the complainant and notify the municipal coordinator.*
      c. *The complainant may have contacted someone from a state or federal agency.*
      d. *If someone on the County Board of Supervisors is involved, the priority of response may need to be elevated, even if it is a minor issue.*

D. Containment – *Self-explanatory.*

E. Alleged Responsible Party
   1. *Mostly self-explanatory.*
   2. *Note if any precautions will be needed in approaching the alleged responsible party. If anyone at the incident site behaves in a threatening manner, leave the site and contact your supervisor for further instruction.*

F. Action Needed – *Self-explanatory.*

IC/ID Incident Investigation Report

Riverside County Flood Control & Water Conservation District

Illicit Connection / Illegal Discharge

Incident Investigation Report

Response Time: 1-6 hrs 12 hrs 24 hrs 48 hrs Other: _____

Responsible Party

Name: _____ Business: _____
Address: _____ City: _____ Zip Code: _____
Phone: _____ Ext.: _____ Pager/Cell: _____ e-mail: _____
Responsible Party Notified: ☐No ☐Yes, via ☐Mail ☐Fax _____ ☐e-mail ☐_____
Repeat Violation: ☐Yes ☐No Discharge Stopped: ☐Yes ☐No ☐Industrial ☐Commercial ☐Residential
Corrective Action Required: ☐No ☐Yes, describe _____
_____

Outreach

Outreach Material Distributed:
☐None ☐Door Hanger ☐Business Card ☐Supplement "A" ☐Brochure _____
Other: _____

Follow-up Visit

Date: _____ Time (24-hr): _____ Investigator's Name: _____
Discharge Stopped: ☐Yes ☐No Proper Cleanup Action Taken: ☐Yes ☐No
Explain "No" answer: _____
_____
Further Action Required: ☐No ☐Yes _____
Additional Follow-up Visit(s) Required: ☐Yes ☐No
Details: _____
_____
_____

Investigation

Description of Discharge and Analyses Made: ☐Attach Field Data Sheet for Additional Details
Date/Time Discharge Started: _____ Date/Time Discharge Ceased: _____ Total Amount: _____
Incident Occurred: ☐On Land ☐In Water ☐In Air Waterbody/MS4 Involved: ☐No ☐Yes _____
Substance(s) Involved: ☐ Oil & Grease ☐Soil/Sediment ☐Sewage ☐Reclaimed Water ☐Petroleum (Gas/Diesel/Jet Fuel)
☐ Chemicals _____ ☐Other _____
Photos Taken: ☐Yes (attach) ☐No Field Testing: ☐Yes ☐No Samples Collected: ☐Yes ☐No
Attach pages as needed for investigation details, photos, analyses, phone logs, meeting notes, etc.
Other parties contacted: ☐HazMat Team ☐County Env. Health ☐County Exec. ☐City of _____
☐RWQCB ____ ☐OES – Control #_____ ☐Other _____
Reason for Investigation: ☐Discharge/Spill Response ☐Citizen Complaint ☐Sewage Spill
☐Visual Monitoring ☐Construction Concern ☐Industrial Concern

Enforcement

Enforcement: ☐None ☐Verbal Warning ☐Door Hanger ☐Written Warning (attach copy)
☐Cease and Desist Order: ☐Verbal ☐Written ☐Stop Work Order
Other Enforcement Actions: _____
_____
Investigator's Name: _____ Agency: _____ Phone No. _____
Signature: _____ Date: _____

Rev 7/2008 ABC

IC/ID Incident Investigation Report Instructions

Fill out this form as completely as possible. All of the information is required for the Annual Reports.

A. Responsible Party
   1. *Self-explanatory.*
   2. *Ensure that the "Received by" information in the box above is filled out.*

B. Outreach
   1. *Self-explanatory.*
   2. *If no outreach materials are distributed, explain why.*

C. Follow-up Visit – *Self-explanatory.*

D. Investigation – *Self-explanatory.*

E. Enforcement
   1. *Self-explanatory.*
   2. *If no enforcement action is taken, explain why.*

APPENDIX O:

MONITORING CONSULTANT APPROVAL AND RESPONSIBILITIES FORMS

Monitoring Contractor Approval and Responsibilities Form

Riverside County Quality Assurance Project Plan for Water Quality Monitoring

Contractor Name:

Address	
County Monitoring Project Name and Elements	General Monitoring Program Support Services
District Agreement Number and Approval Date	
Project Manager	
Signature	
Phone Number	
E-mail	
Quality Assurance Officer	
Signature	
Phone Number	
E-mail	

~~The Project Manager is responsible implementing monitoring activities and data management in accordance with the requirements of this QAPP and the corresponding elements of a Project's Monitoring Plan. The Quality Assurance (QA) Officer and is responsible for quality assurance and quality control procedures for sampling and data management procedures in this QAPP. The QA officer will review and assess procedures during the project against QAPP requirements. The Project Manager will report all findings to the QA Officer and District's Project Manager, including all requests for corrective action. The QA Officer and/or District's Project Manager may stop monitoring activities, if there are significant deviations from required practices or if there is evidence of a systematic failure. The Contractor will be responsible for ensuring QAPP/Monitoring Plan compliance by subcontractors hired on single or various elements of the Monitoring Project named above.~~

The Contractor's Project Manager is responsible implementing monitoring activities and data management in accordance with the requirements of this QAPP and the corresponding elements of a Project's Monitoring Plan. The Contractor's Quality Assurance Officer (QA) is responsible for quality assurance and quality control procedures for the sampling and data management procedures in this QAPP. The Contractor's QA Officer will review and assess procedures during the project against QAPP requirements. The Project Manager will report all findings to the Watershed Monitoring Section Manager and/or District's Project Contact (may vary by watershed/assignment), including all requests for corrective action. The District may stop monitoring activities, if there are significant deviations from required practices or if there is evidence of a systematic failure.

The Contractor will be responsible for ensuring QAPP/Monitoring Plan compliance by subcontractors hired on single or various elements of the Monitoring Project named above.

Monitoring Contractor Approval and Responsibilities Form

Riverside County Quality Assurance Project Plan for Water Quality Monitoring

Contractor Name:
Babcock Laboratories, Inc.

Address: **6100 Quail Valley Ct.** **Riverside, CA 92507**	
County Monitoring Project Name and Elements	General Analytical Laboratory Support Services
District Agreement Number and Approval Date	FCARC-92561-0022-0622 6/12/2018
Project Manager	Kayelani Marshall
Signature	Kayelani Marshall
Phone Number	(951) 653-3351
E-mail	Kmarshall@babcocklabs.com
Quality Assurance Officer	Stacey Fry
Signature	Stacey A. Fry
Phone Number	(951) 653-3351
E-mail	sfry@babcocklabs.com

The Contractor's Project Manager is responsible implementing monitoring activities and data management in accordance with the requirements of this QAPP and the corresponding elements of a Project's Monitoring Plan. The Contractor's Quality Assurance Officer (QA) is responsible for quality assurance and quality control procedures for the sampling and data management procedures in this QAPP. The Contractor's QA Officer will review and assess procedures during the project against QAPP requirements. The Project Manager will report all findings to the Watershed Monitoring Section Manager and/or District's Project Contact (may vary by watershed/assignment), including all requests for corrective action. The District may stop monitoring activities, if there are significant deviations from required practices or if there is evidence of a systematic failure.

The Contractor will be responsible for ensuring QAPP/Monitoring Plan compliance by subcontractors hired on single or various elements of the Monitoring Project named above.

Monitoring Contractor Approval and Responsibilities Form

Riverside County Quality Assurance Project Plan for Water Quality Monitoring

Contractor Name:
Wood Environment & Infrastructure Solutions, Inc.

Address: **9177 Sky Park Ct,** **San Diego, CA 92123**	
County Monitoring Project Name and Elements	General Monitoring Program Support Services
District Agreement Number and Approval Date	FCARC-92561-0018-0622 6/12/2018
Project Manager	Brenda Stevens
Signature	
Phone Number	(858) 514-7729
E-mail	brenda.stevens@woodplc.com
Quality Assurance Officer	Matt Rich
Signature	
Phone Number	(858) 514-6478
E-mail	matt.rich@woodplc.com

The Contractor's Project Manager is responsible implementing monitoring activities and data management in accordance with the requirements of this QAPP and the corresponding elements of a Project's Monitoring Plan. The Contractor's Quality Assurance (QA) Officer is responsible for quality assurance and quality control procedures for the sampling and data management procedures in this QAPP. The Contractor's QA Officer will review and assess procedures during the project against QAPP requirements. The Project Manager will report all findings to the Watershed Monitoring Section Manager and/or District's Project Contact (may vary by watershed/assignment), including all requests for corrective action. The District may stop monitoring activities, if there are significant deviations from required practices or if there is evidence of a systematic failure.

The Contractor will be responsible for ensuring QAPP/Monitoring Plan compliance by subcontractors hired on single or various elements of the Monitoring Project named above.

Monitoring Contractor Approval and Responsibilities Form

Riverside County Quality Assurance Project Plan for Water Quality Monitoring

Contractor Name:
Alta Environmental

Address: **2110 South Coast Hwy, Suite B** **Oceanside, CA 92554**	
County Monitoring Project Name and Elements	General Monitoring Program Support Services
District Agreement Number and Approval Date	FCARC-92561-0017-0622 6/12/2018
Project Manager	Garth Engelhorn
Signature	
Phone Number	(562) 495-5777
E-mail	garth.engelhorn@altaenviron.com
Quality Assurance Officer	David Renfrew
Signature	
Phone Number	(562) 495-5777
E-mail	david.renfrew@altaenviron.com

The Contractor's Project Manager is responsible implementing monitoring activities and data management in accordance with the requirements of this QAPP and the corresponding elements of a Project's Monitoring Plan. The Contractor's Quality Assurance Officer (QA) is responsible for quality assurance and quality control procedures for the sampling and data management procedures in this QAPP. The Contractor's QA Officer will review and assess procedures during the project against QAPP requirements. The Project Manager will report all findings to the Watershed Monitoring Section Manager and/or District's Project Contact (may vary by watershed/assignment), including all requests for corrective action. The District may stop monitoring activities, if there are significant deviations from required practices or if there is evidence of a systematic failure.

The Contractor will be responsible for ensuring QAPP/Monitoring Plan compliance by subcontractors hired on single or various elements of the Monitoring Project named above.

Monitoring Contractor Approval and Responsibilities Form

Riverside County Quality Assurance Project Plan for Water Quality Monitoring

Contractor Name:
Weston Solutions

Address: **5817 Dryden Place, Suite 101** **Carlsbad, CA 92008**	
County Monitoring Project Name and Elements	General Monitoring Program Support Services
District Agreement Number and Approval Date	FCARC-92561-0058-0621 6/12/2018
Project Manager	Sheri Dister
Signature	Sheri Dister
Phone Number	(760) 795-6996
E-mail	Sheri.Dister@WestonSolutions.com
Quality Assurance Officer	Andrea Crumpacker
Signature	
Phone Number	(760) 795-6987
E-mail	Andrea.Crumpacker@WestonSolutions.com

The Contractor's Project Manager is responsible implementing monitoring activities and data management in accordance with the requirements of this QAPP and the corresponding elements of a Project's Monitoring Plan. The Contractor's Quality Assurance Officer (QA) is responsible for quality assurance and quality control procedures for the sampling and data management procedures in this QAPP. The Contractor's QA Officer will review and assess procedures during the project against QAPP requirements. The Project Manager will report all findings to the Watershed Monitoring Section Manager and/or District's Project Contact (may vary by watershed/assignment), including all requests for corrective action. The District may stop monitoring activities, if there are significant deviations from required practices or if there is evidence of a systematic failure.

The Contractor will be responsible for ensuring QAPP/Monitoring Plan compliance by subcontractors hired on single or various elements of the Monitoring Project named above.

APPENDIX P:

CALIFORNIA RAPID ASSESSMENT METHOD (CRAM)

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California Rapid Assessment Method for Wetlands

User's Manual

Version 6.1



April 2013

This report should be cited as:

California Wetlands Monitoring Workgroup (CWMW). 2013. California Rapid Assessment Method (CRAM) for Wetlands, Version 6.1 pp. 67

Funding for initial CRAM development was provided to the San Francisco Estuary Institute, the Southern California Coastal Water Research Project, and the California Coastal Commission through USEPA contracts CD-96911101-0, CD-96911201-0, and CD-96911301-1, respectively. The contents of this document do not necessarily reflect the views and policies of the EPA nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

Cover Photograph: Ash Creek Wildlife Area by Kevin O'Connor, Central Coast Wetlands Group

California Rapid Assessment Method (CRAM) For Wetlands

User's Manual

Version 6.1
April 2013

A Product of the

Level 2-Rapid Assessment Committee

of the

California Wetlands Monitoring Workgroup

Edited by Kevin O'Connor
Central Coast Wetlands Group at Moss Landing Marine Labs





L2 Rapid Assessment Committee of the California Wetlands Monitoring Workgroup	
Name	**Organization**
Lindsey Tunis	AECOM
Kevin Lunde	Bay Area Regional Water Quality Control Board
Rebecca Payne	California Department of Transportation
Glenn Sibbald	CDFW-Aquatic Bioassessment Laboratory
Cara Clark	Central Coast Wetlands Group at Moss Landing Marine Labs
Kevin O'Connor	Central Coast Wetlands Group at Moss Landing Marine Labs
Ross Clark	Central Coast Wetlands Group at Moss Landing Marine Labs
Ayzik Solomesheh	Consultant
Carol Witham	Consultant
Marie Denn	National Park Service
Chad Roberts	Roberts Environmental and Conservation Planning
Michelle Stevens	Sacramento State University
Cristina Grosso	San Francisco Estuary Institute
Josh Collins	San Francisco Estuary Institute
Sarah Pearce	San Francisco Estuary Institute
Chris Solek	Southern California Coastal Water Research Project
Eric Stein	Southern California Coastal Water Research Project
Cliff Harvey (Chair)	State Water Resources Control Board
Dave Weixelman	U.S. Forest Service
Paul Jones	USEPA Region 9
Melissa Scianni	USEPA Region 9

Version History of CRAM Methodology

Version 6.1 released April 2013
Changes in this version:

- Changed Manual cover image and layout
- Updated list of Level 2 Committee member names
- Updated Chapter 3: Procedures for using CRAM, Step 2: Classify the Wetland According to the CRAM typology. The definitions and references were updated to reflect more current information.
- Updated Figure 3.2 with revised wetland names
- Re-inserted Chapter 4: Definition and Rationale for CRAM Attributes and Metrics. This chapter contains general information about each metric and submetric. All rating tables are still maintained in the individual field books.
- Re-inserted Chapter 5: Guidelines to Complete Stressor Checklists.
- Updated the Acronym List
- Removed Appendix I: Protocol for Project Assessment Based on CRAM. This information is now maintained in the CRAM Technical Bulletin (CWMW, 2009).
- Removed Appendix II: Flow Chart to determine plant dominance. This information is maintained in all of the individual field books.
- Removed Appendix 5: Invasive Plant Species List. Please refer to the California Invasive Plant Council website for this information.
- Fixed typos, website addresses, and table of contents

Version 6.0 released March 2012
Changes in this version:

- Removed all of the tables and worksheets from Chapter 4: Guidelines for Scoring CRAM Metrics. This information is now maintained in individual field books.
- Removed some text from Chapter 3: Procedures for Using CRAM. This information is now maintained in individual field books.
- Removed Appendix VI. This information is now maintained in the Vernal Pools field books.
- Updated Appendix III with additional definitions
- Updated References section with additional citations
- Changed authorship, removed original Core and Regional Team information, added L2 Committee members
- Revised several figures and tables
- Replaced Seasonal Estuarine wetland sub-type with Bar-built estuarine wetland sub-type
- Revised wording through out the document to be consistent with recent developments in CRAM and wetland assessment in California.
- Fixed typos; updated heading and table of contents

Version 5.0.2 released 9/30/08
Changes in this version:

- Added section on version history of CRAM methodology and fixed typos

- Added paragraph in Section 2.3.1 to explain separation of assessments of condition and stress
- Added note to Section 3.2.2.2 that the depressional module was primarily based on perennial depressional wetlands and caution should be applied in the interpretation of scores in seasonal depressional wetlands
- Corrected text in various Sections to eliminate inconsistencies in terminology
- Updated figures in Chapter 3
- Revised the ratings for scoring Structural Patch Richness for Estuarine wetlands

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- Minor wording changes for clarification

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- Version numbering changed from 4.6 to 5.0—no other changes

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Changes in this version:

- Substantial changes in nearly all areas
- Changes to metrics included:
  - Wording changes for clarification
  - Added a second "B" rating for scoring Landscape Connectivity for Riverine wetlands
  - Revised the "C" and "D" ratings for scoring Number of Plant Layers Present for Slope and Confined Riverine wetlands

Versions 4.3 - 4.5

- Internal development versions

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- Reorganized volume 2 into three sections: Assessment Forms, Narratives, Tables & Figures; typos fixed

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- Added citation to title page and fixed typos

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Changes in this version:

- Vol 1, p. 15: Table 2.2, added new metric name Plant Community and bulleted its four component submetrics
- Vol 1, p. 36: Added language prescribing the calculation of mean submetric score in order to arrive at Plant Community metric value; in Table 3.8, changed expected maximum value of Biotic Structure attribute from 84 to 36 for Playas and Vernal Pools and 48 for all other wetland classes

- Vol 1, pp. 68-71: Changed "metric" to "submetric" for discussion of the four submetrics of the Plant Community metric
- Vol 2, pp.145-6: removed wrackline or organic debris in channel or on floodplain from worksheet 2 since this patch type is not expected in playas
- Vol 2, p. 55: Revised "D" narrative for number of plants layers present from "No layers are present" to "0-1 layer is present"
- Vol 2, pp. 133, 149, 166: Removed shading from scoring sheet for Interspersion and Zonation since this metric is assessed for vernal pools and playas
- Vol 2: Revised scoring forms to incorporate Plant Community metric

Version 4.2.0 released 8/4/06
Changes in this version:

- Split into two volumes: main manual and assessment forms
- Created separate volume for assessment forms - all supporting documents included with each class
- Updated entrenchment ratio and hydrologic connectivity metric bins
- Revised bins for percent co-dominant species that are non-native
- Added confined v. unconfined diagram
- Revised scoring to a 1-12 scale for all metrics

Version 4.1 released 7/11/06
Changes in this version:

- Separated estuarine class into two sub-classes: saline and non-saline

Version 4.0 released 5/25/06

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EXECUTIVE SUMMARY

Large amounts of public funds and human resources are being invested in the protection, restoration, creation, and enhancement of wetlands in California. The State needs to be able to track the extent and condition of these habitats to evaluate the investments in them now and into the future. The community of wetland scientists, managers, and regulators needs to be able to answer the questions: where are the wetland areas and how are they doing? This need is clearly indicated by the California State Wetlands Conservation Policy.

A consortium of local, state and federal authorities has been developing tools to increase the State's capacity to monitor its wetlands. The effort is guided by the three-level framework for surface water monitoring and assessment issued to the state by the USEPA (USEPA 2006). Level 1 consists of habitat inventories and landscape profiles based on the statewide wetland inventory as mandated by California Assembly Bill 2286, the California Aquatic Resources Inventory, the statewide riparian inventory as planned by the Riparian Habitat Joint Venture, and EcoAtlas of the Regional Data Centers (RDC) being developed by the State Water Resources Control Board and others as part of the California Environmental Data Exchange Network (CEDEN). Level 2 consists of rapid assessment of wetland condition in relation to the broadest suite possible of ecological and social services and beneficial uses. Level 3 consists of standardized protocols for intensive-quantitative assessment of selected services and to validate and explain Level 1 and Level 2 methods and results. All three levels are to be supported by data management systems that enable the State to compile local and regional Level 1-3 data into statewide summary reports. Level 1 and Level 2 methods are supported by open-source, web-based information systems (www.ecoatlas.org and www.cramwetlands.org) that are consistent with existing state and federal environmental databases. Level 3 protocols and results will be added to these information systems as they are developed.

This manual focuses on the California Rapid Assessment Method. CRAM has beendeveloped as a cost-effective and scientifically defensible Level 2 method for monitoring the conditions of wetlands throughout California. The CRAM web site (www.cramwetlands.org) provides access to an electronic version of this manual, training materials, eCRAM and the CRAM database. CRAM results can be uploaded to the database, viewed, and retrieved via the CRAM website using eCRAM. CRAM, eCRAM, and the supporting web sites are public and non-proprietary.

Initial CRAM development had focused on the wetlands of coastal watersheds from Mexico to Oregon. These watersheds in aggregate encompass almost as much variation in climate, geology, and land use as the State as a whole. A special effort was made, however, to involve environmental scientists and managers who are familiar with inland arid montane environments that are not well represented in the coastal watersheds. Seasoned staff from natural resource management and regulatory agencies, NGO science institutions, the private sector, and academia worked together through four coastal Regional Teams and a statewide Core Team to provide the breadth and depth of technical and administrative experience necessary to help assure statewide applicability of CRAM. Since then the ongoing development process has moved inland to include the Central Valley, Inland Empire and Tahoe regions.

CRAM development has incorporated aspects of other approaches to habitat assessment used in California and elsewhere, including the Washington State Wetland Rating System (WADOE

1993), MRAM (Burglund 1999), and ORAM (Mack 2001). CRAM also draws on concepts from stream bio-assessment and wildlife assessment procedures of the California Department of Fish and Wildlife, the different wetland compliance assessment methods of the San Francisco Bay Regional Water Quality Control Board and the Los Angeles Regional Water Quality Control Board, the Releve Method of the California Native Plant Society, and various HGM guidebooks that have been developed in California.

In essence, CRAM enables two or more trained practitioners working together in the field for one half day or less to assess the overall health of a wetland by choosing the best-fit set of narrative descriptions of observable conditions ranging from the worst commonly observed to the best achievable for the type of wetland being assessed. There are four alternative descriptions of condition for each metric of condition. Metrics are organized into four main attributes: (landscape context and buffer, hydrology, physical structure, and biotic structure) for each of six major types of wetlands recognized by CRAM (riverine wetlands, lacustrine wetlands, depressional wetlands, slope wetlands, playas, and estuarine wetlands). To the extent possible, CRAM has been standardized across all these wetland types, and the differences in metrics and narrative descriptions between wetland types have been minimized.

CRAM yields an overall score for each assessed area based on the component scores for the attributes and their metrics. The alternative narrative description for each metric has a fixed numerical value. An attribute score is calculated by combining (methods vary by attribute type) the values of the chosen narrative descriptions for the attribute's component metrics, and then converting the result into a percentage of the maximum possible score for the attribute. The overall score for an area is calculated by averaging the four final attribute scores . The maximum possible score represents the best condition that is likely to be achieved for the type of wetland being assessed. The overall score for a wetland therefore indicates how it is doing relative to the best achievable conditions for that wetland type in the state. Local conditions can be constrained by unavoidable land uses that should be considered when comparing wetlands from different land use settings.

CRAM also provides guidelines for identifying stressors that might account for low scores. Evident stressors are characterized as present or present and having a significant negative effect on an attribute score. The stressor checklist allows researchers and managers to explore possible relationships between condition and stress, and to identify actions to counter stressor effects.

CRAM is a cost-effective ambient monitoring and assessment tool that can be used to assess condition on a variety of scales, ranging from individual wetlands to watersheds and larger regions. Applications could include preliminary assessments to determine the need for more intensive analysis; supplementing information during the evaluation of wetland condition to aid in regulatory review under Section 401 and 404 of the Clean Water Act or other wetland regulations; and assisting in the assessment of restoration or mitigation projects by providing a rapid means of checking progress along a particular restoration trajectory. CRAM is not intended to replace any existing tools or approaches to monitoring or assessment, and will be used at the discretion of each individual agency to complement preferred approaches. Quality assurance and control practices have been developed to ensure that CRAM is appropriately applied in ambient and regulatory applications (California Wetland Monitoring Workgroup 2009).

CHAPTER 1: NEED, GOAL, STRATEGIC CONTEXT, INTENDED USES, AND GEOGRAPHIC SCOPE

1.0 Introduction

This document is the User's Manual for the California Rapid Assessment Method (CRAM) for Wetlands and Riparian Areas. Chapter 1 presents the rationale for CRAM, including why it's needed, its primary goal, its strategic context, intended uses, and the geographic scope of its applicability. Chapter 2 covers key terms, the conceptual framework for CRAM, and its development process. Chapter 3 describes the basic steps of the methodology. Chapter 4 provides background information and rationale for each of the metrics and attributes. Chapter 5 describes the guidelines to completing the stressor checklist.

1.1 Statement of Need

Large amounts of public and private funds are being invested in policies, programs, and projects to protect, restore, and manage wetlands in California. Most of these investments cannot be evaluated, however, because the ambient conditions of wetlands are not being monitored, the methods to monitor individual wetland areas are inconsistent, and there is little assurance of data quality. Furthermore, the results of monitoring are not readily available to analysts and decision makers. CRAM is a new approach that can provide consistent, scientifically defensible, affordable information about wetland conditions throughout California.

1.2 Justification for Rapid Assessment

The three most significant obstacles to developing adequate information about the conditions of California wetlands are (1) the lack of regional or statewide inventories of wetlands and related projects; (2) the high costs of conventional assessment methods; and (3) the lack of an information management system to support regional or statewide wetland assessments. The USEPA has developed a 3-tiered framework for comprehensive assessment and monitoring of surface waters that can guide efforts to overcome these obstacles (USEPA 2006).

> Level 1. Level 1 is a series of tools for landscape-level analysis of the State's aquatic resources. The toolbox consists of a Geographic Information System (GIS)-based inventory of aquatic resources (streams, wetlands, and riparian areas), data visualization, and landscape summary tools. The California Aquatic Resource Inventory, or CARI, is a standardized and comprehensive map of the State's aquatic resources and is essential for identifying their absence or presence and describing their geographic distribution and abundance. While there are various efforts to map wetlands on regional, county, and local levels, CARI is the primary wetland inventory for the State [http://www.sfei.org/it/gis/cari]. CARI is compatible with the National Wetlands Inventory (NWI) of the USFWS and the National Hydrography Dataset (NHD) of the USGS and also meets the needs of regional scientists, managers, and regulators. In addition to CARI, the State is continuing to track wetland restoration, enhancement, and mitigation projects that can be used to assess the cumulative effect of these projects on the extent and overall ambient condition of wetlands. EcoAtlas, an on-line visualization tool, houses these important aquatic resource inventories and allows

for dynamic querying and summarizing of information (www.ecoatlas.org). The landscape profile tool within EcoAtlas allows users to select a geographic area of interest and summarize various data layers within that area to produce a report of the following information: acreage of aquatic resources (existing and historical), CRAM scores, wetland projects, land cover, and census.

The Level 1 toolbox, aquatic resource inventory, project tracking, data visualization, and data analysis tools will aid wetland conservation planning by displaying aquatic resources in the context of other data layers. They will also serve as sample frames for objective, probabilistic surveys of the ambient condition of wetlands and for assessing the effects of projects and other management actions on the ambient wetland condition at various scales ranging from local watersheds to the State as a whole. Through CARI and EcoAtlas, the State can overcome the obstacle of not having an adequate inventory of wetlands and related projects to track changes in their extent and condition or the ability to holistically show and dynamically analyze information that contribute to the health and condition of wetlands.

Level 2. Level 2 methods assess the existing condition of a wetland relative to its broadest suite of suitable functions, services, and beneficial uses, such as flood control, groundwater recharge, pollution control, and wildlife support, based on the consensus of best professional judgment. In this regard, a level 2 assessment represents the overall functional capacity of a wetland. To be valid, rapid assessments must be strongly correlated to Level 3 measures of actual functions or services. Once validated, Level 2 assessments can be used where Level 3 data are lacking or too expensive to collect. Level 2 assessments can thus lessen the amount and kinds of data needed to monitor wetlands across large areas over long periods. CRAM is the most completely developed and tested Level 2 method for California at this time.

Level 3. Level 3 provides quantitative data about selected functions, services, or beneficial uses of wetlands. Such data are needed to develop indicators, to develop standard techniques of data collection and analysis, to explore mechanisms that account for observed conditions, to validate Level 1 and 2 methods, and to assess conditions when the results of Level 1 and Level 2 efforts are too general to meet the needs of wetland planners, managers, or regulators.

CRAM is based on a growing body of scientific literature and practical experience in the rapid assessment of environmental conditions. Several authors have reviewed methods of wetland assessment (Margules and Usher 1981, Westman 1985, Lonard and Clairain 1986, Jain *et al.* 1993, Stein and Ambrose 1998, Bartoldus 1999, Carletti *et al.* 2004, Fennessy *et al.* 2004). Most methods differ more in the details of data collection than in overall approach. In general, the most useful approaches focus on the visible, physical and/or biological structure of wetlands, and they rank or categorize wetlands along one or more stressor gradients (Stevenson and Hauer 2002). The indicators of condition are derived from intensive Level 3 studies that show relationships between the indicators, high-priority functions or ecological services of wetlands, and anthropogenic stress, such that the indicators can be used to assess the effects of management actions on wetland condition.

Existing methods have been used to assess wetlands at a variety of spatial scales, from habitat patches within local projects, to watersheds and regions of various sizes. Methods that are designed to assess large areas, such as the Synoptic Approach (Leibowitz *et al.* 1992), typically produce coarser and more general results than site-specific methods, such as the Hydrogeomorphic Method (HGM; Smith *et al.* 1995, Smith 2000) or the Index of Biotic Integrity (IBI; Karr 1981). Each scale of wetland assessment provides different information. Furthermore, assessments at different scales can be used for cross-validation, thereby increasing confidence in the approach being used. A comprehensive wetland monitoring program might include a variety of methods for assessing wetlands at different scales.

Existing methods also differ in the amount of effort and expertise they require. Methods such as the Wetland Rapid Assessment Procedure (WRAP; Miller and Gunsalus 1997) and the Descriptive Approach (USACOE 1995), are extremely rapid, whereas the Habitat Evaluation Procedure (HEP; USFWS 1980), the New Jersey Watershed Method (Zampella *et al.* 1994), and the Bay Area Watersheds Science Approach (WSA version 3.0, Collins *et al.* 1998), are much more demanding of time and expertise.

None of the existing methods other than CRAM can be applied equally well to all kinds of wetlands in California. The HGM and the IBI are the most widely applied approaches in the U.S. While they are intended to be rapid, they require more time and resources than are usually available, and both have a somewhat limited range of applicability. For example, IBIs are developed separately for different ecological components of wetland ecosystems, such as vegetation and fish, and for different types of wetlands, such as wadeable streams and lakes. HGM guidebooks are similarly restricted to one type of habitat, such as vernal pools or riverine wetlands, and they are typically restricted to a narrowly defined bioregion. Some guidebooks are restricted to individual watersheds. Trial applications of rapid assessment methods developed for other states, including the Florida WRAP and the Ohio Rapid Assessment Method (ORAM; Mack 2001) in California coastal watersheds indicated that significant modifications of these methods would be required for their use in California, and lead to developing CRAM.

1.3 Goal and Intended Use

The overall goal of CRAM is to:

> *Provide rapid, scientifically defensible, standardized, cost-effective assessments of the status and trends in the condition of wetlands and the performance of related policies, programs and projects throughout California.*

CRAM has beendeveloped as a rapid assessment tool to provide information about the condition of a wetland and the stressors that affect that wetland. CRAM is intended for cost-effective ambient monitoring and assessment that can be performed on different scales, ranging from an individual wetland, to a watershed or a larger region. It can be used to develop a picture of reference condition for a particular wetland type or to create a landscape-level profile of the conditions of different wetlands within a region of interest. This information can then be used in planning wetland protection and restoration activities. Additional applications could include:

- *preliminary* assessments to determine the need for more traditional intensive analysis or monitoring;

- providing *supplemental* information during the evaluation of wetland condition to aid in regulatory review under Section 401 and 404 of the Clean Water Act, the Coastal Zone Management Act, Section 1600 of the Fish and Game code, or local government wetland regulations; and
- *assisting* in the monitoring and assessment of restoration or mitigation projects by providing a rapid means of checking progress along restoration trajectories.

CRAM is *not* intended to replace any existing tools or approaches to monitoring or assessment, and will be used at the discretion of each individual agency to complement preferred approaches. Wetland impact analysis and compensatory mitigation planning and monitoring for larger wetland areas that exhibit more complex physical and biological functions will typically require more information than CRAM will be able to provide.

1.4 Related Rapid Assessment Efforts in California and Other States

Development of CRAM has incorporated concepts and methods from other wetland assessment programs in California and elsewhere, including the Washington State Wetland Rating System (WADOE 1993), MRAM (Burglund 1999), and ORAM (Mack 2001). CRAM also draws on concepts from stream bio-assessment and wildlife assessment procedures of the California Department of Fish and Wildlife, the different wetland compliance assessment methods of the San Francisco Bay Regional Water Quality Control Board and the Los Angeles Regional Water Quality Control Board, the Releve Method of the California Native Plant Society, and various HGM guidebooks that are being used in California.

1.5 Geographic Scope

CRAM is intended for application to all kinds of wetlands throughout California. Although centered on coastal watersheds through much of the initial development process, it has now spread inland to the Central Valley, Inland Empire and Tahoe regions. CRAM development to date has involved scientists and managers from other regions to account for the variability in wetland type, form, and function that occurs with physiographic setting, latitude, altitude, and distance inland from the coast. Validation efforts have indicated that CRAM is broadly applicable throughout the range of conditions commonly encountered. However, since CRAM emphasizes the functional benefits of structural complexity, it may yield artificially low scores for wetlands that do not naturally appear to be structurally complex. CRAM should therefore be used with caution in such wetlands. This can include riverine wetlands in the headwater reaches of very arid watersheds, montane depressional wetlands above timberline, and vernal pools on exposed bedrock. Future refinements of CRAM will be used to adjust CRAM metrics as needed to remove any systematic bias against any particular kinds of wetlands or their settings[1].

1.6 Supporting Information Systems

Information management is an essential part of a successful program of environmental monitoring and assessment. CRAM is supported by a public web site (www.cramwetlands.org) that provides downloadable versions of this User's Manual, training materials, and access to an

[1] The riverine and module of CRAM will be revised based on additional field work during FY 2012-14 to better accommodate assessment of arid headwater and other types of aridland streams.

open-source database that allows registered CRAM practitioners to upload, view, and download CRAM results (eCRAM). The CRAM website and database are being developed in the context of a broad initiative in California to improve data and information sharing throughout the community of environmental scientists, managers, and the concerned public. The California Wetlands Monitoring Workgroup (CWMW) has developed the California Wetlands Portal (waterboards.ca.gov/mywaterquality/eco_health/wetlands/) as a mechanism to improve communication with the public about the extent and condition of California's wetland resources.

1.7 Organization and Coordination to Develop CRAM

An organization was created to foster collaboration and coordination among the regional CRAM developers. USEPA awarded Wetland Program Development Grants through Section 104b(3) of the US Clean Water Act to the Southern California Coastal Water Research Project (SCCWRP), to a partnership of the Association of Bay Area Governments (ABAG) and the San Francisco Estuary Institute (SFEI), to a partnership of the Central Coast District of the California Coastal Commission (CCC) and the Moss Landing Marine Laboratories (MLML), and to the North Coast Region of the California Department of Fish and Wildlife (CDFW) to develop and begin implementing Level 1-3 methods, with an emphasis on Level 2 (CRAM) and information management. The Principal Investigators (PIs) worked with sponsoring agencies to form a statewide Core Team and Regional Teams that have provided the breadth and depth of technical and administrative experience necessary to develop and begin implementing CRAM.

1.7.1 Core Team

The Core Team fostered collaboration and coordination among the regions to produce a rapid assessment method that is consistent for all kinds of wetlands throughout California. The Core Team consists of the PIs plus technical experts in government agencies, non-governmental organizations, and academia. Core Team members are listed in the acknowledgments at the front of this document. The Core Team set the direction for the PIs and the Regional Teams, reviewed their products, and promoted CRAM to potential user groups.

1.7.2 Regional Teams

The Regional Teams advised and reviewed the work of the PIs to ensure that CRAM addressed regional differences in wetland form, structure, and ecological service. Members of the Regional Teams assisted in the verification and validation of CRAM, and provided feedback through the PIs to the Core Team about the utility of CRAM in the context of regional wetland regulation and management. Each Regional Team consisted of the PIs, local and regional wetland experts having experience with assessment methodologies, Core Team members who work within the region, and technical representatives from potential user groups.

1.7.3 Institutional Support

In 2010, the California Water Quality Monitoring Council (Kehoe 2006) directed the California Wetland Monitoring Workgroup (CWMW) to create a Level 2 Committee to coordinate the review, development and implementation of CRAM and other rapid assessment methods for all state agencies. CRAM is a core methodology of the Wetland and Riparian Area Monitoirng Plan (WRAMP), a statewide strategy developed by the CWMW to coordinate ongoing wetland monitoring and assessment efforts that consists of standardized methods to monitor the distribution, abundance, and condition of wetlands and riparian areas throughout California.

CRAM is also proposed as a key element of the State Water Board's emerging Wetland and Riparian Area Protection Policy (State Water Board Resolution No. 2008-0026) and is currently being tested by many other state and federal agencies for application to various regulatory and non-regulatory programs.

CHAPTER 2:
KEY TERMS, CONCEPTS, ASSUMPTIONS, AND DEVELOPMENTAL PROCESS

2.0 Overview

CRAM uses standardized definitions for key terms, including "wetland," "disturbance," "stress," and "condition." CRAM is based on basic assumptions about functional relationships between condition and function or ecological service, and about the spatial relationships between stress and condition, as explained below. Please see Appendix I for a complete Glossary of terms.

2.1 Key Terms

Assessment Area (AA). An AA is the portion of a wetland that is the subject of a CRAM assessment. Multiple AAs might be needed to assess large wetlands. Rules for delineating an AA are presented in Section 3.5.

Stress. Stress is the consequence of anthropogenic events or actions that measurably affect conditions in the field. The key stressors tend to reduce the amount of wetlands, or they significantly decrease the quantity and/or quality of sediment supplies and/or water supplies upon which the wetlands depend. Gradients of stress result from spatial variations in the magnitude, intensity, or frequency of the stressors.

Disturbance. Disturbance is the consequence of natural phenomena, such as landslides, droughts, floods, wildfires, and endemic diseases that measurably affect conditions in the field.

Condition. The condition of a wetland is the state of its physical and biological structure and form relative to their best achievable states.

Buffer. For the purposes of CRAM, the buffer is the area outside the assessment area, including adjoining uplands and other wetland areas that can reduce the effects of stressors on the wetland's condition.

Landscape Context. The landscape context of a wetland consists of the lands, waters, and associated natural processes and human uses that directly affect the condition of the wetland or its buffer.

Ecological Services or Beneficial Uses. These are the benefits to society that are afforded by the conditions and functions of a wetland. Key ecological services for many types of wetlands in California include flood control, shoreline and stream bank protection, groundwater recharge, water filtration, conservation of cultural and aesthetic values, and support of endemic biological diversity.

Attribute. Attributes are categories of metrics used to assess condition of the wetland as well as its buffer and landscape context. There are four CRAM attributes: Buffer and Landscape Context, Hydrology, Physical Structure, and Biotic Structure.

Metric. A metric is a measurable component of an attribute. Each metric should be field-based (Fennessy *et al.* 2004), ecologically meaningful, and have a dose-dependent response to stress that can be distinguished from natural variation across a stressor gradient (Barbour *et al.* 1995).

Narrative Descriptions of Alternative States. For each type of wetland, the narrative descriptions of alternative states represent the full range of possible condition from the worst conditions that are commonly observed to the best achievable conditions, for each metric of each attribute in CRAM.

Indicators. These are visible clues or evidence about field conditions used to select the best-fit narrative description of alternative states for CRAM metrics.

Metric Score. The score for a CRAM metric is the numerical value associated with the narrative description of an alternative state that is chosen because it best-fits the condition observed at the time of the assessment.

Attribute Score. An attribute score is the percent of the maximum possible combination of the metric scores for the attribute.

CRAM Index Score or Overall Score. A CRAM Indx score or Overall score indicates the overall condition of an Assessment Area. It is calculated as the average of the four final attribute scores for the Assessment Area.

2.2 Conceptual Framework

CRAM was developed according to a set of underlying conceptual models and assumptions about the meaning and utility of rapid assessment, the best framework for managing wetlands, the driving forces that account for their condition, and the spatial relationships among the driving forces. These models and assumptions are explicitly stated in this section to help guide the interpretation of CRAM scores.

2.2.1 Management Framework

The management framework for CRAM is the Pressure-State-Response model (PSR) of adaptive management (Holling 1978, Bormann *et al.* 1994, Pinter *et al.* 1999). The PSR model states that human operations, such as agriculture, urbanization, recreation, and the commercial harvest of natural resources can be sources of stress or *pressure* affecting the condition or *state* of natural resources. The human *responses* to these changes include any organized behavior that aims to reduce, prevent or mitigate undesirable stresses or state changes. Natural resource protection depends on monitoring and assessment to understand the relationships between stress, state, and management responses. The managers' concerns guide the monitoring efforts, and the results of the monitoring should influence the managers' actions and concerns.

Assessment approaches vary in that they may evaluate any or all aspects of the pressure-state-response model. Pressure indicators describe the variables that directly cause (or may cause) wetland problems, such as discharges of fill or urban encroachment. State indicators evaluate the current condition of the wetland, such as plant diversity or concentration of a particular contaminant in the water. Response indicators demonstrate the efforts of managers to address the wetland problem, such as the implementation of best management practices. The approach used by CRAM is to focus on *condition* or *state*. A separate stressor checklist is then used to note

which, if any, stressors appear to be exerting *pressure* affecting condition. It is assumed that managers with knowledge of pressures and states will exact more effective *responses*.

The PSR framework is a simple construct that can help organize the monitoring components of adaptive management. It can be elaborated to better represent complex systems involving interactions and nonlinear relations among stressors, states and management responses (e.g., Rissik *et al.* 2005) For the purposes of CRAM, the PSR model is simply used to clarify that CRAM is mainly intended to described state conditions of wetlands.

2.2.2 Rapid Assessment

CRAM embodies the basic assumption of most other rapid assessment methods that ecological conditions vary predictably along gradients of stress, and that the conditions can be evaluated based on a fixed set of observable indicators. CRAM metrics were built on this basic assumption according to the following three criteria common to most wetland rapid assessment methods (Fennessy *et al.* 2004):

1. *the method should assess existing conditions* (see Section 2.1 above), without regard for past, planned, or anticipated future conditions;
2. *the method should be truly rapid,* meaning that it requires two people no more than one half day of fieldwork plus one half day of subsequent data analysis to complete; and
3. *the method is a site assessment* based on field conditions and does not depend largely on inference from Level 1 data, existing reports, opinions of site managers, etc.

2.2.3 Forcing Functions, Stress, Buffer, and Condition

The condition of a wetland is determined by interactions among internal and external hydrologic, biologic (biotic), and physical (abiotic) processes (Brinson, 1993). CRAM is based on a series of assumptions about how these processes interact through space and over time. First, CRAM assumes that the condition of a wetland is mainly determined by the quantities and qualities of water and sediment (both mineral and organic) that are either processed on-site or that are exchanged between the site and its immediate surroundings. Second, the supplies of water and sediment are ultimately controlled by climate, geology, and land use. Third, geology and climate govern natural disturbance, whereas land use accounts for anthropogenic stress. Fourth, biota (especially vegetation) tend to mediate the effects of climate, geology, and land use on the quantity and quality of water and sediment (Figure 2.1). For example, vegetation can stabilize stream banks and hillsides, entrap sediment, filter pollutants, provide shade that lowers temperatures, reduce winds, etc. Fifth, stress usually originates outside the wetland, in the surrounding landscape or encompassing watershed. Sixth, buffers around the wetland can intercept and otherwise mediate stress (Figure 2.2).

2.2.4 Condition, Ecological Service, and CRAM Scores

Three major assumptions govern how wetlands are scored using CRAM. First, it is assumed that the societal value of a wetland (i.e., its ecological services) matters more than whatever intrinsic value it might have in the absence of people. This assumption does not preclude the fact that the support of biological diversity is a service to society. Second, it is assumed that the value depends more on the diversity of services than the level of any one service. Third, it is assumed

that the diversity of services increases with structural complexity and size. CRAM therefore favors large, structurally complex examples of each type of wetland.

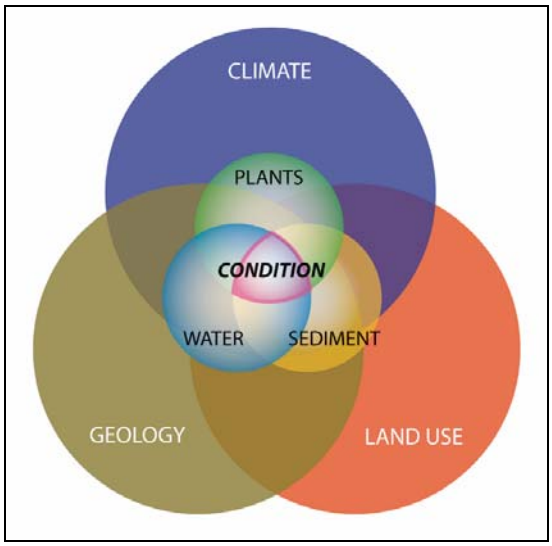


Figure 2.1: Spatial hierarchy of factors that control wetland conditions, which are ultimately controlled by climate, geology, and land use.

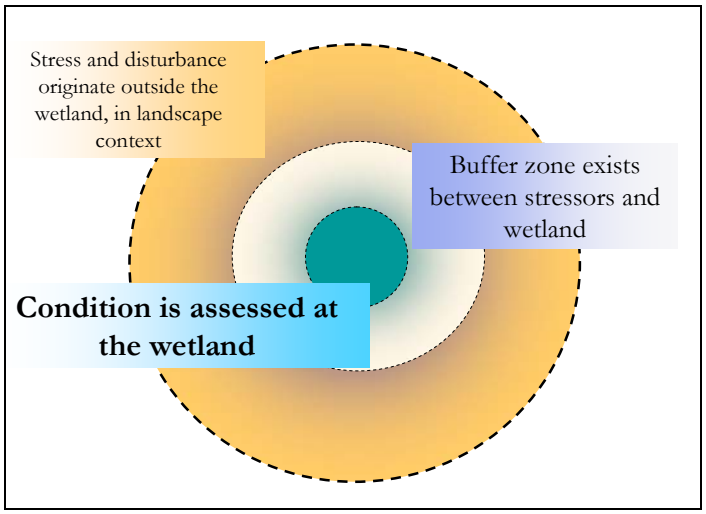


Figure 2.2: Spatial hierarchy of stressors, buffers, and wetland condition. Most stressors originate outside the wetland. The buffer exists between the wetland and the sources of stress, and serves to mediate the stress

2.3 Developmental Framework

The CRAM developmental process consisted of nine steps with distinct products organized into three phases: basic design, calibration, and validation (Table 2.1).

Table 2.1: Basic outline of CRAM development.

Core Team	Basic Design Phase	Develop conceptual models of wetland form and function
		Identify universal Attributes of wetland condition
		Nominate Metrics of the Attributes
		Nominate descriptions of alternative states for each Metric
Core and Regional Teams	Calibration Phase	Clarify and revise the Metrics and narrative descriptions of alternative states based on regional team input and inter- and intra-team comparisons
		Develop a checklist to identify stressors
		Test and select methods of scaling and weighting Attributes and Metrics
		Test and select formulas for calculating Attribute scores and AA scores
	Validation Phase	Validate Metrics and Attributes using Level 3 data
		Conduct independent peer review
		Provide outreach and training

2.3.1 Basic Design

This phase of CRAM development involved creating conceptual models of wetland form and function, defining key terms, developing the wetland typology, identifying the attributes, and formulating metrics that describe each attribute. The basic design work was done primarily through initial field-testing and feedback by Regional Teams and the Core Team. Version 2.0 of CRAM marked the completion of the basic design phase.

Each CRAM attribute is represented by a set of metrics (Table 2.2 below), and each metric is represented by a set of mutually exclusive narrative descriptions of alternative states. In aggregate, the alternative states of all the metrics for any type of wetland represent its full range of visible form and structure.

An effort was made to separate assessments of condition from assessments of stress. This was done to explore correlations between stress and condition. For example, CRAM AAs can be grouped according to their associated stressors, and the groups can be compared based on their CRAM scores. The separation has been difficult to achieve, however. For example, the Plant Community metric of the Biotic Structure attribute includes a sub-metric about the relative abundance of non-native plant species, although biological invasion is usually considered a significant stressor. Some autocorrelation can therefore be expected between stress and condition as assessed using the current version of CRAM

2.3.2 Verification

The verification phase was used to determine if the draft wetland classification scheme, the attributes, the metrics, and the narrative descriptions of alternative states were (1) clear and understandable; (2) comprehensive and appropriate; (3) sensitive to obvious variations in condition; (4) able to produce similar scores for areas subject to similar levels of the same kinds of stress; and (5) tended to foster repeatable results among different practitioners. The verification phase was also used to test and select methods of calculating, scaling, and weighting scores for metrics, attributes, and AAs.

Verification involved iterative adjustments to the classification system and the metrics during multiple field tests by each Regional Team. The amount of revision has declined steadily, but minor changes are expected to continue as the number of CRAM users and the amount of its use increases. For the CRAM version used in the Validation Phase, all the regional teams were able to meet the targeted within-team and between-team QAQC standards of 10% and 20%, respectively, for each metric.

Table 2.2: CRAM Attributes, Metrics, and submetrics

Attributes		Metrics and Submetrics
Buffer and Landscape Context		Aquatic Area Abundance or Steam Corridor Continuity
		Stream Corridor Continuity (Bar-built estuaries only)
		Aquatic Area in Adjacent Landscape (Bar-built estuaries only)
		Marine Connectivity (Bar-built estuaries only)
		Buffer:
		Percent of AA with Buffer
		Average Buffer Width
		Buffer Condition
Hydrology		Water Source
		Hydroperiod or Channel Stability
		Hydrologic Connectivity
Structure	Physical	Structural Patch Richness
		Topographic Complexity
	Biotic	Plant Community:
		Number of Plant Layers Present or Endemic Species Richness (vernal pools only)
		Number of Co-dominant Species
		Percent Invasion
		Horizontal Interspersion
		Vertical Biotic Structure

2.3.3 Validation

The purpose of the validation phase was to assess the overall performance of CRAM by regressing metric scores and attribute scores on Level 3 data representing expected relationships between condition and function or service (Table 2.3). The same models were used to guide alternative approaches for weighting and combining scores. CRAM performed best using the simplest combination rules without any weighting. The level of performance was adequate for the functions and services represented by the selected Level 3 data. The validation phase for estuarine wetlands and riverine/riparian systems was completed with CRAM version 4.0. The other types of wetlands will be validated as CRAM is implemented. The current status of development of each of the CRAM wetland modules is available on the CRAM website (www.cramwetlands.org).

Table 2.3: Expected relationships among CRAM attributes, metrics, and key services.

KEY SERVICES	**Buffer and Landscape Context**	**Hydrology**			**Physical Structure**		**Biotic Structure**				
	Buffer and Landscape Connectivity Metrics	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	Structural Patch Richness	Topographic Complexity	Number of Plant Layers	Number of Co-dominant Species and Endemic Species Richness	Percent Invasion	Horizontal Interspersion and Zonation	Vertical Biotic Structure
Short- or long-term surface water storage	X		X	X	X	X				X	X
Subsurface water storage		X	X	X		X					
Moderation of groundwater flow or discharge	X	X									
Dissipation of energy					X	X	X			X	X
Cycling of nutrients	X		X	X	X	X	X	X	X		X
Removal of elements and compounds	X		X	X		X	X			X	
Retention of particulates			X	X	X	X	X	X		X	
Export of organic carbon			X	X			X		X	X	X
Maintenance of plant and animal communities	X		X	X	X	X	X	X	X	X	X

CHAPTER 3:
PROCEDURES FOR USING CRAM

3.0 Summary

The general procedure for using CRAM consists of eight (8) steps (Table 3.1).

Table 3.1: Steps for using CRAM.

Step 1	Assemble background information about the management of the wetland.
Step 2	Classify the wetland using the CRAM typology and this manual (see Section 3.2 and Figure 3.2).
Step 3	Verify the appropriate season and other timing aspects of the field assessment.
Step 4	Estimate the boundary of the AA in the office (subject to field verification).
Step 5	Conduct the office assessment of stressors and on-site conditions of the AA.
Step 6	Conduct the field assessment of stressors and on-site conditions of the AA.
Step 7	Complete CRAM assessment scores and QA/QC Procedures.
Step 8	Upload CRAM results into statewide information data management system.

3.1 Step 1: Assemble Background Information

CRAM assessments are aided by background information about the management objectives, history, known or expected stressors, and general ecological character of the wetland to be assessed. Background materials may include the following (Table 3.2).

Table 3.2: Example of background materials.

- USGS topographic quadrangles, National Wetlands Inventory (NWI), State Wetlands Inventory, road maps, and other maps of geology, soils, vegetation, land uses, etc.
- Air photos and other imagery, preferably geo-rectified with 1-3 m. pixel resolution.
- California Natural Diversity Database (CNDDB) search results.
- Relevant reports on geology, geotechnical conditions, hydrology, soils, environmental impacts, cultural history, land use, restoration and mitigation projects, management plans, etc., from water districts, flood control districts, open space districts, state and federal agencies, etc.

3.2 Step 2: Classify the Wetland according to the CRAM typology

Wetland classification requires the application of a standard wetland definition followed by the application of a standard typology or classification system.

3.2.1 General Definitions of Wetlands and Riparian Areas

CRAM employs the following wetland definition recommended by the Technical Advisory Team (TAT) to the SWRCB Policy Development Team for the California Wetland and Riparian Area Protection Policy (WRAPP):

> *An area is **wetland** if, under normal circumstances, (1) the area has continuous or recurrent saturation of the upper substrate caused by groundwater or shallow surface water or both; (2) the duration of such saturation is sufficient to cause anaerobic conditions in the upper substrate; and; (3) the area either lacks vegetation or the vegetation is dominated by hydrophytes (SFEI-ASC 2009).*

This definition reflects current scientific understanding of the formation and functioning of wetlands (Lewis *et al.* 1995, Mitsch and Gosselink 2007) and uses field indicators of hydrology, substrate condition, and plant community composition to distinguish wetland areas from other areas of a landscape. This is commonly regarded as the "three-criterion approach" to defining, identifying, and delineating wetland areas in the field (Tiner 1999). Hydrology is the dominant factor in wetland formation because it controls the development of anaerobic chemical conditions, and thus strongly influences the abundance of plant species tolerant of such conditions (Voesenek *et al.* 2003) or indicative of them (Reed 1988).

This wetland definition recognizes that all three criteria might not be evident or present in some areas that provide wetland functions, beneficial uses, or ecological services at some times of the year or in some years (especially during prolonged dry periods), and that some of these areas lack vegetation and therefore may satisfy only two criteria (i.e., wetland hydrology and hydric substrates). The vegetation criterion in this definition requires dominance by hydrophytes only when the wetland is vegetated. That is, non-vegetated areas that satisfy the hydrology and substrate criteria, such as some tidal flats, playas, and shallow non-vegetated ponds, are still considered wetlands. The definition also includes wetland creation, restoration, enhancement, and mitigation sites that have not yet been colonized by vegetation.

CRAM is intended to assess "condition" in wetland areas that satisfy the criteria according to the above definition. However, because CRAM was originally designed to assess vegetated wetlands, meaning wetlands that support at least 5% cover of vegetation during the peak growing season, CRAM may have limited applicability in non-vegetated wetlands (e.g. tidal flats, mudflats) or any wetlands with less than 5% cover of vegetation. While the current version of CRAM can be used in these systems, this must be appropriately annotated in the comments section of the CRAM Basic Information page and the Plant Community metric so that the results of these assessments can be tracked and, if necessary, additional metrics or modules can be proposed.

For the purposes of CRAM, an assessable wetland is further defined as the portion of a discrete area of wetland habitat (as defined by the Draft SWRCB Policy) that is large enough to contain one or more CRAM Assessment Areas (AAs). An assessable wetland may be the same size as an AA or larger than multiple AAs, but it is never smaller than an AA (see AA delineation guidelines in Section 3.5 and AA size recommendations in Table 3.7 below). This modification is necessary to convert a Level 1 wetland inventory based on the TAT definition into a sample frame for ambient surveys of wetland condition using CRAM. A sample frame is a list or map of every wetland or potential CRAM AA within the population of wetlands to be surveyed (Särndal *et al.* 1992).

CRAM recognizes that all wetlands have some amount of adjacent riparian area that reflect various ecological and/or physical processes and local management. For this reason, CRAM employs the riparian definition provided by the US National Research Council (NRC):

> *"**Riparian Areas** are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes and biota. They are areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems. Riparian areas are adjacent to perennial, intermittent, and ephemeral streams, lakes and estuarine-marine shorelines" (National Research Council 2002).*

The same functions typically associated with wetlands are, to varying degree, also associated with its accompanying riparian areas (National Research Council 2002). The riparian areas adjacent to rivers and stream corridors are particularly connected through various ecological and hydrological processes. Although the term "riparian" has traditionally been synonymous with "woody" vegetation occurring at the edge or margin of a wetland, many wetlands often contain a woody riparian vegetation component within the boundary of the wetland itself. In other instances, riparian areas only occur outside the wetland boundary, where they may function at various distances from the wetland edges to "buffer" wetland conditions. Some wetlands may lack a woody vegetation component entirely. Individual CRAM AAs for some wetland types (such as riverine) may always include the portions of the adjacent riparian area. For other types of wetlands (such as depressional or estuarine), AAs may occur near the edge of the wetland and include riparian areas, or in the interior of a wetland and lack riparian areas.

The boundaries of a wetland can be determined on the basis of a jurisdictional delineation (JD; this requires compliance with established standards in approved regulatory reference documents; e.g., the 1987 USACE Manual and the two Regional Supplements, pursuant to the federal Clean Water Act), and may be approximated from mapping such as the National Wetland Inventory (NWI). A JD is especially useful for determining the boundaries of a wetland when assessing impacted sites or mitigation sites as defined under Section 404 of the Clean Water Act (CWA). Identifying wetlands under the Draft SWRCB Wetland Policy (2013) is based on similar wetland identification criteria to those used by the US Army Corps of Engineers (USACE) and US Environmental Protection Agency (USEPA) under Section 404 of the CWA, and delineation is proposed to be based on the same references as for the federal program.

If the wetland cannot be identified from an existing inventory or a JD, then its boundaries should be sketched on the base imagery for the CRAM assessment, using Best Professional Judgement and the general guidelines in Table 3.3 and Figure 3.1 below. A sketch map based on these guidelines cannot replace results from a JD,or the NWI. Although a JD is helpful in identifying the boundaries of a wetland where a CRAM assessment is to be conducted, it is NOT a prerequisite for conducting CRAM. CRAM can still be conducted on wetlands that do not have an associated JD. In most cases, however, wetland and "riparian" boundaries are based on features that can only be identified with certainty during field evaluations

Table 3.3: Guidelines to delineate a wetland for the purpose of CRAM.

Delineating Feature	Description of Features
Backshore	The backshore of a wetland is the boundary between the wetland and the adjoining upland, where the upland is at least 5m wide. The high-water contour of the wetland is a good proxy for its backshore boundary.
Foreshore	The foreshore of a wetland is the boundary between the vegetated wetland and any adjoining semi-aquatic, non-wetland area, such as an intertidal flat or a non-vegetated riverine channel bar, or a fully aquatic area such as the open water area of a lake or estuary that is at least 30m wide.
Adjoining Wetland	Any wetland that is mostly less than 5m distant from the wetland being assessed is an adjoining wetland.

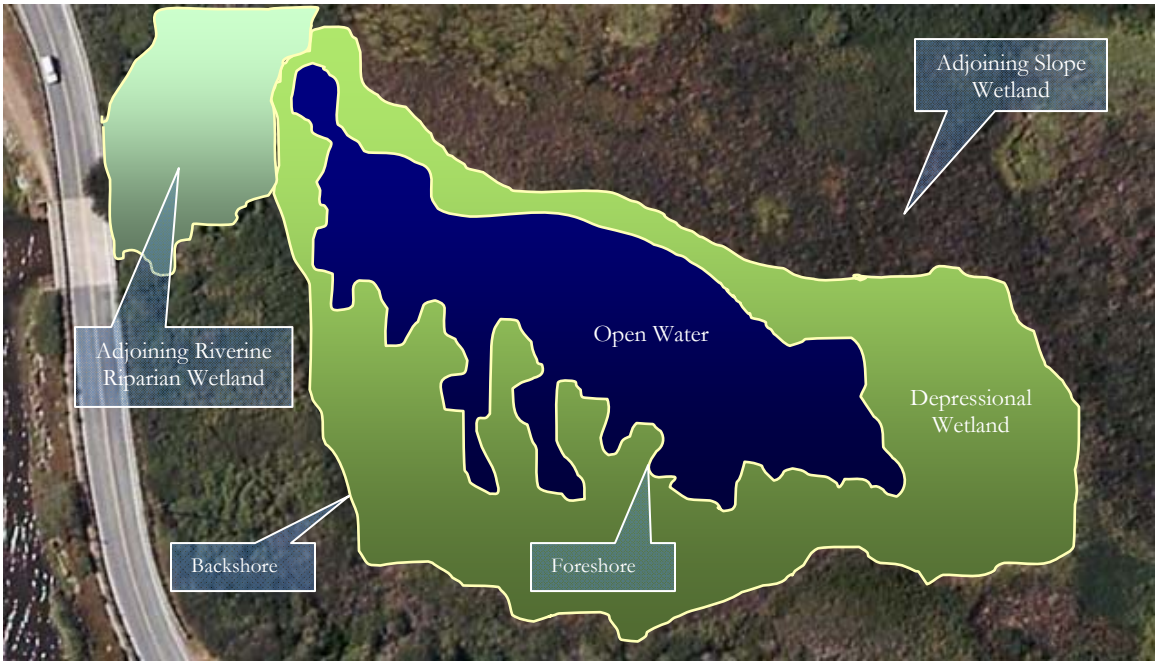


Figure 3.1: Using the backshores, foreshores, and the boundaries between wetland types to delineate a wetland.

3.2.2 Wetland Typology

CRAM provides excellent support for aquatic resource condition assessment in California. Its typology is based on a functional classification approach similar to HGM (Brinson 1993) that uses geomorphic setting, water source, and hydrology to infer function and ecology. CRAM "modules" were developed in direct response to California's assessment and policy needs, and includes many rare wetland types for California, such as vernal pools. CRAM typology supports the Wetland and Riparian Area Monitoring Plan (WRAMP) of the California Wetlands Monitoring Workgroup (CWMW; CWMW 2010). Furthermore, CRAM typology can be cross-walked to other classification systems as needed and allows for seamless integration between Level 1 mapping and Level 2 condition assessment in California.

At this time, CRAM modules have been developed for six major aquatic resource types, four of which have sub-types (Table 3.4 and Figure 3.2). These modules are not comprehensive, modification and refinement are ongoing, and new modules will be created with time.

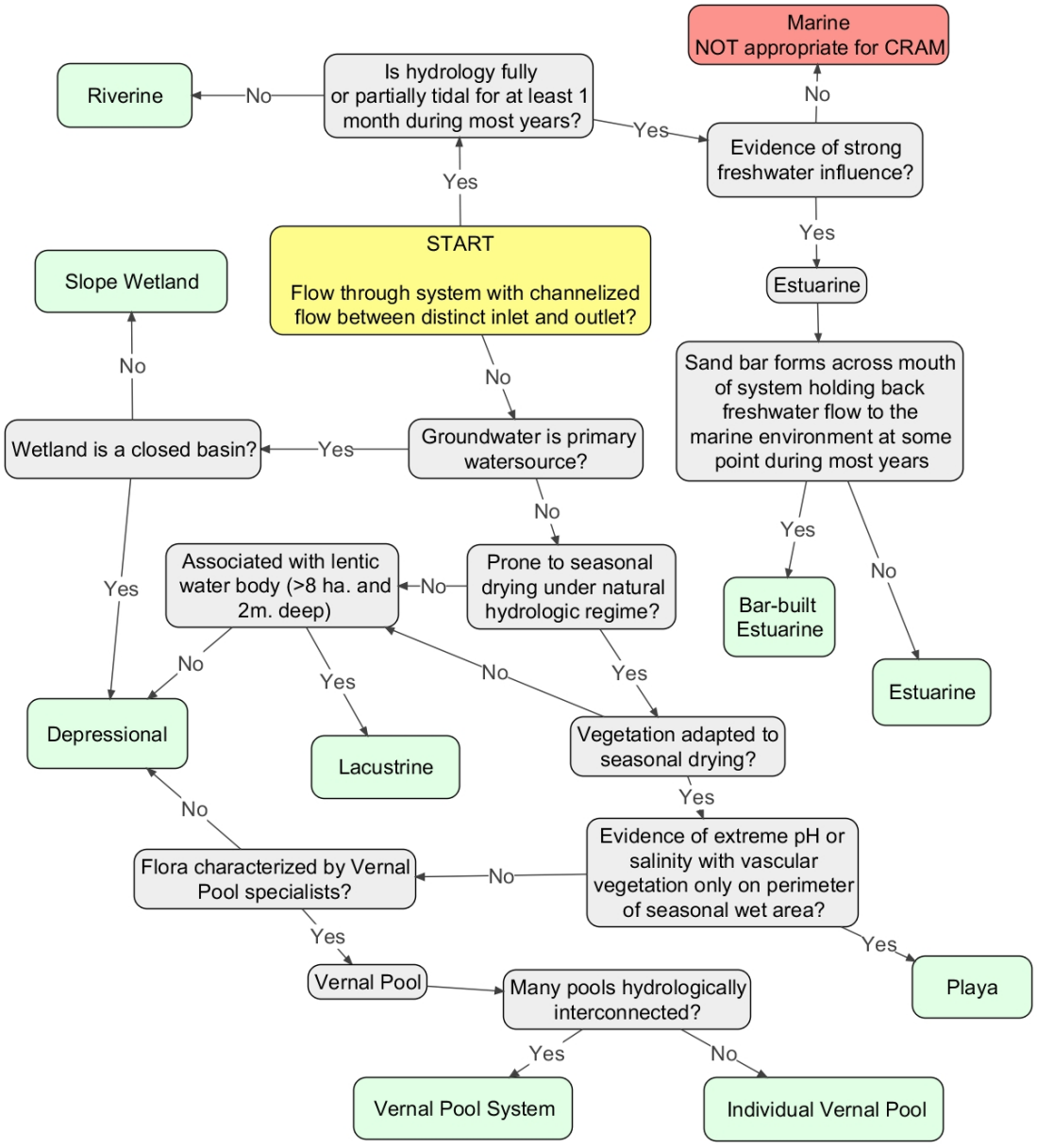
Table 3.4: The CRAM Wetland Typology.

CRAM Wetland Types	CRAM Sub-types
Riverine	Confined Riverine
	Non-confined Riverine
Depressional	Individual Vernal Pools
	Vernal Pool Systems
	Depressional
Playas	no sub-types
Estuarine	Perennial Saline Estuarine
	Perennial Non-saline Estuarine
	Bar-Built Estuarine
Lacustrine	no sub-types
Slope	Seeps and Springs
	Forested Slope
	Wet Meadows

Some wetlands will have undergone a conversion from one type to another due to either natural or anthropogenic events. For example, a channel avulsion may capture a depressional wetland and convert it to a riverine system, or construction of a dam may impound a stream and convert it to a lacustrine system. In any case, the wetland should be evaluated according to its current type and condition. Metric scores should be assigned using the ratings for the current state of the wetland, without regard for what the wetland might have been in the past, or what it might become in the future.

However, for converted wetlands, the historical type (if identifiable) as well as the existing type should be noted. The stressor checklist enables the user to document whether the wetland is currently being stressed by the conversion (i.e., if the process of conversion is continuing and a significant source of stress).

Figure 3.2: Flowchart to determine wetland type and sub-type.



3.2.2.1 Riverine (Including Closely Associated Riparian Areas)

A riverine wetland consists of the riverine channel and its active floodplain, plus any portions of the adjacent riparian areas that are likely to be strongly linked to the channel and immediate floodplain through bank stabilization and allochthonous organic material (productivity) inputs. An active floodplain is defined as the relatively level area that is periodically flooded, as evidenced by deposits of fine sediment, wrack lines, vertical zonation of plant communities, etc. The water level that corresponds to incipient flooding can vary depending on flow regulation and whether the channel is in equilibrium with water and sediment supplies. Under equilibrium conditions, the usual high water contour that marks the inboard margin of the floodplain (i.e., the margin nearest the center of the channel) corresponds to the height of bankfull flow, which

typically has a recurrence interval of about 1.5 to 2.0 years under mesic climate conditions (see Special Notes below for a definition of bankfull). The active floodplain can include broad areas of vegetated and non-vegetated bars and low benches among the distributaries of deltas and braided channel systems. The active floodplain does not include terraces that are geomorphically disconnected from channel-forming processes, although riparian areas along sloping terrace margins may be included as part of the AA since they can affect the floodplain by contributing material and providing shading. Vegetated wetlands can develop along the channel bottoms of intermittent and ephemeral streams during the dry season. Dry season assessment in these systems therefore includes the channel beds. However, the channel bed is excluded from the assessment when it contains non-wadeable flow. To help standardize the assessment of riverine wetlands, the assessments should be restricted to the dry season. Based on the proposed California state wetland definition, vegetated and non-vegetated wetlands can develop within riverine channels and their associated riparian areas. Unless otherwise determined, CRAM assumes that all riverine channels satisfy the proposed state wetland definition.

There may be a limit to the applicability of this module in low order (i.e., headwater) streams, in very arid environments, and in desert streams that tend not to support species-rich plant communities with complex horizontal and vertical structure. CRAM may be systematically biased against such naturally simple riverine systems. In addition, this module has limited application in river reaches with extremely broad floodplains, such as those which occur where large rivers occupy valleys with very low channel slopes, or near coastal embayments or the ocean, unless the extent of the floodplain included in the Assessment Area is limited to an area less than about two times bankfull width on each side of the channel (see below). There is ongoing research and development of CRAM modules for both arid streams and large rivers, which will be made available as they are completed. In the interim, caution should be used when interpreting results from these types of streams.

Riverine wetlands are further classified as confined or non-confined, based on the ratio of valley width to channel bankfull width (see Figure 3.3 below). A channel can be considered confined by artificial levees and urban development if the average distance across the channel at bankfull stage is more than half the distance between the levees or more than half the width of the non-urbanized lands that border the stream course. This assumes that the channel would not be allowed to migrate past the levees or into the urban development, or that levee breaches will be promptly repaired. Confined or non-confined channels can also be entrenched, based on the ratio of flood prone width to bankfull width (Figure 3.3 below). Entrenchment is separate from channel confinement, and strongly affects the hydrologic connectivity between riverine wetlands and their surrounding landscapes.

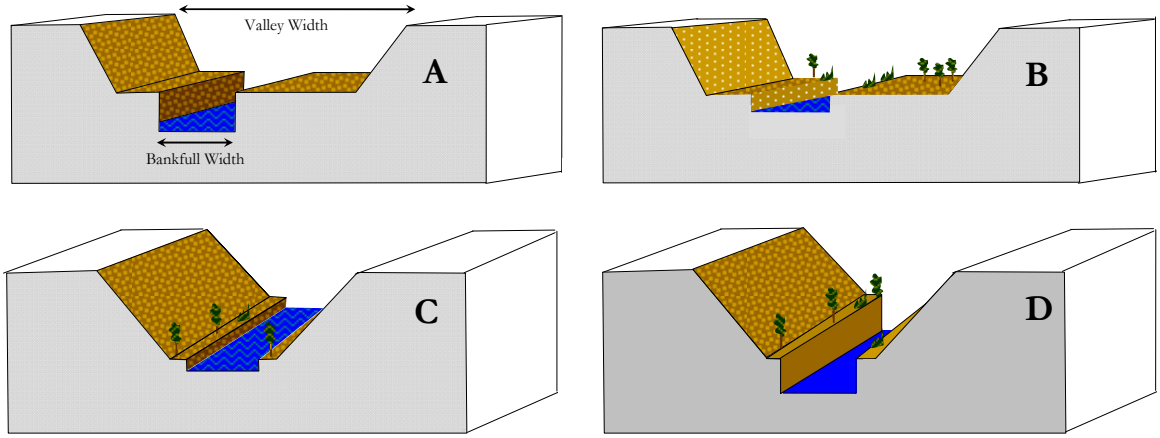


Figure 3.3: Illustrations of riverine confinement and entrenchment. (A) non-confined entrenched, (B) non-confined not entrenched, (C) confined not entrenched, and (D) confined entrenched riverine sub-types.

3.2.2.1.1 Non-confined Riverine Sub-type

In non-confined riverine systems, the width of the valley across which the system can migrate without encountering a hillside, terrace, or other feature that is likely to prevent further migration **is at least twice** the average bankfull width of the channel. Non-confined riverine systems typically occur on alluvial fans and plains, in low gradient landscapes, and along broad valleys.

3.2.2.1.2 Confined Riverine Sub-type

In confined riverine systems, the width of the valley across which the system can migrate without encountering a hillside, terrace, man-made levee, or urban development **is less than twice** the average bankfull width of the channel. Confined riverine systems are typically found in the lower order, higher gradient upper reaches of watersheds, or in constrained urban systems.

3.2.2.2 Depressional Wetlands

Depressional wetlands occur in topographic lows (i.e., closed elevation contours) that allow the accumulation of surface water and, in some cases, groundwater. These systems can be natural or artificial in origin and can occur on the landscape as isolated basins with distinct boundaries, or as a complex of shallows and seasonally wet depressions created by the slight topographic relief with indistinct boundaries, or as a large complex of interconnected basins. The margins of distinct depressional wetlands are relatively easy to discern in aerial photos and in the field. Ponds on fault traces (e.g. sag ponds, snow melt ponds), valley bottoms (e.g. cutoff ox-bows on floodplains), landslide impoundments, and on broad saddles along ridges (e.g. kettle-holes in moraines) are examples of naturally occurring depressional wetlands. Stormwater treatment ponds, wildlife habitat enhancements (e.g., duck ponds), stock ponds, and water hazards on golf courses are examples of artificially constructed depressional wetlands.

Depressional wetlands often lack a direct hydrologic connection to surface waters, and their hydrologic regime may be determined by groundwater discharge, overland runoff, and precipitation. However, many depressional wetlands (e.g., stockponds, constructed wetlands, or oxbows) are directly connected to surface waters and. Depressional wetlands can be perennial

(perennially/permanently flooded) or seasonal (seasonally or temporarily flooded), and may lack surface ponding or saturated conditions during dry years[1]. As defined by CRAM, perennially flooded depressional wetlands have some amount of surface ponding for at least 9 months during most years (i.e. in greater than 5 out of 10 years). Seasonally flooded depressional wetlands are defined as supporting surface ponding for between 4 and 9 months of the year, and temporarily flooded depressional wetlands possess surface water between 2 weeks and 4 months of the year.

CRAM recognizes that all wetlands have some amount of adjacent riparian area, as defined by the US National Research Council (see glossary). For the purposes of CRAM, the riparian areas adjacent to depressional wetlands are considered part of the wetland and are included in the Assessment Area.

3.2.2.2.1 Artificial Depressional Wetlands

A large variety of types and configurations exist for artificially constructed depressional wetlands. In the more urbanized areas of California, many depressional wetlands have been constructed and/or engineered primarily to treat urban runoff for water quality improvement or to store flood flows. In some areas of the state, such as the Central Valley, the majority of depressional wetlands are intensively managed and artificially flooded to promote a variety of benefits to many species of wildlife, especially waterfowl (vegetation for food and cover, adequate water quality, breeding and resting sites).

3.2.2.2.2 Vernal Pool Wetlands

Vernal pools are ephemeral wetlands that form in shallow depressions underlain by bedrock or by an impervious, near-surface soil horizon. These depressions fill with rainwater and runoff during the winter and may remain inundated until spring or early summer, sometimes filling and emptying repeatedly during the wet season. Vernal pools undergo four distinct annual phases: (1) the wetting phase with the onset of the first rains; (2) the aquatic phase when the peak rainfall and inundation occurs; (3) the drying phase when many plants flower and produce seed and many animals disperse; and finally (4) the drought phase when the soil dries and cracks, and the plants succumb to extreme dry conditions. Vernal pools typically support a minimum of 30% cover of native plant species during the aquatic or drying phase. Vernal pools in disturbed areas or subjected to abnormal rainfall patterns might not meet this criterion due to invasion by non-native plants. If the wetland is mostly characteristic of a vernal pool but also has characteristics of other kinds of wetlands, such that its classification as a vernal pool is not completely certain, then it should be considered a vernal pool.

3.2.2.2.3 Vernal Pool Systems

Vernal pools often occur together and with vernal swales as vernal pool systems. These can have many pools of various sizes and shapes, varying floral and faunal composition, and various hydroperiods. Water can move between adjacent pools and swales through the thin soils above

[1] There may be a limit to the applicability of CRAM in extremely seasonal depressional wetlands (inundated less than 1-2 months/year) that tend not to support species-rich plant communities with complex horizontal and vertical structure. CRAM may be systematically biased against such naturally simple depressional systems. Therefore, while the current version of the CRAM depressional module can be used in these systems, the results are being tracked carefully.

the underlying impervious substrate. The lack of surface flow between pools does not necessarily indicate that they are not hydrologically inter-connected.

3.2.2.2.4 Other Depressional Systems

Depressional wetlands other than vernal pools can be seasonal[1] or perennial, but their flora and fauna are mostly not characteristic of vernal pools, and they lack the impervious substrate that controls vernal pool hydrology. They differ from lacustrine wetlands by lacking an adjacent area of open water (at least 2 m deep and 8 ha total area). They differ from playas by lacking an adjacent area larger than the wetland of either alkaline or saline open water less than 2 m deep or non-vegetated, fine-grain sediments. Unlike slope wetlands (i.e., springs and seeps), depressional wetlands depend more on precipitation than groundwater as their water source.

3.2.2.3 Playa Wetlands

The central feature of a playa is a seasonal or perennial body of very sodic (i.e., strongly alkaline) or saline water less than 2m deep that is larger than the adjacent, fringing wetland. The benthic sediments of a playa are mostly very fine-grain clays and silts. The fringing wetlands are characterized by grasses and herbaceous plants tolerant of the soluble salts that accumulate along the margins of the playas (Gustavson *et al.* 1994, Rocchio 2006). Playas differ from vernal pools by having little or no vascular vegetation within the area that is seasonally saturated or inundated. Vernal pools are generally much smaller than playas. And, unlike vernal pools, playas are more dependent on runoff than direct precipitation. The condition of a playa can be strongly influenced by the condition of its watershed (Keate 2005). The shallowness of playas and their high salinity or alkalinity distinguishes them from lacustrine systems.

3.2.2.4 Estuarine Wetlands

An estuary consists of aquatic (i.e., sub-tidal) and semi-aquatic (i.e., intertidal) environments that are strongly influenced by mixtures of ocean water and upland runoff due to tidal processes operating through an ocean inlet. Estuaries are mostly enclosed by land. Their inlets may be natural or unnatural. Typical sources of freshwater include rivers, streams, lakes and reservoirs, point discharges (e.g., effluent from sewage treatment facilities), and storm drains.

An estuarine wetland consists of the vegetated marsh plain, its pannes, potholes, hummocks, and other habitat elements of the plain, as well as the natural levees, shell beds, submerged plant beds, and other habitat elements created or supported by tidal processes and associated with tidal channels that tend to dewater at low tide or that are less than 30m wide. Tidal channels that do not tend to dewater at low tide or that are wider than 30m are not considered to be part of the wetland and can serve to separate one estuarine wetland from another.

[1] There may be a limit to the applicability of CRAM in seasonal depressional wetlands that tend not to support species-rich plant communities with complex horizontal and vertical structure. CRAM may be systematically biased against such naturally simple depressional systems. Therefore, while the current version of CRAM depressional module can be used in these systems, the results are being tracked carefully. The depressional wetlands CRAM module will be revised based on additional field work during FY 2012-03.

3.2.2.4.1 Perennial Saline Estuarine Wetland Sub-type

For the purposes of CRAM, saline estuarine wetlands are distinguished from non-saline estuarine wetlands by the obvious dominance of salt-tolerant species of emergent vascular vegetation, such as cordgrass (*Spartina* spp.), pickleweed (*Salicornia* spp.), and salt grass (*Distichlis* spp.) along the foreshore of the wetland and along the immediate banks of the larger tidal channels that tend to dewater at low tide.

3.2.2.4.2 Perennial Non-saline Estuarine Wetland Sub-type

In non-saline wetlands (i.e., brackish or freshwater estuarine wetlands), the plant community along the foreshore of the wetland and along the immediate banks of the larger tidal channels that tend to dewater at low tide is dominated by species that don't tolerate high salinities, such as cattails (*Typha* spp.), rushes (*Scirpus species),* and willows (*Salix* spp.).

3.2.2.4.3 Bar-Built Esturaine Sub-type

Bar-built estuaries are the reaches of coastal rivers and streams that are ecologically influenced by seasonal closures of their tidal inlets. The frequency and duration of inlet closure can be natural or managed. The tidal regime can be muted or not (i.e., the tidal range can be the same or less than that of the adjacent marine or estuarine system when the tidal inlet is open). The salinity regime of a bar-built estuary can be highly variable. It can be fresh throughout very wet years or hypersaline during extended droughts. Bar-built estuaries are often referred to as "lagoons;" geomorphologically this term refers to any coastal water feature behind a bay-mouth bar.

This module is not used for large coastal lagoons, such as Big Lagoon and Stone Lagoon in Humboldt County and Lake Earl/Tolowa in Del Norte County, even though these lagoons are intermittently tidal. These lagoons are not associated with significant fluvial sediment sources from streams or rivers, and their hydrodynamics differ from the bar-built estuaries covered by this module. These large lagoons are covered, in part, by the Lacustrine Module, and additional development work in appropriate elements of other modules is in progress.

It should be noted that tidal influences on streamflow dynamics may extend many meters above the upstream limit of estuarine mixing when estuaries are open to full tidal exchanges, but this module does not apply to tidal but non-estuarine reaches of rivers or streams. Additionally, if a system has been altered such that hardened structures at its mouth prevent the formation of a sand bar that would close off the system to marine influence, this is considered a type change to a perennially saline estuary and is not covered by this module.

3.2.2.5 Lacustrine Wetlands

Lacustrine systems are lentic water bodies that usually exceed 8 hectares in total area during the dry season and that usually have a maximum dry season depth of at least 2m. They are deeper and larger than depressional wetlands or vernal pools or playas. Some lacustrine systems are separated from estuarine or marine systems by barrier beaches, dunes, or other natural or artificial barriers that are occasionally but irregularly breached. Some of these coastal lacustrine systems are locally referred to as lagoons. Here they are regarded as lacustrine systems because they resemble other lacustrine systems based on CRAM attributes and metrics.

3.2.2.6 Slope Wetlands

Slope Wetland is a broad category of groundwater-dominated wetlands inclusive of wet meadows, forested slopes, seeps and springs sub-types. In these wetlands groundwater may emerge into the root zone or across the ground surface seasonally or perennially, but mainly has unidirectional flow. The term "slope" refers to the uni-directional flow of ground and surface water within the wetland, rather than to a geomorphic feature (e.g. hillslope, toe-slope).

3.2.2.6.1 Seeps and Springs

These wetlands occur on hillsides or at the base of dunes, hills, alluvial fans, levees, etc. Springs are indicated by groundwater emerging and flowing across the ground surface and sometimes through indistinct or very small rivulets, runnels, and other features that are too small to be called a creek or riverine system. They often lack the features of riverine channels, such as a thalweg or floodplain. Seeps are similar to springs but lack a single-dominant origin of surface flow. Most of the flow is confined to the root zone and is not evident on the ground surface. Seeps and Springs may have, or may lack woody vegetation; no distinction is made in CRAM.

3.2.2.6.2 Wet Meadows

Wet meadows include bogs, fens, and alpine meadows where the hydrology is controlled mainly by fluctuations in ground water levels. They are associated with broad, gentle topographic gradients along which the near-surface ground water moves advectively, albeit slowly, in one dominant direction. If the hydroperiod of a wetland that looks like a wet meadow mainly depends on direct precipitation, then it is a depressional wetland (see Sections 3.2.2.2 and 3.2.2.3 above). Some wet meadows are associated with fluvial riverine channels, while others do not contain any distinct channel and have only sub-surface flow or surface sheet flow. Because the meadows with channels often have unique features that are not found in those without channels, this classification splits wet meadows into two types: Channeled Meadows and Non-channeled Meadows.

3.2.2.6.3 Forested Slopes

Forested slope wetlands are separated from wet meadows, by the percent coverage of trees. Forested Slope Wetlands are slope wetlands larger than 0.5 acres (0.2 ha) that form due to a seasonal or perennial emergence of groundwater into the root zone and in some cases onto the ground surface, and that support more than 30% cover of tall woody vegetation, as evidenced in aerial imagery, a LiDAR-derived tree height hillshade, or other sources of plant height information (Cayce et al., 2012). These wetlands can adjoin non-forested slope wetlands (i.e., wet meadows). They can include wetland areas with less than 30% woody cover (i.e., non-forested slope wetlands) that are not larger than 0.5 acres (0.2 ha).

3.4 Step 4: Verify the Appropriate Assessment Window

The Assessment Window is the period of time each year when assessments of wetland condition based on CRAM should be conducted. One Assessment Window exists for all attributes and metrics of each wetland type, but different types of wetlands can have different Assessment Windows. For example, the window is not the same for vernal pools and estuarine wetlands.

In general, the CRAM Assessment Window falls within the *growing season for the characteristic plant community of the wetland type to be assessed*. For wetlands that are not subject to snowfall and that are

non-tidal, the main growing season usually extends from March through September, although it may begin earlier at lower latitudes and altitudes. The growing season tends to start earlier and last longer in tidal wetlands than adjoining non-tidal wetlands due to the seasonal variations in tidal inundation. For wetlands subject to snowfall, the start of the growing season is retarded by the spring thaw, which at very high elevations may not happen until late May or early June, depending on the depth of the snow pack. For seasonal wetlands (e.g., vernal pools, playas, and some seeps), the growing season will generally be March through June, although it can be much shorter for vernal pools.

Since the timing of the growing season varies with altitude and latitude, the Assessment Window might vary within and between regions, and local or regional cues may be needed to determine when the window opens and closes each year. The best cues will be the early evidence of new growth of plants, and the subsequent senescence of the plants, for any given wetland types. For example, the assessment of seasonal depressional wetlands might begin after the start of the growing season (the window is opening) but before summertime desiccation of the wetland soils (the window is closing). Some experts can reconstruct conditions for the Assessment Window after it closes based on forensic botany and other field techniques. It should be clearly noted on the CRAM data sheets, however, if an assessment is being done outside the designated Assessment Window.

Note that the assessment of estuarine wetlands should occur at low tide, when most of the smaller intertidal channels of the wetland are dewatered and associated benthic indicators of conditions are visible.

Also note that riverine wetlands should not be assessed during high water, not only because some important indicators of channel condition might be concealed, but also because of the dangers presented by high flows. Riverine wetlands should be assessed late in the growing season, near the onset of base flow.

3.5 Step 5: Establish the Assessment Area (AA)

The Assessment Area (AA) is the portion of the Wetland that is assessed using CRAM. An AA might include a small wetland in its entirety. But, in most cases the wetland will be larger than the AA. Rules are therefore needed to delineate the AA.

Establishing a proper AA is a critical step in correctly performing a rapid assessment using CRAM. As explained below, the use of an incorrect AA can yield results that are not reproducible, and that are not likely to relate to stressors or management actions. The delineation of the boundary of an AA must adhere to the following guidelines.

It is assumed that different wetlands, even neighboring wetlands of the same type, can be managed differently, or for different purposes, and can be subject to different stressors. Therefore, each AA must not encompass or involve more than one wetland, as defined in the Level 1 inventory.

Since CRAM metrics vary between wetland types, each AA must only represent one type of wetland. Different types of wetlands can be contiguous with each other, or even nested one within the other, but each AA must only represent one wetland type.

The wetland AA must be classified using the typology provided in Section 3.2.2 and it must be assessed using the metrics designed for its wetland type. Misclassification of wetlands can lead to using the wrong CRAM module, which in turn will lead to spurious assessments.

Each of the additional considerations outlined below, if applied alone, could lead to defining a different AA for the same wetland. The delineation of an AA is therefore an optimization among these considerations. Experience has shown, however, that for the purpose of standardizing the AAs for any wetland type, the overriding considerations are hydro-geomorphic integrity and size.

3.5.1 Hydro-geomorphic Integrity

Wetland managers need to be able to distinguish between the effects of management actions and the natural variability within and among wetlands of any given type based on CRAM scores. In effect, the AA should help maximize the CRAM signal-to-noise ratio.

Each AA must therefore encompass most if not all of the natural spatial variability in the visible form and structure of its encompassing wetland, and the AA should also encompass most of the internal workings of the wetland that account for its homeostasis – its tendency to maintain a certain overall condition or return to it during or after significant stress or disturbance.

For an AA to have this desired level of integrity, it should be bounded by obvious physical changes in topography, hydrology, or infrastructure that significantly control the sources, volumes, rates, or general composition of sediment supplies or water supplies within the AA at the time of the field assessment. In essence, the boundaries of an AA should not extend beyond any features that represent or cause a major spatial change in water source or sediment source.

One way to visualize the AA is to identify the spatial scale at which the structure and form of the wetland seem to repeat themselves (i.e., the scale at which self-similarity becomes evident). This is assumed to be the scale at which the internal workings of the wetland yield the least variability in form and structure. For example, the s-shaped curve created by two consecutive river bends tends to have a wave length equal to 10x the average width of the river through the bends (Leopold 1994). Also, large estuarine wetlands tend to consist of a number of drainage networks of very similar length and drainage area for any given drainage order (Collins *et al.* 1987, Collins and Grossinger 2004). Shorelines can be characterized by alternating reaches of erosion and deposition that repeat themselves at certain spatial scales relating to wave fetch and shoreline geology (e.g., Philips 1986). Observing the patterns of self-similarity for a given wetland type can help identify the dimensions of the appropriate AA.

3.5.2 AA Size

For any given wetland type, larger AAs might tend to yield higher CRAM scores. This is because CRAM is especially sensitive to wetland structural complexity, and larger AAs can afford more opportunity to encounter variability in structure. For any given wetland type, having AAs of very different sizes can introduce variability into CRAM scores.

As stated above, one of the primary considerations for delineating an AA is its hydro-geomorphic integrity. The boundaries of the AA should be established based on clear breaks in

surface hydrology, sediment supply, or geomorphology (see Tables 3.5 and 3.6 below). Experience has shown, however, that most of the AAs of each wetland type that are delineated according to indicators of hydro-geomorphic integrity fall within a narrow range of size, although their shapes are more variable. This suggests that size guidelines can be applied to the process of establishing an AA without necessarily violating the criterion for the hydro-geomorphic integrity of the AA.

Furthermore, in some cases the self-similar, self-organizing, integral area of a wetland is not clearly evident. For example, some wet meadows, brackish estuarine wetlands, large riverine systems, and fringing wetlands of playas and lacustrine systems lack obvious hydrological breaks or other features that clearly demarcate changes in water supplies or sediment supplies. In these cases, overall size may be the dominant criterion for delineating the AA.

The preferred AA size is generally greater for types of wetlands that tend to have broad, level planes than for wetlands fringing steep terrain. The size-frequency distribution of wetlands for each wetland type (a Level 1 analysis) was also considered when the recommendations for AA sizes were being developed.

Examples of features that should be used to delineate an AA, and other features that should not be used, are listed in Tables 3.5 and 3.6 below. The preferred and minimum AA sizes for each wetland type are presented below in Table 3.7.

To the degree possible, the delineation of an AA should first be based on the hydro-geomorphic considerations presented in Tables 3.5 and 3.6. But, if these considerations are not applicable, or if the resulting AA is more than about 25% larger than the preferred size presented in Table 3.7, then the AA delineation should rely only on the size guidelines. The number of AAs per wetland will depend on the purpose of the assessment, as outlined in Table 3.8.

In addition to the guidance below, there are special considerations for establishing a AA for each wetland type located in the field books of each CRAM module.

Table 3.5: Examples of features that should be used to delineate AA boundaries. A more complete list is presented in the field books for each wetland type.

Flow-Through Wetlands	**Non Flow-Though Wetlands**	
Riverine, Estuarine and Slope Wetlands	**Lacustrine, Wet Meadows, Depressional, and Playa Wetlands**	**Vernal Pools and Vernal Pool Systems**
• diversion ditches • end-of-pipe large discharges • grade control or water height control structures • major changes in riverine entrenchment, confinement, degradation, aggradation, slope, or bed form • major channel confluences • water falls • open water areas more than 30 m wide on average or broader than the wetland • transitions between wetland types • foreshores, backshores and uplands at least 5 m wide • weirs, culverts, dams, levees, and other flow control structures	• above-grade roads and fills • berms and levees • jetties and wave deflectors • major point sources or outflows of water • open water areas more than 30 m wide on average or broader than the wetland • foreshores, backshores and uplands at least 5 m wide • weirs and other flow control structures	• above-grade roads and fills • major point sources of water inflows or outflows • weirs, berms, levees and other flow control structures

Table 3.6: Examples of features that should not be used to delineate any AAs. A more complete list is presented in the field books for each wetland type.

- at-grade, unpaved, single-lane, infrequently used roadways or crossings
- bike paths and jogging trails at grade
- bare ground within what would otherwise be the AA boundary
- equestrian trails
- fences (unless designed to obstruct the movement of wildlife)
- property boundaries
- riffle (or rapid) – glide – pool transitions in a riverine wetland
- spatial changes in land cover or land use along the wetland border
- state and federal jurisdictional boundaries

Table 3.7: Preferred and minimum AA sizes for each wetland type. Wetlands smaller than the preferred AA sizes can be assessed in their entirety.

Wetland Type	Recommended AA Size
Slope	
Spring or Seep	Preferred size is 0.50 ha (about 75m x 75m, but shape can vary); there is no minimum size (least examples can be mapped as dots).
Wet Meadow	Preferred size is 1.0 ha (about 140m x 140m, but shape can vary); Maximum size is 2.0 ha; minimum size is 0.1 ha (about 30m x 30m).
Depressional	
Vernal Pool	There are no size limits.
Vernal Pool System	Preferred size is <10 ha (about 300m x 300m; shape can vary); there is no minimum size so long as there are between 3 and 6 pools. If the system has between 3 and 6 pools, assess all of them. If there are more than 6 pools, select 6 that represent the range in size of pools present on the site.
Other Depressional	Preferred size is 1.0 ha (a 56 m radius circle or about 100m x 100m, but shape can vary); Maximum size is 2.0 ha (an 80 m radius circle or about 140m x 140m, but shape can vary); There is no minimum size.
Riverine	
Confined and Non-confined	Recommended length is 10x average bankfull channel width; maximum length is 200 m; minimum length is 100 m. AA should extend laterally (landward) from the bankfull contour to encompass all the vegetation (trees, shrubs vines, etc.) that probably provide woody debris, leaves, insects, etc. to the channel and its immediate floodplain; minimum width is 2 m.
Lacustrine	Preferred size is 2.0 ha (about 140m x 140m, but shape can vary); Minimum size is 0.5 ha (about 75m x 75m).
Playa	Preferred size is 2.0 ha (about 140m x 140m, but shape can vary); Minimum size is 0.5 ha (about 75m x 75m).
Estuarine	
Perennial Saline	Preferred size and shape for estuarine wetlands is a 1.0 ha circle (radius about 55m), but the shape can be non-circular if necessary to fit the wetland and to meet hydro-geomorphic and other criteria. The minimum size is 0.1 ha (about 30m x 30m).
Perennial Non-saline	
Bar-Built	Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary), The minimum size is 0.1 ha (about 30m x 30m).

3.5.3 Assessment Purpose

There are two primary purposes for using CRAM. It is used to assess the ambient condition of a population of wetlands or to assess the condition of an individual wetland or wetland project. The same guidelines for delineating AAs (see Tables 3.5 through 3.7 above) pertain to project assessments and ambient assessments using CRAM.

However, the number of AAs per wetland can vary between ambient surveys and individual wetland assessments. Multiple AAs might be required to assess the average condition of a wetland project that is many times larger than one AA, whereas just one AA would be required in the same wetland if it were only being assessed as part of an ambient survey (see Table 3.8).

Table 3.8: Guidelines for determining the number of AAs per wetland.

	Assessment Scenario
Single AA	If the size of the wetland is within the size limits given in Table 3.7, then the entire wetland constitutes the AA, regardless of the purpose of the assessment. Or If the wetland is one in a population of wetlands to be assessed as part of an ambient survey, then delineate one AA around each point randomly selected within the wetland as part of the sample draw from the ambient sample frame. For more information about ambient sampling design go to http://epa.gov/nheerl/arm/designing/design_intro.htm.
Multiple AAs	If the wetland is about twice as large as the preferred size AA from Table 3.7, and if the purpose is to assess the average condition of the wetland, then assess the second AA and report the results for both AAs. Or If the wetland is at least thrice as large as the preferred size AA from Table 3.7, and if the purpose is to assess the average condition of the wetland, then randomly select and assess three AAs from the array of all possible AAs for the wetland. If the overall score for the third AA differs from the average of the first two scores by more than 15%, then assess a randomly selected fourth AA; if its score differs from the average of the first three by more than 15%, then assess a randomly selected fifth AA. Repeat this procedure until the overall score for the latest AA is no more than 15% different than the average of all previous scores, or until the array of possible AAs is exhausted. For more detailed instructions on assessing multiple AAs per wetland, see the CRAM Technical Bulletin).
Reporting	The final boundaries of all the AAs of a wetland should be mapped using either the eCRAM software mapping tool or by drawing a heavy pencil line on a hardcopy of the site imagery. Hardcopy maps will need to be digitized using the online version of eCRAM as part of the process of entering CRAM results into the online CRAM database.

3.5.3 Special Considerations for Post-assessment Analysis

For CRAM scores to be comparable they must be standardized in terms of time (i.e., scores should represent comparable amounts of assessment effort during comparable years and times of year), and in terms of space (i.e., for any given wetland type, the scores should represent comparable amounts of wetlands, and these should have hydrological and ecological integrity; see Section 3.5.2 above).

For a variety of reasons, scores that do not meet these standards cannot be compared and cannot be combined into datasets. For example, assessments that take longer or that involve larger areas are likely to encounter more structural complexity and therefore yield higher scores.

The use of Assessment Windows (see Section 3.4 above), fixed assessment times (i.e., no assessment should take longer than one half day in the field), recommended AA sizes, and guidelines for assembling data of varying vintage will achieve more consistent assessment results.

To achieve the spatial standards, each AA for each wetland type should fall within a standard size range that is large enough to incorporate the natural processes of homeostasis that characterize the wetland (see discussion of AA integrity in Section 3.5.2), but small enough to meet the time constraints (see Table 3.7).

An additional spatial consideration for ambient surveys is that the probability of any wetland within a given area being selected for assessment increases with its size, and weighting CRAM scores for the inclusion probabilities of their associated AAs depends on having a standard AA size range for each wetland type. For more information about ambient sampling design go to http://epa.gov/nheerl/arm/designing/design_intro.htm.

Standardizing the shape of AAs (e.g., having all AAs be circles or squares of fixed size) may increase the ease with which they are delineated, but may also lead to a disregard of features such as water control structures that affect AA integrity. Standardizing the shapes of AAs is less important than standardizing their sizes.

3.5.4 Special Considerations for Assessing Projects

For the purposes of CRAM, a "project" includes any on-the-ground activity which results in a physical change in the area or condition of an aquatic resource[1]. Projects can be associated with a regulatory or funding decision. Such projects are often at least partly delimited by property lines or other administrative or legal boundaries. Wetland restoration projects, mitigation projects, mitigation banks, and wetlands that are targeted for development (i.e., impacted wetlands) are often delimited by property lines. However, for the purposes of CRAM, the definition of *project* is independent of any regulatory or administrative definition under the Clean Water Act, Porter Cologne, Section 1600 of the State's Fish and Game Code, Coastal Zone Management Act, CEQA, or NEPA.

Property lines, jurisdictional limits, and other administrative or legal boundaries should not automatically be used to delineate AAs, except for the assessment of a project, in which case the

[1] Projects can include the acquisition or placement of a wetland, riparian area, or other aquatic habitat in a conservation easement (or other permanent protection).

wetland and its AA(s) are confined to the project boundaries. A formal wetland Jurisdictional Delineations (JD) in good standing for a project can be used in the absence of any other wetland map to define the wetland and to help delimit the AA(s). If the project is much larger than one AA, then the process outlined in the CRAM Technical Bulletin should be used to assess multiple AAs.

The best achievable condition of a project might be unavoidably constrained by adjacent or nearby land uses. In these situations, the expected or target level of performance of a project might be adjusted for the land use constraints. In other words, although a project is assessed relative to the best achievable conditions for its wetland type throughout the State, what is expected or deemed acceptable for any particular project might reflect its land use setting. For example, stream restoration projects in urban landscapes need not be held to the same standards of high performance as projects in rural or non-developed landscapes. As CRAM scores accumulate throughout the State, their relationship to land use setting can be analyzed to guide local adjustments in project performance criteria that are based on CRAM.

3.6 Step 6: Conduct Initial Office Assessment of Condition Metrics and Stressors

For each CRAM assessment, there is initial office work to acquire the site imagery, plan logistics for the site visit, and to assemble information about the management of the site and its possible stressors. Preliminary scores can be developed for some metrics, based on existing documentation (e.g., aerial photography, reports, etc.), prior to conducting any fieldwork. Such preliminary scoring is not necessary, however, and any preliminary scores must be verified during the site visit. The initial office work is itemized in Table 3.10 below.

Table 3.10: CRAM metrics suitable for pre-site visit draft assessment.

Background Information to Assemble Prior to the Site Visit			
• 1m-3m pixel resolution digital geo-rectified site imagery • Site-specific and neighboring reports on hydrology, ecology, chemistry, etc. • Access permission if needed • Preliminary map of the Assessment Area • Maps to the site, access points, and other logistical information			
Metrics/Submetrics Suitable for Preliminary Scoring Prior to Site Visit			
Attributes		Metrics/Submetrics	Suitable?
Buffer and Landscape Context		Aquatic Area Abundance	Yes
		Stream Corridor Continuity(riverine, BBE)	Yes
		Aquatic Area in Adjacent Landscape (BBE)	Yes
		Marine Connectivity (BBE)	Yes
		Percent of AA with Buffer	Yes
		Average Buffer Width	Yes
		Buffer Condition	No
Hydrology		Water Source	Yes
		Hydroperiod or Channel Stability	No
		Hydrologic Connectivity	No
Structure	Physical	Structural Patch Richness	No
		Topographic Complexity	No
	Biotic	Number of Plant Layers Present	No
		Number of Co-dominant Species	No
		Endemic Plant Species Richness (vernal pools)	No
		Percent Invasion	No
		Horizontal Interspersion and Zonation	No
		Vertical Biotic Structure	No

For air photos and other imagery, the minimum pixel resolution is 3m (i.e., each pixel in the digital image of a site should represent no more than about $9m^2$ of area). National Agriculture Imagery Program (NAIP; http://www.fsa.usda.gov) aerial imagery with a spatial resolution of 1m is available for the entire state (years 2005, 2009, and 2010) as either Digital Orthogonal Quarterly Quadrangle (DOQQ) tiles or as compressed county mosaics (CCMs) from the Cal-Atlas website (atlas.ca.gov). Older, lower resolution (3m) imagery in DOQQ format is also available.

3.7 Step 7: Conduct Field Assessment of Condition Metrics and Stressors

After assembling the background information about the wetland to be assessed, the next step is to conduct an assessment of the wetland in the field. A complete description of CRAM metrics and the Stressor Checklist is provided in the individual field books for each CRAM module. Fieldwork for CRAM consists of finding and confirming the boundaries of the AA, and scoring

the AA based on the condition metrics and stressor checklist. Any field-based modifications of the preliminary AA boundary must be recorded on the site imagery.

3.8 Step 8: Complete CRAM Scores and Basic QA/QC Procedures

3.8.1 Calculating CRAM Scores

Scores for CRAM are easily calculated. There is no weighting of any metrics or attributes. Weightings are not supported by theory or the validation exercises. Letter scores for each metric (A, B, C, D) are simply converted into whole integer scores (12, 9, 6, 3, respectively; see Step 1 in Table 3.11).

For the Hydrology and Physical Structure attributes, the attribute scores are simply calculated as the sum of the component metric scores (see Step 2 in Table 3.11).

For the Buffer and Landscape Context attribute, the submetric scores relating to buffer are combined into an overall buffer score that is added to the score for the Landscape Connectivity metric, using the formula in Step 2 in Table 3.11.

For the Biotic Structure attribute, the Plant Community metric consists of three submetrics (Number of Plant Layers Present; Number of Co-dominant Species; and Percent Invasion). Prior to calculating the Biotic Structure attribute score, the values for these submetrics must be averaged. Then the Biotic Structure attribute score can be calculated as described in Table 3.11.

Each raw attribute score is then converted into a percentage of the maximum possible score (see Step 3 in Table 3.11). This eliminates any weighting of one attribute relative to another due to their differences in numbers of component metrics and numbers of alternative states of the metrics.

An overall AA score is calculated by averaging the attribute scores. All scores are rounded to the nearest whole percentage value (see Step 4 in Table 3.11).

Different wetlands are likely to have different functions and ecological services due to differences in wetland form, structure, geomorphic setting, climatic regime, evolutionary stage, stressor regime, etc. It is therefore unlikely that the same CRAM score represents the same level of function or even the same set of functions for different wetlands. CRAM scores cannot be used to infer wetland function except in the context of correlations between CRAM scores and actual functional levels, as measured using Level 3 methods. Validation efforts to date indicate that CRAM scores are strongly correlated to a variety of wetland functions and services.

It is expected that the same scores for different wetlands of the same type probably represent the same overall condition and functional capacity. CRAM can therefore be used to track the progress of restoration efforts over time, to compare impacted sites to their in-kind mitigation sites, or to compare an individual wetland to the status and trends in ambient condition of its wetland type.

CRAM scores can also be used to compare the status and trends of different types of wetlands. This is because all wetlands are assessed relative to their best achievable condition. For example, separate ambient surveys of lacustrine and estuarine wetlands might reveal that one type is doing better than the other, relative to their particular overall best achievable conditions.

Table 3.11: Steps to calculate attribute scores and AA scores for most wetland types.

Step 1: Calculate Metric Score	For each Metric, convert the letter score into the corresponding numeric score: A=12, B=9, C=6 and D=3.
Step 2: Calculate raw Attribute Score	For each Attribute, calculate the Raw Attribute Score as the sum of the numeric scores of the component Metrics, except in the following cases: • For Attribute 1 (Buffer and Landscape Context), the submetric scores relating to buffer are combined into an overall buffer score that is added to the score for the Aquatic Area Abundance, using the following formula: $\left(\text{Buffer Condition} \times \left(\text{\% AA with Buffer} \times \text{Average Buffer Width}\right)^{1/2}\right)^{1/2} + \text{Aquatic Area Abundance}$ • For Attribute 4 (Biotic Structure) Prior to calculating the Raw Attribute Score, average the three Plant Community sub-metrics. Then sum this result with the other two Biotic Structure metrics. • Do not round the Raw Attribute scores to the nearest integer.
Step 3: Calculate final Attribute Score	For each Attribute, divide its Raw Attribute Score by its maximum possible score, which is 24 for Buffer and Landscape Context, 36 for Hydrology, 24 for Physical Structure, and 36 for Biotic Structure. Do not round the final Attribute scores to the nearest integer before calculating the AA Index Score. You may round the final Attribute score to the nearest integer for reporting purposes.
Step 4: Calculate the AA Index Score	Calculate the AA Index Score by averaging the Final Attribute Scores. Round this average to the nearest whole number (integer) to get the AA Index Score (0.5 or greater rounds up, less than 0.5 rounds down).

There are many possible ways to graphically present CRAM scores. The choice should depend on the information to be conveyed and the intended audience. It will not usually be necessary to present metric scores except in the context of validation efforts and to explain attribute scores. The metric scores can be presented effectively, however, as a circular graph that depicts the contribution of each metric to the overall score (e.g., Figure 3.4A). Site-specific and ambient scores can be compared in bar charts (Figure 3.4B). The progress of a restoration or mitigation project can be shown as the change in average overall score relative to performance standards (Figure 3.4C). The ambient conditions of two different types of wetlands can be compared based on the frequency distributions of the overall scores (Figure 3.4D). The ambient condition of any given wetland type can be displayed as the cumulative frequency of overall scores (Figure 3.4E). The graphs pertaining to ambient condition or to any population of wetlands can be produced for a variety of spatial scales, from watersheds or regions to the State as a whole.

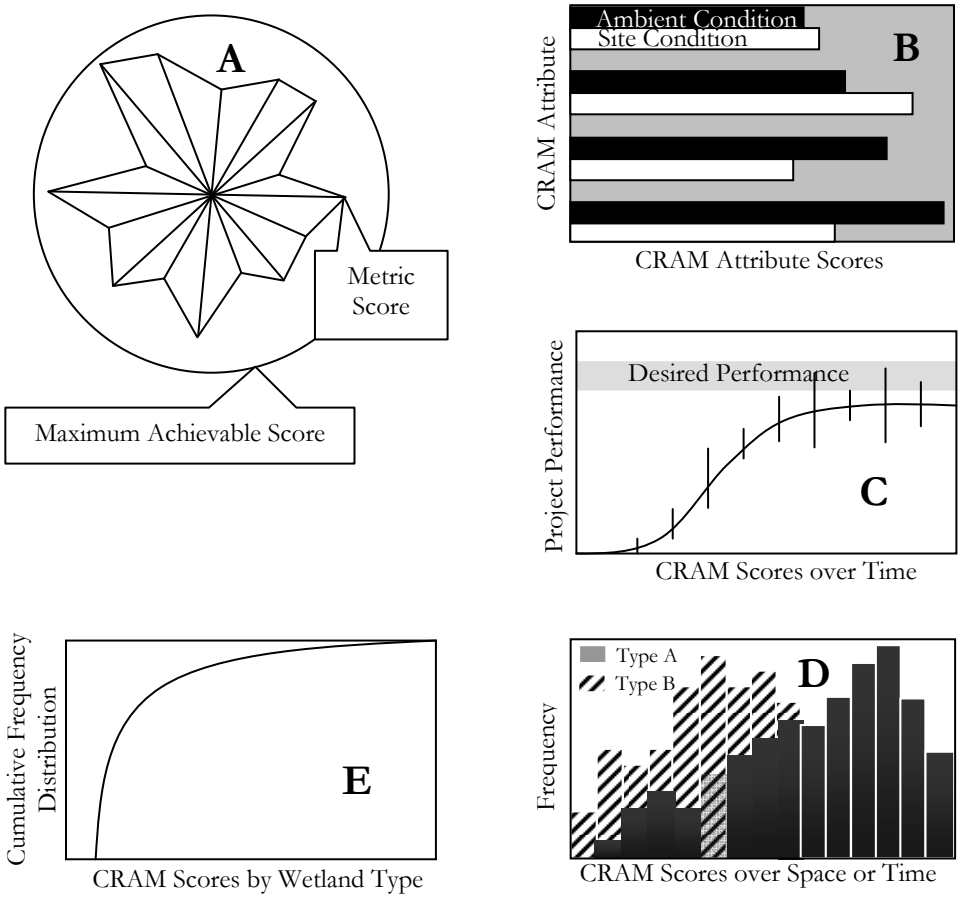


Figure 3.4: Example graphs for displaying CRAM results.

Figure shows (A) "spider plot" of metric scores for one or more AAs (multiple areas would be represented by average scores) (see Ambrose *et al.* 2006); (B) site-specific attribute scores compared to ambinet conditions or reference conditions; (C) changes in AA scores over time for a wetland an project; (D) comparison of two different populations of wetlands based on the frequency distribution of their AA scores; and (E) cummulative frequency distribution of scores for one population of wetlands.

3.8.2 Initial QA/QC Procedures for Data Collectors

Part of the value of CRAM is its ability to yield reproducible results for wetlands of similar condition, regardless of the data collector. Quality control procedures should be employed to assure that the data collectors or assessors are using the same approach and are obtaining information accurately when conducting CRAM assessments. For large wetland projects having numerous AAs and for ambient assessments involving multiple wetlands, it is recommended that at least 10% of the AAs be revisited by an independent CRAM assessment team and compared to the original assessments for the same AAs. The replicate scores should be within 10% of the original scores for each attribute.

In addition to taking on or more CRAM training courses, all CRAM practitioners are advised to carefully read and understand the most recent version of the CRAM User's Manual before they begin conducting assessments. The User's Manual and CRAM training materials are available at the CRAM web site (www.cramwetlands.org). Supporting materials include a photo-glossary with picture examples of many of the terms and wetland characteristics described or referenced in the User's Manual. These materials are intended to help users develop an understanding of the complete range of conditions for each metric, and arrive at consistent conclusions about wetland condition.

The initial quality control procedures for any assessment involve a basic review of the AA map and the summary scoring sheet. The recommended topics for the initial quality control are listed in Table 3.12 below.

Table 3.12: Recommended topics of initial QA/QC.

Recommended Topics of Initial QA/QC for CRAM Results
• *AA map quality:* hardcopy maps must be clear enough to be readily digitized. AA maps must be on geo-rectified imagery with minimum pixel resolution of 3 m (i.e., each pixel should represent no more than 9 m^2). • *Summary data sheet:* make sure all fields of information for site name, wetland type, date of assessment, personnel making the assessment, etc. are complete and legible. • *Summary score sheet*: make sure that every metric and attribute has a correct score, and that the overall site score is also correct. • *Summary stressor sheet:* make sure the stressor checklist has been completed.

3.8.3 Initial Quality Control Procedures for Data Managers

The main objective of data management is to assure that the data are accurately collected and verified for analysis and interpretation by CRAM practitioners and resource managers. Procedures described in this User's Manual are designed to help assure the accuracy and consistency of data collection and processing. Since metric scores are combined into more complex attribute and overall CRAM site scores, any errors in data collection can be compounded if quality control measures are not followed.

Data management involves maintaining various types of data and information, including hardcopy and electronic imaging and other background information for sites to be assessed using CRAM, as well as completed field data sheets. Routine backups of the computing systems and databases should be performed daily, along with measures to assure network and computer security. Backup files containing CRAM data should be stored in fireproof facilities. In addition, hardcopies of the data should be maintained and, if the data are only in electronic form, printouts of these data should be stored separately from the electronic versions.

These basic criteria for secure data management are currently met through administration of the CRAM web site and supporting database at the San Francisco Estuary Institute as a regional Information Center of CEDEN. The eCRAM interface, the CRAM database, and its supporting

web sites are open source. No aspect of CRAM programming is proprietary. The CRAM database incorporates numerous measures to assure accurate data entry and processing, including the following.

- Each database field that requires a value is checked for null or missing values.
- Standard codes are provided in look-up lists for populating the data table fields.
- The entry of duplicate records is prevented, based on a unique combination of fields that define the primary key.
- If one record set is related to another, it is checked for orphan records (parent records have child records and child records have parent records).
- Users are prompted to complete data fields as data are being uploaded into the database via the CRAM web site.
- Data entry and editing are password-protected; data authors can only access and edit their own data.
- All data are time-stamped and automatically assigned to a unique site code.
- Database users are automatically prompted to download new versions of CRAM if the version they have is outdated.

3.9 Step 9: Upload Assessment Data and Results

No CRAM assessment is complete until the results are uploaded into the CRAM database. The database is accessible at www.cramwetlands.org/dataentry. Anyone who wants to enter data into the database must register on the CRAM website to obtain a database log-in name and password. Results for hardcopy versions of CRAM must be transcribed into the electronic version on the web site. The database is only accessible to registered users, and they can only access and edit their own data. All results marked as "public" when entered into eCRAM can be viewed by the public through interactive maps at the CRAM web site.

CHAPTER 4: DEFINITION AND RATIONALE FOR CRAM ATTRIBUTES AND METRICS

4.0 Summary

This chapter contains background information for each metric of CRAM. Each metric is supported by a definition, rationale, and an indication of the metric's sensitivity to seasonal variability in wetland condition.

A field book describing the standard operating procedures for each wetland type is provided on the CRAM website (www.cramwetlands.org) along with datasheets for conducting CRAM assessments.

4.1 Attribute 1: Buffer and Landscape Context

For the purposes of CRAM, a buffer is a zone of transition between the immediate margins of a wetland and its surrounding environment that is likely to help protect the wetland from anthropogenic stress (see Figure 2.2). Areas adjoining wetlands that probably do not provide protection are not considered buffers.

Buffers can protect wetlands by filtering pollutants, providing refuge for wetland wildlife during times of high water levels, acting as barriers to disruptive incursions by people and pets into wetlands, and moderating predation by ground-dwelling terrestrial predators. Buffers can also reduce the risk of invasion by non-native plants and animals, by either obstructing terrestrial corridors of invasion or by helping to maintain the integrity and therefore the resistance of wetland communities to invasions.

Because regulation and protection of wetlands historically did not extend to adjacent uplands, these areas in some cases have been converted to recreational, agricultural, or other human land uses and might no longer provide their critical buffer functions for wetlands.

CRAM includes two metrics to assess the Buffer and Landscape Context attribute of wetlands: the Aquatic Area Abundance metric and the Buffer metric. The buffer metric is composed of three submetrics: (1) percentage of the AA perimeter that has a buffer; (2) the average buffer width; and (3) the condition or quality of the buffer.

4.1.1 Metric 1: Aquatic Area Abundance (Stream Corridor Continuity)

A. Definition: The aquatic area abundance of an Assessment Area is assessed in terms of its spatial association with other areas of aquatic resources, such as other wetlands, lakes, streams, etc. It is assumed that wetlands close to each other have a greater potential to interact ecologically and hydrologically, and that such interactions are generally beneficial.

B. Rationale: Wetlands are often important components of local mosaics of multiple types of habitat. The components of such mosaics tend to be inter-connected by the flow of water and movements of wildlife, such that they have additive influences on the timing and extent of many landscape-level processes, including flooding, filtration of pesticides and other contaminants, and wildlife support. In turn, these processes can strongly influence the form and function of

wetlands. The functional capacity of a wetland is therefore determined not only by its intrinsic properties, but by its relationship to other habitats across the landscape. For example, Frissell *et al.* (1986) concluded that the structure and dynamics of stream habitats are determined by the surrounding watershed. Several researchers have concluded that landscape-scale variables are often better predictors of stream and wetland integrity than localized variables (Roth *et al.* 1996; Scott *et al.* 2002). Wetlands that are close together without hydrological or ecological barriers between them are better able to provide refuge and alternative habitat patches for meta-populations of wildlife, to support transient or migratory wildlife species, and to function as sources of colonists for primary or secondary succession of newly created or restored wetlands. In general, good landscape connectivity exists only where neighboring wetlands or other habitats do not have intervening obstructions that could inhibit the movements of wildlife.

For the purposes of CRAM, 500 m has been surmised as the maximum distance between wetlands and other water-dependent habitats that does not by itself function as a barrier to the easy regular movements of small mammals, birds, amphibians, or reptiles. Greater distances between the wetland of interest and neighboring habitats are considered breaks in landscape connectivity.

C. Seasonality: This metric is not sensitive to seasonality.

4.1.2 Metric 2: Buffer

The buffer is the area adjoining the AA that is in a natural or semi-natural state and currently not dedicated to anthropogenic uses that would severely detract from its ability to entrap contaminants, discourage visitation into the AA by people and non-native predators, or otherwise protect the AA from stress and disturbance.

4.1.2.1 Submetric A: Percent of AA with Buffer

A. Definition: This submetric is based on the relationship between the extent of buffer and the functions provided by aquatic areas. Areas with more buffer typically provide more habitat values, better water quality and other valuable functions.

B. Rationale: The ability of buffers to protect a wetland increases with buffer extent along the wetland perimeter. For some kinds of stress, such as predation by feral pets or disruption of plant communities by cattle, small breaks in buffers may be adequate to nullify the benefits of an existing buffer. However, for most stressors, small breaks in buffers caused by such features as trails and small, unpaved roadways probably do not significantly disrupt the buffer functions.

C. Seasonality: This metric is not sensitive to seasonality.

4.1.1.2 Submetric B: Average Buffer Width

A. Definition: The average width of the buffer adjoining the AA is estimated by averaging the lengths of straight lines drawn at regular intervals around the AA from its perimeter outward to the nearest non-buffer land cover, or to a maximum distance of 250 m, whichever is first encountered. The maximum buffer width is 250 m. The minimum buffer width is 5 m, and the minimum buffer length along the AA perimeter is also 5 m. Any area that is less than 5 m wide and 5 m long is assumed to be too small to provide buffer functions.

B. Rationale: A wider buffer has a greater capacity to serve as habitat for wetland edge-dependent species, to reduce the inputs of non-point source contaminants, to control erosion, and to generally protect the wetland from human activities.

C. Seasonality: This metric is not sensitive to seasonality.

4.1.1.3 Submetric C: Buffer Condition

A. Definition: The condition of a buffer is assessed according to the extent and quality of its vegetation cover, the overall condition of its substrate, and the amount of human visitation. Buffer conditions are assessed only for the portion of the wetland border that has already been identified as buffer. Thus, evidence of direct impacts (parking lots, buildings, etc.) by people are excluded from this metric, because these features are not included as buffer land covers; instead these impacts are included in the Stressor Checklist.

B. Rationale: The condition or composition of the buffer, in addition to its width and extent around a wetland, determines the overall capacity of the buffer to perform its critical functions.

C. Seasonality: This metric is not sensitive to seasonality.

4.2 Attribute 2: Hydrology

Hydrology includes the sources, quantities, and movements of water, plus the quantities, transport, and fates of water-borne materials, particularly sediment as bed load and suspended load. Hydrology is the most important direct determinant of wetland functions (Mitsch and Gosselink 2007). The physical structure of a wetland is largely determined by the magnitude, duration, and intensity of water movement. For example, substrate grain size, depth of wetland sediments, and total organic carbon in sediments tend to be inversely correlated to duration of inundation in a lacustrine wetland. The hydrology of a wetland directly affects many physical processes, including nutrient cycling, sediment entrapment, and pollution filtration. For example, Odum and Heywood (1978) found that leaves in freshwater depressional wetlands decomposed more rapidly when submerged. The hydrology of a wetland constitutes a dynamic habitat template for wetland plants and animals. For example, Richards *et al.* 2002 concluded that meandering and braiding in riverine systems control habitat patch dynamics and ecosystem turnover. Additionally, the spatial distribution of plants and animals in a tidal marsh closely correspond to patterns of tidal inundation or exposure (Sanderson *et al.* 2000).

4.2.1 Metric 1: Water Source

A. Definition: Water Sources directly affect the extent, duration, and frequency of saturated or ponded conditions within an Assessment Area. Water Sources include direct inputs of water into the AA as well as any diversions of water from the AA. Diversions are considered a water source because they affect the ability of the AA to function as a source of water for other habitats while also directly affecting the hydrology of the AA. Direct inputs of water affecting conditions during the dry season are especially important because they strongly influence the structure and composition of wetland plant and animal communities. The Water Source metric therefore focuses on conditions that affect dry season hydrology.

Direct, natural water sources include precipitation, ground water discharge, and flooding of the AA due to high tides or naturally high riverine flows. Examples of direct, unnatural sources include stormdrains that empty into the AA or into an immediately adjacent area. For seeps and springs that occur at the toes of earthen dams, the reservoirs behind the dams are water sources. Indirect sources that should not be considered in this metric include large regional dams that have ubiquitous effects on broad geographic areas of which the AA is a small part. For example,

although the salinity regimes of some estuarine wetlands in San Francisco Bay are indirectly affected by dams in the Sierra Nevada, others are directly affected by nearby discharges from sewage treatment facilities. However, the effects of urbanization on hydrological dynamics in the immediate watershed containing the AA ("hydromodification") are considered in this metric; because hydromodification both increases the volume and intensity of runoff during and immediately after rain events and reduces infiltration that supports base flow discharges during the drier seasons later in the year. Engineered hydrological controls, such as pumps, weirs, and tide gates can serve to demarcate the boundary of an AA, but they are not considered water sources.

B. Rationale: Wetlands depend on constant or recurrent, shallow inundation or saturation at or near the surface of the substrate (National Research Council 2001). Consistent, natural inflows of water to a wetland are important to their ability to perform and maintain most of their intrinsic ecological, hydrological, and societal functions and services. The flow of water into a wetland also affects its sedimentary processes, geo-chemistry, and basic physical structure. Sudol and Ambrose (2002) found that one of the greatest causes of failed wetland mitigation or restoration projects is inadequate or inappropriate hydrology.

C. Seasonality: Water source should be evaluated during the dry season.

4.2.2 Metric 2: Hydroperiod or Channel Stability

A. Definition: Hydroperiod is the characteristic frequency and duration of inundation or saturation of a wetland during a typical year. The natural hydroperiod for estuarine wetlands is governed by the tides, and includes predictable variations in inundation regimes over days, weeks, months, and seasons. Depressional, lacustrine, playas, and riverine wetlands typically have daily variations in water height that are governed by diurnal increases in evapotranspiration and seasonal cycles that are governed by rainfall and runoff. Seeps and springs that depend on groundwater may have relatively slight seasonal variations in hydroperiod.

Channel stability only pertains to riverine wetlands. It is assessed as the degree of channel aggradation (i.e., net accumulation of sediment on the channel bed causing it to rise over time), or degradation (i.e., net loss of sediment from the bed causing it to be lower over time). There is much interest in channel entrenchment (i.e., the inability of flows in a channel to exceed the channel banks) and this is addressed in the Hydrologic Connectivity metric.

B. Rationale: For all wetlands except riverine wetlands, hydroperiod is the dominant aspect of hydrology. The pattern and balance of inflows and outflows is a major determinant of wetland functions Mitch and Gosselink (1993). The patterns of import, storage, and export of sediment and other water-borne materials are functions of the hydroperiod. In most wetlands, plant recruitment and maintenance are dependent on hydroperiod. The interactions of hydroperiod and topography are major determinants of the distribution and abundance of native wetland plants and animals. Natural hydroperiods are key attributes of successful wetland projects (National Research Council 2001).

For riverine systems, the patterns of increasing and decreasing flows that are associated with storms, releases of water from dams, seasonal variations in rainfall, or longer term trends in peak flow, base flow, and average flow are more important than hydroperiod. The patterns of flow, in

conjunction with the kinds and amounts of sediment that the flow carries or deposits, largely determine the form of riverine systems, including their floodplains, and thus also control their ecological functions. Under natural conditions, the opposing tendencies for sediment to stop moving and for flow to move the sediment tend toward a dynamic equilibrium, such that the form of the channel in cross-section, plan view, and longitudinal profile remains relatively constant over time (Leopold 1994). Large and persistent changes in either the flow regime or the sediment regime tend to destabilize the channel and cause it to change form. Such regime changes are associated with upstream land use changes, alterations of the drainage network, and climatic changes. A riverine channel is an almost infinitely adjustable complex of interrelations between flow, width, depth, bed resistance, sediment transport, and riparian vegetation. Change in any of these factors will be countered by adjustments in the others. The degree of channel stability can be assessed based on field indicators.

This metric evaluates recent changes in the hydroperiod, flow regime, or sediment regime of a wetland and the degree to which these changes affect the structure and composition of the wetland plant community or, in the case of riverine wetlands, the stability of the riverine channel.

C. Seasonality: For all wetland types other than depressional wetlands, vernal pools, and playas, hydroperiod should be evaluated during the dry season. For depressional wetlands and playas, hydroperiod should be assessed during the latter part of the wet season (i.e., June and July, in most years). The assessment window for vernal pools can be relatively short, and varies from one year to the next. As a general rule, however, hydroperiod for vernal pools should be assessed near the end of their growing season, when botanical indicators of successional change in hydroperiod are evident (i.e., April or May in most years).

4.2.3 Metric 3: Hydrologic Connectivity

A. Definition: Hydrologic Connectivity describes the ability of water to flow into or out of the wetland, or to accommodate rising flood waters without persistent changes in water level that can result in stress to wetland plants and animals.

B. Rationale: Hydrologic connectivity between wetlands and adjacent uplands promotes the exchange of water, sediment, nutrients, and organic carbon. Inputs of organic carbon are of great importance to ecosystem function. Litter and allochthanous input from adjacent uplands provides energy that subsidizes the aquatic food web (Roth *et al.* 1996). Connection with adjacent water bodies promotes the import and export of water-borne materials, including nutrients. Hydrologic connections with shallow aquifers and hyporheic zones influence most wetland functions. Plant diversity tends to be positively correlated with connectivity between wetlands and natural uplands, and negatively correlated with increasing inter-wetland distances (Lopez *et al.* 2002). Amphibian diversity is directly correlated with connectivity between streams and their floodplains (Amoros and Bornette 2002). Linkages between aquatic and terrestrial habitats allow wetland-dependent species to move between habitats to complete life cycle requirements. For estuarine wetlands, the function of upland transitions as refuge for intertidal wildlife during extreme high tides is especially important

For all wetland types except riverine, this metric is scored by assessing the degree to which the lateral movement of rising tides or flood waters are restricted by features such as levees, dikes,

sea walls, or road grades in the AA, its encompassing wetland and the associated upland transition zone.

For riverine wetlands, Hydrologic Connectivity is assessed based on the degree of channel entrenchment (Leopold *et al.* 1964, Rosgen 1996, Montgomery and MacDonald 2002). Entrenchment is calculated as the flood-prone width divided by the bankfull width. The flood-prone width is measured at the elevation equal to twice the maximum bankfull depth; maximum bankfull depth is the height of bankfull flow above the thalweg.

C. Seasonality: This metric is not sensitive to seasonality.

4.3 Attribute 3: Physical Structure

Physical structure is defined as the spatial organization of living and non-living surfaces that provide habitat for biota (Maddock 1999). For example, the distribution and abundance of organisms in riverine systems are largely controlled by physical processes and the resulting physical characteristics of habitats (e.g., Frissell *et al.* 1986). Metrics of the Physical Structure attribute in CRAM therefore focus on physical conditions that are indicative of the capacity of a wetland to support characteristic flora and fauna.

4.3.1 Metric 1: Structural Patch Richness

A. Definition: Patch richness is the number of different obvious types of physical surfaces or features that may provide habitat for aquatic, wetland, or riparian species. This metric is different from topographic complexity in that it addresses the number of different patch types, whereas topographic complexity evaluates the spatial arrangement and interspersion of the types. Physical patches can be natural or unnatural.

B. Rationale: The richness of physical, structural surfaces and features in a wetland reflects the diversity of physical processes, such as energy dissipation, water storage, and groundwater exchange, which strongly affect the potential ecological complexity of the wetland. The basic assumption is that natural physical complexity promotes natural ecological complexity, which in turn generally increases ecological functions, beneficial uses, and the overall condition of a wetland. For each wetland type, there are visible patches of physical structure that typically occur at multiple points along the hydrologic/moisture gradient. But not all patch types will occur in all wetland types. Therefore, the rating is based on the total number of expected patch types present in an AA for a given type of wetland.

C. Seasonality: This metric is not sensitive to seasonality.

4.3.2 Metric 2: Topographic Complexity

A. Definition: Topographic complexity refers to the micro- and macro-topographic relief within a wetland due to abiotic features and elevations gradients.

B. Rationale: Topographic complexity promotes variable hydroperiods and concomitant moisture gradients that, in turn, promote ecological complexity by increasing the spatial and temporal variability in energy dissipation, surface water storage, groundwater recharge, particulate matter detention, cycling of elements and compounds, and habitat dynamics. Areas that are aerated due to flow across complex surfaces may promote volatilization of compounds, or re-suspension and export of water-borne material.

Topographic complexity is assessed by noting the overall variability in physical patches and topographic features. Care must be taken to distinguish indicators of topographic complexity or habitat features within a wetland. For each type of wetland, topographic complexity can be evaluated by observing the number of elevational features that affect moisture gradients or that influence the path of water flow along a transect across the AA, and the amount of micro-topographic relief along the gradients or flow paths. Topographic gradients may be indicated by plant assemblages with different inundation/saturation or salinity tolerances.

C. Seasonality: This metric is not sensitive to seasonality.

4.4 Attribute 4: Biotic Structure

The biotic structure of a wetland includes all of its organic matter that contributes to its material structure and architecture. Living vegetation and coarse detritus are examples of biotic structure. Plants strongly influence the quantity, quality, and spatial distribution of water and sediment within wetlands. For example, in many wetlands, including bogs and tidal marshes, much of the sediment pile is organic. Vascular plants in estuarine and riverine wetlands entrap suspended sediment. Plants reduce wave energies and decrease the velocity of water flowing through wetlands. Plant detritus is a main source of essential nutrients, while vascular plants and large patches of macroalgae function as habitat for wetland wildlife.

4.4.1 Metric 1: Plant Community

A. Definition: The Plant Community Metric is composed of three submetrics for each wetland type. Two of these sub-metrics, Number of Co-dominant Plants and Percent Invasion, are common to all wetland types. For all wetlands except Vernal Pools and Vernal Pool Systems, the Number of Plant Layers as defined for CRAM is also assessed. For Vernal Pools and Pool Systems, the Number of Plant layers submetric is replaced by the Endemic Species Richness submetric. A thorough reconnaissance of an AA is required to assess its condition using these submetrics. The assessment for each submetric is guided by a set of a set of rules (Figure 4.1) and the Plant Community Worksheets. The Plant Community metric is calculated based on these worksheets.

A "plant" is defined as an individual of any vascular macrophyte species of tree, shrub, herb/forb, or fern, whether submerged, floating, emergent, prostrate, decumbent, or erect, including non-native (exotic) plant species. Mosses and algae are not included among the species identified in the assessment of the plant community. For the purposes of CRAM, a plant "layer" is a stratum of vegetation indicated by a discreet canopy at a specified height that comprises at least 5% of the area of the AA *where the layer is expected.*

Non-native species owe their occurrence in California to the actions of people since shortly before Euroamerican contact. Many non-native species are now *naturalized* in California, and may be widespread in occurrence. "Invasive" species are non-native species that "(1) are not native to, yet can spread into, wildland ecosystems, and that also (2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes" (CalIPC 2012). CRAM uses the California Invasive Plant Council (CalIPC) list to determine the invasive status of plants, *with augmentation by regional experts.*

B. Rationale: The functions of whole-wetland systems are optimized when a rich native flora dominates the plant community, and when the botanical structure of the wetland is complex in 3-dimensional space, due to species diversity and recruitment, and resulting in suitable habitat for multiple animal species. Much of the natural microbial, invertebrate, and vertebrate communities of wetlands are adjusted to the architectural forms, phenologies, detrital materials, and chemistry of the native vegetation. Furthermore, the physical form of wetlands is partly the result of interactions between plants and physical processes, especially hydrology. A sudden change in the dominant species, such as results from plant invasions, can have cascading effects on whole-system form, structure, and function.

The Plant Community Metric is assessed in terms of the similarity between the dominant species composition of the plant community and what is expected based on CRAM verification and validation studies, regional botanical surveys, and historical resources. This metric requires the ability to recognize the most common and abundant plants species of wetlands. When a CRAM field team lacks the necessary botanical expertise, photographs and/or voucher specimens will need to be collected using standard plant presses and site documentation. This can greatly increase the time required to complete a CRAM assessment.

C. Seasonality: This suite of metrics is ideally assessed during the latter third of the growing season, when all plant layers have developed to their full extent.

4.4.1.1 Submetric A: Number of Plant Layers Present

The first submetric of the Plant Community Metric is the Number of Plant Layers Present in the AA. This submetric does not pertain to Vernal Pools or Playas. Plant layers play a large role in the assessment of the biotic structure attribute. They are distinguished from one another by the differences in average maximum heights of their co-dominant plant species. To be counted in CRAM, a layer must cover at least 5% of *the portion of the AA that is suitable for the layer*. This would be the littoral zone of lakes and depressional wetlands for the one aquatic layer, called "floating." The "short," "medium," and "tall" layers might be found throughout the non-aquatic areas of each wetland class, except in areas of exposed bedrock, mudflat, beaches, active point bars, etc. The "very tall" layer is usually expected to occur along the backshore, except in forested wetlands.

It is essential that the layers be identified by the actual plant heights (i.e., the approximate maximum heights) of plant species in the AA, regardless of the growth potential of the species. For example, in a riverine system a young sapling redwood between 0.5 m and 1.5 m tall would belong to the "medium" layer, even though in the future the same individual redwood might belong to the "very tall" layer. Some species might belong to multiple plant layers. For example, groves of red alders of all different ages and heights might collectively represent all four non-aquatic layers in a riverine AA. Riparian vines, such as wild grape, might also dominate all of the non-aquatic layers.

Standing (upright) dead or senescent vegetation from the previous growing season can be used in addition to live vegetation to assess the number of plant layers present. However, the lengths of prostrate stems or shoots are disregarded. In other words, fallen vegetation should not be "held up" to determine the plant layer to which it belongs. The number of plant layers must be determined based on the way the vegetation presents itself in the field.

4.4.1.2 Submetric B: Number of Co-dominant Species

The second submetric, Number of Co-dominant Species, deals directly with dominant plant species richness in each plant layer and for the AA as a whole. For each plant layer in the AA, all species represented by living vegetation that comprises at least 10% relative cover within the layer are considered to be dominant. Only living vegetation in growth position is considered in this metric. Dead or senescent vegetation is disregarded.

The investigator lists the names of all co-dominant plant species in each layer. The list is used to determine the total number of co-dominant species for all the layers that are represented in the AA. Some species, such as wild grapes and poison oak, can dominate multiple layers. Even though such plants provide have functional differences between layers, they should only be counted once when calculating the Number of Co-dominant Species for the AA. No matter how many layers a given species dominates, it should only be counted once as a co-dominant.

4.4.1.3 Submetric C: Percent Invasion

For the third submetric, Percent Invasion, the number of invasive co-dominant species for all plant layers combined is assessed as a percentage of the total number of co-dominants, based on the results of the Number of Co-dominant Species sub-metric. The invasive status for many California wetland and riparian plant species is based on the Cal-IPC list. However, the best professional judgment of local experts may be used instead to determine whether or not a co-dominant species is invasive. If the status cannot be determined in the field, then a voucher specimen and field photographs of the plants in question should be used in conjunction with the Jepson Manual (Baldwin, et al. 2012) or in consultation with appropriate experts to determine invasive status.

4.4.1.4 Submetric C (vernal pools): Endemic Species Richness

This submetric only applies to Vernal Pools and Vernal Pool Systems. These wetlands are distinguished from all other wetland types by a unique endemic flora. This submetric is based on the total number of endemic plant species that appear in the AA as listed in the CRAM Vernal Pools Plant List.

4.4.2 Metric 2: Horizontal Interspersion

A. Definition: Horizontal biotic structure refers to the variety and interspersion of plant "zones." Plant zones are plant monocultures or obvious multi-species associations that are arrayed along gradients of elevation, moisture, or other environmental factors that seem to affect the plant community organization in plan view. Interspersion is essentially a measure of the number of distinct plant zones and the amount of edge between them.

B. Rationale: The existence of multiple horizontal plant zones indicates a well-developed plant community and predictable sedimentary and bio-chemical processes. The amount of interspersion among these plant zones is indicative of the spatial heterogeneity of these processes. Richer native communities of plants and animals tend to be associated with greater zonation and more interspersion of the plant zones.

C. Seasonality: This metric is not sensitive to seasonality.

4.4.3 Metric 3: Vertical Biotic Structure

A. Definition: The vertical component of biotic structure assesses the degree of overlap among plant layers. The same plant layers used to assess the Plant Community Composition metrics are used to assess Vertical Biotic Structure. To be counted in CRAM, a layer must cover at least 5% of the portion of the AA that is suitable for the layer. This metric does not pertain to Vernal Pools, Vernal Pool Systems, or Playas.

B. Rationale: The overall ecological diversity of a wetland tends to correlate with the vertical complexity of the wetland's vegetation. For many types of wetlands in California, overlapping layers of vegetation above or below the water surface contribute to vertical gradients in light and temperature that result in greater species diversity of macroinvertebrates, fishes, amphibians, and birds. In riparian areas, the species richness of birds and small mammals tends to increase with the density and number of well-developed, overlapping plant layers. Many species of birds that nest near the ground or water surface in wetlands commonly require a cover of vegetation at their nest sites. Multiple layers of vegetation also enhance hydrological functions, including rainfall interception, reduced evaporation from soils, and enhanced filtration of floodwaters.

In many depressional wetlands and some wet meadows, the detritus of above-ground growth of low and medium layers of herbaceous plants and emergent monocots tends to get entrained within the layers as an internal canopy below the maximum height of the upper plant layer. These "entrained canopies" serve as cover for many wildlife species.

In estuarine wetlands, the entrained canopies entrap debris including coarse plant litter that is lifted into the canopies by rising tides. As the tide goes out, the material is left hanging in the plant cover. Over time, these entrained canopies can gain enough density and thickness to provide important shelter for many species of birds and small mammals that inhabit estuarine wetlands. Most passerine birds and rails that nest in estuarine wetlands choose to nest below an entrained canopy because it protects them from avian predators, including owls and harriers.

C. Seasonality: This metric should be assessed late during the growing season.

CHAPTER 5:
GUIDELINES TO COMPLETE STRESSOR CHECKLISTS

A. Definition: For the purposes of CRAM, a stressor is an anthropogenic perturbation within a wetland or its setting that is likely to negatively impact the functional capacity of a CRAM Assessment Area (AA). In contrast, disturbances are distinctly defined as natural phenomena, although they might have similar impacts as stressors.

B. Rationale: Physical and biological processes connect wetlands to their environmental settings and thus help shape wetland conditions, which are therefore influenced by land use practices within the settings (Frissell *et al.* 1986, Roth *et al.* 1996, Scott *et al.* 2002). Wetland conditions can also be affected by stressors operating directly within the wetlands, although these tend to be less abundant than stressors originating in the surrounding landscape.

The purpose of the Stressor Checklist is to identify stressors within a CRAM Assessment Area (AA) or its immediate vicinity that might help account for any low CRAM scores. In some cases, a single stressor might be the primary cause for low-scoring conditions, but conditions are usually due to interactions among multiple stressors (USEPA 2002).

There are four underlying assumptions of the Stressor Checklist: (1) stressors can help explain CRAM scores; (2) wetland condition declines as the number of stressors acting on the wetland increases (there is no assumption that the decline is additive (linear), non-linear, or multiplicative); (3) increasing the intensity or the proximity of the stressor results in a greater decline in condition; and (4) continuous or chronic stress increases the decline in condition.

C. Seasonality: The Stressor Checklist is not sensitive to seasonality.

D. Office and Field Indicators: The process to identify stressors is the same for all wetland types. For each CRAM attribute, a variety of possible stressors are listed. Their presence and likelihood of significantly affecting the AA are recorded in the Stressor Checklist Worksheet. For the Hydrology, Physical Structure, and Biotic Structure attributes, the focus is on stressors operating within the AA or within 50 m of the AA. For the Buffer and Landscape Context attribute, the focus is on stressors operating within 500 m of the AA. More distant stressors that have obvious, direct, controlling influences on the AA can also be noted.

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APPENDIX I: GLOSSARY

aggradation – filling and raising of the level of the bed of a stream by deposition of sediment; the opposite of degradation

algal mat- macroalgae occurring on the water surface of a wetland.

allochthonous – external source of energy (carbon) for a stream (e.g., dead leaves, branches, and dead trees that fall into the river)

alluvial – refers to natural, channelized runoff from terrestrial terrain and the material borne or deposited by such runoff

anthropogenic – arising from human activity

aquatic area abundance- for the purposes of CRAM, a measure an aquatic area's spatial association with other areas of aquatic resources, such as other wetlands, lakes, streams, etc. For riverine systems, this metric is scored as the continuity of the riparian corridor over a prescribed distance upstream and downstream of the CRAM Assessment Area (AA).

arcuate- shaped or bent like an arc or bow (i.e. broadly curving)

assessment area – the portion of a wetland or riverine system that is the subject of the CRAM evaluation

assessment window – the period of time when assessments of wetland condition should be conducted. In general, it is during the growing season for the characteristic plant community of the wetland type to be assessed.

attribute – attributes constitute the obvious, universal aspects of wetland condition; CRAM recognizes a total of four attributes of condition within a wetland: (1) buffer and landscape context; (2) hydrology; (3) physical structure; and (4) biotic structure.

avulsion – sudden shift or movement of fluvial flow entirely or in part from one channel to another, less sinuous and steeper channel. Avulsions are typically formed during large storm events when high discharge erodes a new channel in the floodplain. Avulsions are more common in braided or aggrading stream channels.

backshore- the boundary between the wetland and the adjoining upland, where the upland is at least 5m wide. The high-water contour of the wetland is a good proxy for its backshore boundary.

bankfull – height of fluvial flow corresponding to the floodplain. This is the stage when water in the channel just begins to flow onto the floodplain.

bank slump- a portion of a bank that has broken free from the rest of the bank but has not eroded away

bar – a transient sedimentary feature within an intertidal and fluvial channel that is often exposed during low-water periods. Bars direct flows and form along the inside of a meander bend (point-bar) or in the middle of straight channel reach (in-channel bar). They are convex in profile and are comprised of alluvial or tidal deposits of sand, gravel, cobble, or other material. Their surface material varies in size from small on top to larger along their lower margins and they sometimes support vegetation.

barrier beach – a natural area of sand or gravel along a lacustrine, marine or estuarine shore that blocks the landward action of tides or waves

benthic – pertaining to the sea bed, river bed, or lake floor

berm- A flat strip of land, raised bank, or terrace bordering a wetland. Berms can be natural or artificial in origin.

borrow ditch-a ditch dug along a roadway to furnish fill and provide drainage

boulder- a size category of rock having a long axis greater than 25 cm

braided – a stream that forms an interlacing network of branching and recombining channels separated by floodplains, channel bars, or islands

buffer – for the purposes of CRAM, the area extending from the immediate edge of the AA that is in a natural, or semi-natural, state and protects the AA from stressors

catchment – synonymous with watershed. An area of land, bounded by a drainage divide, which drains to a fluvial channel or water body.

channel- a feature in tidal and fluvial systems consisting of a bed, its opposing banks, plus its floodplain, that confines and conveys surface water flow. The system of diverging and converging channels that characterize braided and anastomosing fluvial systems usually consist of one or more main (primary) channels plus secondary channels.

channel stability- a measure of the degree of channel aggradation (i.e. net accumulation of sediment on the channel bed causing it to rise over time) or degradation (i.e. net loss of sediment from the bed causing it to be lower over time).

coarse woody debris- a single piece of woody material, greater than 30 cm in diameter and greater than 3 m long

cobble-a size category of rock having a long axis from about 6 cm to about 25 cm

condition – condition is defined as the ability of a wetland to maintain its complexity and capacity for self-organization with respect to species composition, physio-chemical characteristics, and functional processes, relative to healthy wetlands of the same type. There are three primary aspects of condition: location, form, and structure.

confinement – the degree to which levee, terraces, or hillsides prevent the lateral migration of a fluvial channel

crenulated- having a margin that is very finely indented, notched, or with rounded (scalloped), projections, as in a crenulated foreshore of a wetland.

culvert- a drain or covered channel that crosses under a road, railway, etc.

debris jam – an accumulation of material, organic or inorganic, floating or submerged, that has been lodged into place by the action of a flowing water. Debris jams partially or completely obstruct surface water flow and sediment causing a change in the course of flow.

deciduous – plants (trees and shrubs) that shed all of their leaves annually, such that there is a time each year at which individuals of the species are essentially devoid of leaves

deposition – the settlement of materials out of moving water and onto the bed, banks, or floodplain of a wetland or riverine channel.

degradation – the long-term lowering of a fluvial channel due to erosion of its bed

detritus – deposition of newly dead or decaying organic matter

disturbance – the consequence of natural changes in forcing functions, or controlling factors, through space and over time; disturbance is natural, regardless of its frequency, persistence, or magnitude

drop structure- an artificial structure, typically small and built on streams with steep gradients, to pass water to a lower elevation while controlling the energy and velocity of the water as it passes over.

dryland farming-a system of growing crops in arid or semiarid regions without artificial irrigation, by reducing evaporation and by special methods of tillage.

duff – a spongy layer of decaying leaves, branches, and other organic materials along a wetland shore or in a riverine riparian area

ecological services – the services, or beneficial uses, for which a wetland can be managed; key ecological services for many types of wetland include flood control, groundwater recharge, water filtration, conservation of cultural values, aesthetics, and the support of special-status species.

emergent vegetation - plant species typically growing on saturated soils or on soils covered with water for most of the growing season; the leaves of emergent aquatic species are partly or entirely borne above the water surface; examples of such species include *Rorippa nasturtium-aquaticum* (watercress) and *Schoeneoplectus californicus* (tule, bulrush).

entrenchment – the inability of flows in a channel to exceed the channel banks (i.e. the vertical containment of stream); a measure of the degree to which fluvial flood flows are contained within channel banks without access to the effective valley. Entrenchment as a field measurement is calculated as the flood-prone width divided by the bankfull width.

effective valley width – the portion of a valley within which its fluvial channel is able to migrate without cutting into hill slopes, terraces, man-made levees, etc.

floodplain – the bench or broader flat area of a fluvial channel that corresponds to the height of the bankfull flow. It is a relatively flat depositional area that is periodically flooded, as evidenced by deposits of fine sediment, wrack lines, vertical zonation of plant communities, etc.

flood prone - land susceptible to inundation by extreme flood events. The height of the flood prone area approximately corresponds to twice bankfull height.

fluvial – of, relating to, or happening in, a river or stream

forb – a plant with a soft, rather than permanent, woody stem that is not a grass or grass-like

foreshore- the boundary between the vegetated wetland and any adjoining semi-aquatic, non-wetland area, such as an intertidal flat or a non-vegetated riverine channel bar, or a fully aquatic area such as the open water area of a lake or estuary that is at least 30m wide.

free-floating – plants that float at or just beneath the water surface without attachment to the substrate; free-floating aquatic species are transported freely by wind and water currents

function – for the purposes of Level 2 assessment, a function is something that a wetland stream or riparian area does. For example, groundwater recharge, flood-stage desynchronization, pollution filtration, wildlife support, and recreation are wetland functions. In this context, functions are identified separately from the processes that cause them to happen. In most cases, Level 3 tools are needed to assess the processes that account for functions.

herbaceous – a plant having stems that are not secondarily thickened and that die down annually

headcut- an erosional feature of some streams where an abrupt vertical drop in the stream bed occurs. The process of headcutting involves the initiation of channel incision at a nick point as the stream channel bed elevation adjusts to a natural or human induced disturbance. In flowing streams, head cuts resemble a small waterfall. A small plunge pool may be present

at the base of the head cut due to the high energy of falling water. When not flowing, the head cut will resemble a very short cliff or bluff in the stream channel.

hummock – a mound composed of organic materials (typically less than 1m high) along the banks and floodplains of fluvial systems created by the collection of sediment and biotic material around wetland plants such as sedges.

hydrologic connectivity- a measure of the ability of water to flow into or out of the wetland, or to accommodate rising flood waters without persistent changes in water level that can result in stress to wetland plants and animals

hydroperiod- the characteristic frequency and duration of inundation or saturation of a wetland during a typical year

hyporheic – saturated zone under a river or stream, comprising substrate with the interstices filled with water

knick point – an abrupt change of gradient in the profile of a stream or river, typically due to a change in the rate of erosion. This is the point where the stream is actively eroding the streambed to a new base level; nick points tend to migrate upstream. See definition for *headcut*.

in-channel bar- a transient sedimentary feature within an intertidal or fluvial channel that forms in the middle of straight channel reach.

interfluve – the region of higher land between two fluvial channels or swales on a floodplain or in a braided channel system

interspersion-a measure of the number of distinct patches (as in plant zones) and the amount of edge between them.

invasive – species that have been introduced from other regions by the actions of people and that exhibit a tendency to significantly displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes.

litter- a layer of organic matter (partly decomposed leaves, twigs, etc) on the ground.

littoral zone – the nearshore area of a water body, where it is sufficiently shallow to allow light to penetrate to the bottom and reach rooted vegetation; corresponds with the limit of submerged aquatic vegetation

meander – the curves of a fluvial or tidal channel as viewed from above; a meander cutoff is a new, shorter channel across the narrow neck of a meander

metric – a measurable component of a CRAM attribute

muted- pertaining to an estuarine tidal regime in which the fluctuation of the water level is lower in amplitude than would be expected due to levees, culverts, tide gates, or other artificial devices which inhibit the exchange of water between the site and the tidal body. These obstructions reduce the range of tides but still allow frequent inundation and exposure.

natural levee – a low ridge landward of the active floodplain of a channel that forms by deposition during flood events.

nonpoint source discharge- any discharge to a wetland resulting from diffuse sources (e.g. land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification). Includes any type of discharge that does not meet the legal definition of "point source" (see definition below)

organic – pertaining to, or derived from, living organisms, or to compounds containing carbon as an essential component

panne – a shallow topographic basin that forms on a fluvial floodplain or tidal marsh plain. Pannes lack vegetation but exist on a well-vegetated wetland plain and fill with water at least seasonally due to overland flow.

patch – a spatially distinct structural element of a wetland system large enough to serve as habitat for wildlife, or to serve as an indicator of spatial variations in hydrological or edaphic (soil) conditions within a wetland

planar bed- a reach of a stream characterized by long, relatively straight channel of uniform depth

periphyton – benthic algae that grow attached to surfaces such as rocks or larger plants

point-bar- a transient sedimentary feature within an intertidal and fluvial channel that form along the inside of a meander bend

point-source discharge- any discernible confined and discrete conveyance (e.g. a pipe, ditch, channel, or conduit) from which pollutants are or may be discharged into a waterway. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.

pool (on floodplain)- a shallow topographic basin on a fluvial floodplain or tidal marsh plain that has been inundated by water.

pool (in channel)- a depression within a fluvial or tidal channel that is much deeper than the average depth of the channel. Pools tend to retain water longer than other areas of the channel during periods of low or no surface flow.

POTW-publicly-owned treatment work; a term used in the United States for a sewage treatment plant that is owned, and usually operated, by a local government agency. They are usually designed to treat domestic sewage and not industrial wastewater.

primary channel-a channel in fluvial and tidal systems that conveys the majority of the surface water flow

rating – for a CRAM metric, a rating represents its state relative to the full range of possible states, from worst possible state to best

reach – a length of stream, lacustrine shore, or estuarine shore that has generally consistent physical and biological characteristics

riffle or rapid – a submerged, topographical high area in a fluvial channel created by the accumulation of relatively coarse-grained sediment (gravel, cobble, or boulders) causing turbulent surface flow and indicated by standing waves

riparian – a transitional area between terrestrial and aquatic ecosystems, distinguished by gradients in biophysical conditions, ecological processes and biota; areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands, including those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems; riparian areas are adjacent to perennial, intermittent, and ephemeral streams, lakes and estuarine-marine shorelines (National Research Council 2002).

riprap- broken stones loosely deposited in water or on a soft bottom to provide a foundation and protect a riverbed or river banks from scour: used for revetments, embankments, breakwaters, etc.

run – a reach of straight, smooth, fast-moving fluvial flow between riffles; also called a glide

scour – concentrated erosive action of flowing water in streams that removes and carries away material from the bed and banks

secondary channel-a channel in fluvial and tidal systems that conveys flood flows, but not the majority of the flow

sediment – organic or inorganic material that has been transported and/or deposited by wind or water action. Sediment can be coarse (i.e., gravel or larger) or fine (i.e. clay, silt, sand). A fresh splay of sediment is one that has been deposited during the current or previous season's runoff event.

sediment mound- a depositional feature (typically less than 1m high) along the banks and floodplains of fluvial systems formed from repeated flood flows depositing sediment on the floodplain. Sediment mounds lack plant cover.

slough – a large tidal channel, or a large fluvial channel lacking an obvious terminal water body, can also refer to an abandoned fluvial channel within the effective valley

snag – a standing, dead tree or shrub at least 3 m (10 feet) tall

sorting-a measure of the spread of particle size in the substrate. Well-sorted particles are made up of similarly sized particles. Poorly sorted particles are made up of a wide variety of different particle sizes.

stress – the consequence of unnatural, anthropogenic changes in forcing functions or controlling factors; key stressors are anthropogenic actions that tend to modify the quantity and/or quality of physical or biological habitat, sediment supplies, and/or water supplies upon which the desired functions of the wetland depend

stressor – an agent that inflicts stress on a wetland

submerged or submergent vegetation - plant species that are adapted to spending their lifespan, from germination to fruiting, completely or nearly completely under water. Submerged vegetation consists of aquatic macrophytes such as *Elodea canadensis* (common elodea)*, Ruppia cirrhosa* (ditchgrass), and *Zannichellia palustris* (horned pondweed) that are rooted in the sub-aqueous substrate but do not usually grow high enough in the overlying water column to intercept the water surface.

swale –broad, elongated, vegetated, shallow depressions that can sometimes help to convey flood flows to and from vegetated marsh plains or floodplains. However, they lack obvious banks, regularly spaced deeps and shallows, or other characteristics of channels. Swales can entrap water after flood flows recede. They can act as localized recharge zones and they can sometimes receive emergent groundwater.

thalweg – the line connecting the lowest or deepest points along the riverbed

thatch- a matted layer of partly decayed leaves, stems, etc. between growing vegetation and the soil.

tide gate- an opening through which water may flow freely when the tide sets in one direction, but which closes automatically and prevents the water from flowing in the other direction.

transportation corridor- a linear pathway for a particular mode of transportation (highway, road, rail, canal, etc.)

tributary- a type of secondary channel that originates in the wetland and only conveys flow between the wetland and the primary channel. Short tributaries that are entirely contained within the CRAM Assessment Area (AA) are regarded as secondary channels.

undercutting- the removal of material at the base of a streambank or shoreline of a wetland by the erosive action of flowing water

unnatural levee- an artificially raised embankment along a wetland that constrains water flows. Their primary purpose is to provide hurricane, storm, and flood protection relating to seasonal high water, storm surges, precipitation, and other weather events.

variegated- having variety in form. As viewed from above, a variegated shoreline resembles a meandering pathway. Variegated shorelines provide greater contact between water and land.

island- an area of land above the usual high water level and, at least at times, surrounded by water. Islands differ from hummocks and other mounds by being large enough to support trees or large shrubs.

vegetation management-the practice of manipulating vegetation within a prescribed management area. Includes prescribed burning, grazing, chemical applications, timber harvesting, and any other economically feasible methods of enhancing, retarding, or removing the above-ground parts of plants.

wetlands – lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water; wetlands must have one or more of the following attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin *et al.* 1979).

wier- a small overflow barrier used to alter the flow characteristics of a river or stream. Weirs are commonly used to prevent flooding, measure discharge, and to help render a river navigable.

wrack or wrackline – an accumulation of natural floating debris (kelp, plastic debris, wood, and similar material) left along the shore of a river, lake, tidal marsh, or other water body by high water levels

xeric – characterized by an extremely dry habitat

zonation – distribution of plants or animals arranged in zones or bands, caused by gradations of abiotic and/or biotic factors

APPENDIX II: ACRONYM LIST

AA	Assessment Area
Cal-IPC	California Invasive Plant Council
CDFW	California Department of Fish and Wildlife
CEDEN	California Environmental Data Exchange Network
CNDDB	California Natural Diversity Database
CRAM	California Rapid Assessment Method for Wetlands
CWMW	California Wetland Monitoring Workgroup
DOQQ	Digital Orthogonal Quarterly Quadrangles
eCRAM	A web-based data submission tool for CRAM
GIS	Geographic Information System
HEP	Habitat Evaluation Procedure
HGM	Hydrogeomorphic Functional Assessment Method
IBI	Index of Biotic Integrity
JD	Jurisdictional Delineation
NAIP	National Agriculture Imagery Program
NGO	Non-governmental Organization
NHD	National Hydrography Dataset
NRC	National Research Council
NWI	National Wetlands Inventory
ORAM	Ohio Rapid Assessment Method
PI	Principal Investigator
PSR	Pressure-State-Response Model
QA/QC	Quality Assurance/Quality Control
RDC	Regional Data Center
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WADOE	Washington State Department of Ecology

WRAMP	Wetland and Riparian Area Monitoring Plan
WRAP	Wetland Rapid Assessment Procedure
WRAPP	Wetland and Riparian Area Protection Policy

Appendix 5E – Toxicity Identification Evaluation/Toxicity Reduction Evaluation Implementation Draft Work Plan

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Toxicity Identification Evaluation / Toxicity Reduction Evaluation Implementation Draft Work Plan

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January 16, 2015

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LIST OF ACRONYMS

2007 Permit	RWQCB Order No. R9-2007-0001
2013 Permit	RWQCB Order No. R9-2013-0001
BMP	best management practice
BSA	bovine serum albumin
CLRP	Comprehensive Load Reduction Plan
Copermittees	San Diego Regional Copermittees
EDTA	ethylenediaminetetraacetic acid
IWC	instream waste concentration
JRMP	Jurisdictional Runoff Management Plan
LC_{50}	median lethal concentration
LID	low impact development
MAP	Monitoring and Assessment Plan
MEP	maximum extent practicable
MS4	multiple separate storm sewer system
NOEC	no observed effect concentration
NPDES	National Pollutant Discharge Elimination System
PBO	piperonyl butoxide
QA/QC	quality assurance/quality control
RWQCB	Regional Water Quality Control Board
SMC	Stormwater Monitoring Coalition
SPE	solid phase extraction
STS	sodium thiosulfate
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
TIE	toxicity identification evaluation
TMDL	Total Maximum Daily Load
TRE	toxicity reduction evaluation
TST	Test of Significant Toxicity
USEPA	United States Environmental Protection Agency
WMA	Watershed Management Area
WQIP	Water Quality Improvement Plan
WURMP	Watershed Urban Runoff Management Program

UNITS OF MEASURE

ppt	parts per thousand
%	percent
<	less than
>	greater than

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1.0 INTRODUCTION

In May of 2013, San Diego Regional Water Quality Control Board (RWQCB) Order No. R9-2013-0001 (2013 Permit) was adopted, replacing Order No. R9-2007-0001 (2007 Permit), effective June 27, 2013. Provision B of the 2013 Permit requires the development of Water Quality Improvement Plans (WQIPs) which will utilize an adaptive planning and management process to identify the highest priority water quality conditions within a Watershed Management Area (WMA) and develop water quality improvement goals and strategies to address these priorities. The WQIPs are currently in development; final WQIP document submittal is due to the RWQCB by June 27, 2015.

The WQIP's integrated Monitoring and Assessment Program (MAP) will describe monitoring and assessment procedures, incorporating at a minimum the monitoring and assessment requirements of Provision D of the 2013 Permit. Provision D.1.c.(4)(f) specifies:

> "Toxicity Identification Evaluation (TIE) / Toxicity Reduction Evaluation (TRE): If chronic toxicity is detected in receiving waters, the Copermittees must discuss the need for conducting a TIE/TRE in the assessments required under Provision D.4.a.(2), and develop a plan for implementing the TIE/TRE to be incorporated in the Water Quality Improvement Plan."

A TIE is defined by the 2013 Permit as "A set of procedures for identifying the specific chemical(s) responsible for toxicity. These procedures are performed in three phases (characterization, identification, and confirmation) using aquatic organism toxicity tests." A TRE is defined as "A study conducted in a step-wise process designed to identify the causative agents of effluent or ambient toxicity, isolate the sources of toxicity, evaluate the effectiveness of toxicity control options, and then confirm the reduction in toxicity. The first steps of the TRE consist of the collection of data relevant to the toxicity, including additional toxicity testing, and an evaluation of facility operations and maintenance practices and best management practices. A TIE may be required as part of the TRE, if appropriate."

This Work Plan outlines the process used to identify chronic toxicity in receiving waters, as well as guidance to prioritize the need to implement a TIE/TRE based on the magnitude and persistence of chronic toxicity. The Work Plan refers to the appropriate references for detailed sampling and analytical/toxicity test methods specific to the TIE/TRE treatment process. An example of a potential TRE decision process for receiving water samples (Stormwater Monitoring Coalition (SMC) Model Monitoring Technical Committee, 2004) is presented in Figure 1-1. The process should be modified on location-specific and pollutant-specific basis, and a detailed work plan should be developed for the implementation of a pollutant reduction program once the specific pollutant(s) causing toxicity exceedances are identified.

This Work Plan focuses primarily on the implementation of the TIE/TRE process, recognizing the limitations of utilizing TRE guidance developed for point source discharges. Receiving water stations potentially capture pollutants from many sources with runoff flows and contaminant concentrations likely more variable than those from point source discharges. However, with modifications to the TRE guidance developed for point source discharges, a TRE may be conducted to attempt to identify sources of toxicity, propose mitigation measures for these sources, and conduct follow-up studies to confirm toxicity reduction. Any activities that result in

consistently reducing toxicity to an acceptable level may be considered TRE activities (USEPA 2001).

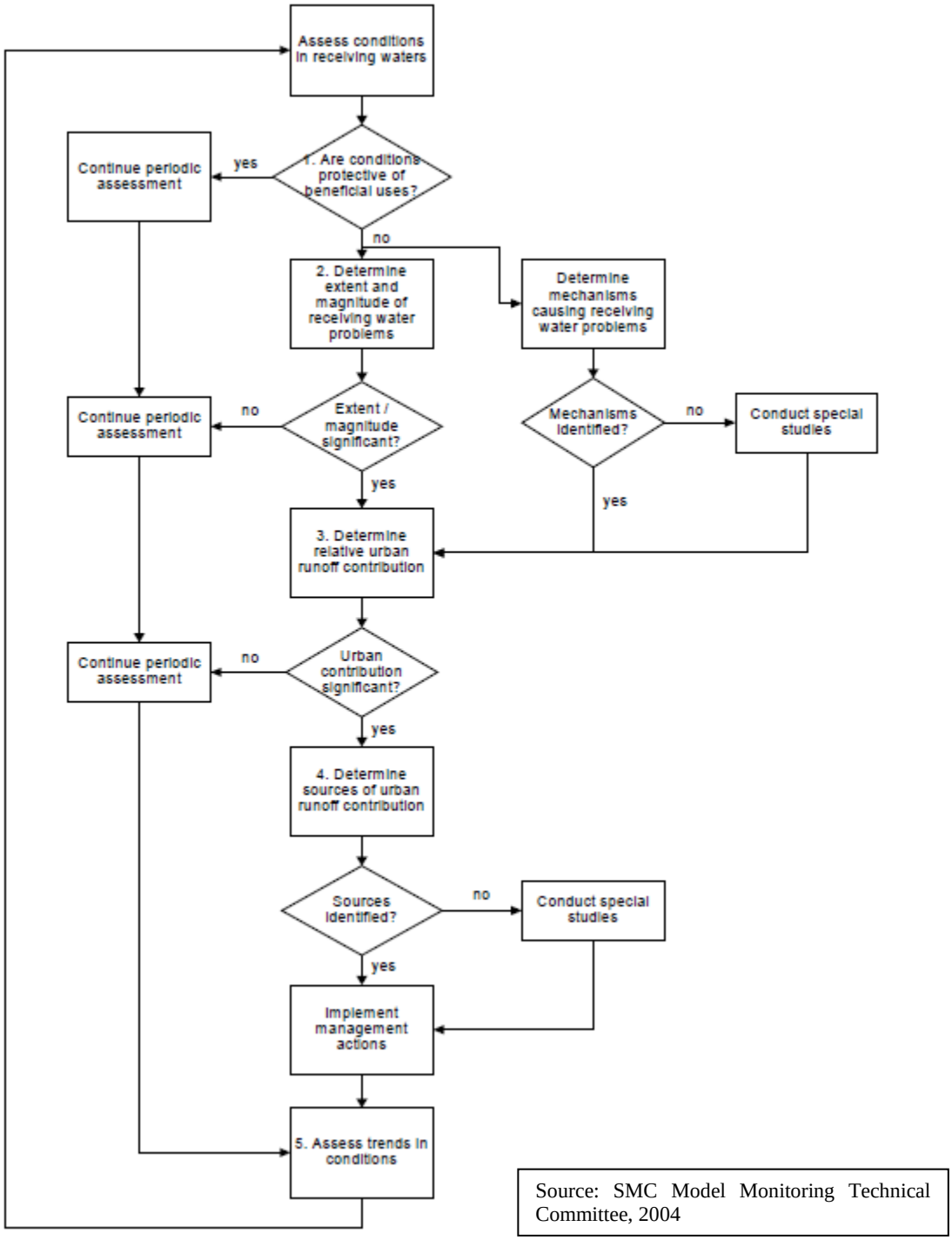

Figure 1-1. Example Receiving Water Monitoring and TIE/TRE Decision Framework

2.0 RECEIVING WATER TOXICITY TESTING

Receiving water monitoring is conducted by the San Diego Regional Copemittees (Copermittees) in accordance with Provision D of the 2013 Permit. Specific receiving water sampling procedures will be detailed in the MAP. Chronic toxicity is one of the parameters evaluated in both wet and dry weather receiving water samples. Under the transitional monitoring requirements of the 2013 Permit prescribed between the end of the 2007 Permit term and the completion of the WQIPs, acute and chronic toxicity tests are conducted in accordance with the 2007 Permit, as summarized in Table 2-1. Under the long-term monitoring requirements of the 2013 Permit, chronic toxicity tests are conducted in accordance with Provision D.1.c.(4)(e) of the 2013 Permit as summarized in Table 2-1, with sample salinity dictating which test organisms are used. When sample salinity is less than (<) 1 part per thousand (ppt), chronic toxicity tests are conducted utilizing *Pimephales promelas*, *Ceriodaphnia dubia*, and *Selenastrum capricornutum* in accordance with United States Environmental Protection Agency (USEPA) 2002. Once the most sensitive of these species is determined for a station, monitoring will continue utilizing the most sensitive species. When sample salinity is greater than (>) or equal to 1 ppt, a chronic toxicity test is conducted utilizing *Strongylocentrotus purpuratus* in accordance with USEPA 1995.

While transitional monitoring test endpoint data is evaluated based on no observed effect concentration (NOEC) and median lethal concentration (LC_{50}) data, endpoint data from toxicity testing of long-term monitoring as well as other receiving water quality monitoring under the MAP is evaluated using the Test of Significant Toxicity (TST) outlined in the *National Pollutant Discharge Elimination System Test of Significant Toxicity Implementation Document* (USEPA, 2010). The TST approach assigns a Pass or Fail result based on whether the organism response observed at the chronic instream waste concentration (IWC) of 100 percent (%) receiving water is significantly different from that in the control treatment. When chronic toxicity is observed in receiving water samples (i.e., the sample receives a "Fail" based on the TST), implementation of a TIE/TRE process following the phased approach described in subsequent sections will be considered, as appropriate.

Table 2-1. Transitional and Long-Term Receiving Water Toxicity Tests

Organism	Endpoint	Toxicity Threshold	USEPA Protocol
Monitoring in accordance with Order No. R9-2013-0001, Salinity < 1 ppt			
Ceriodaphnia dubia	Chronic survival and reproduction	Pass/Fail	EPA-821-R-02-013
Selenastrum capricornutum	Chronic growth		
Pimephales promelas	Chronic survival and growth		
Monitoring in accordance with Order No. R9-2013-0001, Salinity $\geq$ 1 ppt			
Strongylocentrotus purpuratus	Chronic development	Pass/Fail	EPA-600-R-95-136
Transitional Monitoring in accordance with Order No. R9-2007-0001*			
Ceriodaphnia dubia	Chronic survival and reproduction	NOEC < 100%	EPA-821-R-02-013
Selenastrum capricornutum	Chronic growth		
Hyalella azteca	Acute survival	$LC_{50} \leq 100\%$	EPA-821-R-02-012

*N/A under MAP

3.0 TIE/TRE PROCESS

3.1 Information and Data Acquisition

Prior to initiating the TIE/TRE process, an evaluation of procedures utilized during sampling and toxicity testing should be conducted to assess whether toxicity may have been introduced during these procedures or errors may have been made. This test acceptability evaluation may include a review of the following:

- Sampling equipment decontamination procedures
- Field and laboratory logs
- Laboratory reports

If chronic toxicity is observed, all test acceptability criteria are met, no errors or sources of contamination are suspected, and the data supports the need to discuss implementing the TIE/TRE process, conducting a TIE is often the first step to identifying the toxicant.

3.2 TIE Testing

TIEs may be conducted in accordance with USEPA guidance for characterizing, identifying, and confirming toxicity (USEPA 1991, 1992, 1993a, and 1993b). Because a maximum of three TIEs have historically been conducted per monitoring year, priority is generally given to stations exhibiting significant and persistent toxicity that has not previously been characterized and where analytical results indicate that a specific toxicant may be causing or contributing to toxicity. The sample may be evaluated for TIE suitability using the following assessments:

- Presence of Persistent Toxicity: For receiving water samples collected by the Copermittees in accordance with Provision D of the 2013 Permit, toxicity is considered persistent if more than 50% of samples (generally during a monitoring year) collected at a station receive a "Fail" based on the TST (i.e., both wet or dry receiving water samples exhibit toxicity for transitional monitoring or at least two of three samples for long-term monitoring).
- Magnitude of Toxicity: The magnitude of toxicity should be sufficient such that increases or decreases in organism response as a result of the TIE treatments are likely to be quantifiable. Experience conducting TIEs in receiving waters supports using a 50% effect trigger (i.e., a 50% organism response in the 100% receiving water sample) to provide a reasonable opportunity for a successful TIE.
- Previous Characterization: TIEs are generally prioritized for receiving water stations where previous TIEs have not characterized the pollutant(s) causing toxicity. However, TIE/TRE procedures should not be ruled out for previously characterized stations since contributor(s) to toxicity may change over time.

The TIE approach is divided into three phases, as described in USEPA 1991 and summarized as follows:

- Phase I – characterizes the physical/chemical nature of the constituent(s) which cause or contribute to toxicity. Such characteristics as solubility, volatility and filterability are determined without specifically identifying the toxicants.
- Phase II – utilizes methods to specifically identify toxicants.
- Phase III – utilizes methods to confirm the suspected toxicants.

Phase I (characterization) manipulations of receiving water samples generally include those presented in Table 3-1.

Table 3-1. Phase I TIE Receiving Water Sample Manipulations

Physical and Chemical Manipulations on Receiving Water Samples	Purpose of Test
Baseline	Confirms toxicity is still present in the sample at time of TIE testing
Filtration	Detects particulates or particulate-bound toxicants
Aeration	Detects volatile, oxidizable, sublatable, or spargeable compounds
Ethylenediaminetetraacetic acid (EDTA) addition	Detects cationic metals (e.g., cadmium)
Sodium thiosulfate (STS) addition	Detects oxidative compounds (e.g., chlorine)
Solid phase extraction (SPE) over C18 column (may be followed by methanol elution)	Detects non-polar organics and some surfactants (methanol elution adds toxicity back to sample)
Piperonyl butoxide (PBO) addition	Detects organophosphate pesticides and pyrethroids
Carboxyl esterase addition*	Hydrolyzes pyrethroids
Bovine serum albumin (BSA) addition	Protein BSA is used as a control for the carboxyl esterase
Temperature reduction	Increases toxicity of pyrethroid pesticides
pH adjustment	Detects pH-dependent toxicants (e.g., ammonia and sulfides)

* Carboxylesterase addition has been used in recent studies to help identify pyrethroid-associated toxicity (Wheelock et al., 2004; Weston and Amweg, 2007). However, this treatment is experimental in nature and should be used along with other pyrethroid-targeted TIE treatments (e.g., PBO addition).

Adjustments may be made to these TIE protocols if specific contaminants are suspected to be contributing to toxicity. For example, total dissolved solids (TDS) controls and/or mock effluents to mimic TDS concentrations observed in samples are often added to the treatments listed in Table 3-1 if ionic imbalance or elevated TDS are suspected. Toxicity due to ionic imbalance occurs when ion concentrations are not within the tolerance range of the selected test organism; utilizing *S. purpuratus* for toxicity tests conducted for samples with salinity > 1 ppt may help to alleviate this common issue, especially during dry weather.

Phase II and III TIEs may be necessary, depending whether the Phase I determination of toxicant class is sufficient for identifying pollutants for outfall monitoring and/or identifying source control measures. If necessary, Phase II and III procedures may include toxicant removal and add-back, serial additions, and/or toxicant spiking experiments in accordance with USEPA 1993a and 1993b.

It should be noted that, due to intermittent toxicity and/or toxicity resulting from multiple toxicants, TIEs are not always conclusive. In such cases, conducting toxicity tests with additional organisms (SMC Model Monitoring Technical Committee, 2004) and/or serially identifying toxicants (USEPA, 2001) may help characterize observed toxicity. When a receiving water sample exhibits persistent toxicity of a high magnitude, as is generally the case when TIEs are conducted, TIEs are typically successful (USEPA, 2001).

3.3 Toxicity Source Evaluation

Once any toxicants have been identified during the TIE process, Copermittees must discuss the need for continuing the TRE. The following sections provide an outline for developing specific monitoring elements intended to focus the effort in locating the source(s) of the pollutant(s) characterized by a TIE.

If urban runoff is suspected as a significant source of the pollutant(s) characterized by a TIE to be a contributor to toxicity at a receiving water station, source identification procedures may need to be considered. An evaluation of chemistry and bioassessment data for the receiving water station and chemistry data for upstream outfalls may help to confirm whether urban runoff is a significant source of the pollutant(s) causing toxicity and may justify further source identification procedures.

More comprehensive source identification procedures, if warranted, may include compiling descriptions of all potential sources to the receiving water station, determining actual sources and their relative magnitudes, and quantitatively estimating loads from these sources. A model for a source identification investigation study is outlined in the *Model Monitoring Program for Municipal Separate Storm Sewer Systems in Southern California* (SMC Model Monitoring Technical Committee, 2004) and more detailed source identification study methodology is outlined in USEPA 1993c and Pitt 2004. The general approach may include a combination of the components presented in Figure 3-1.

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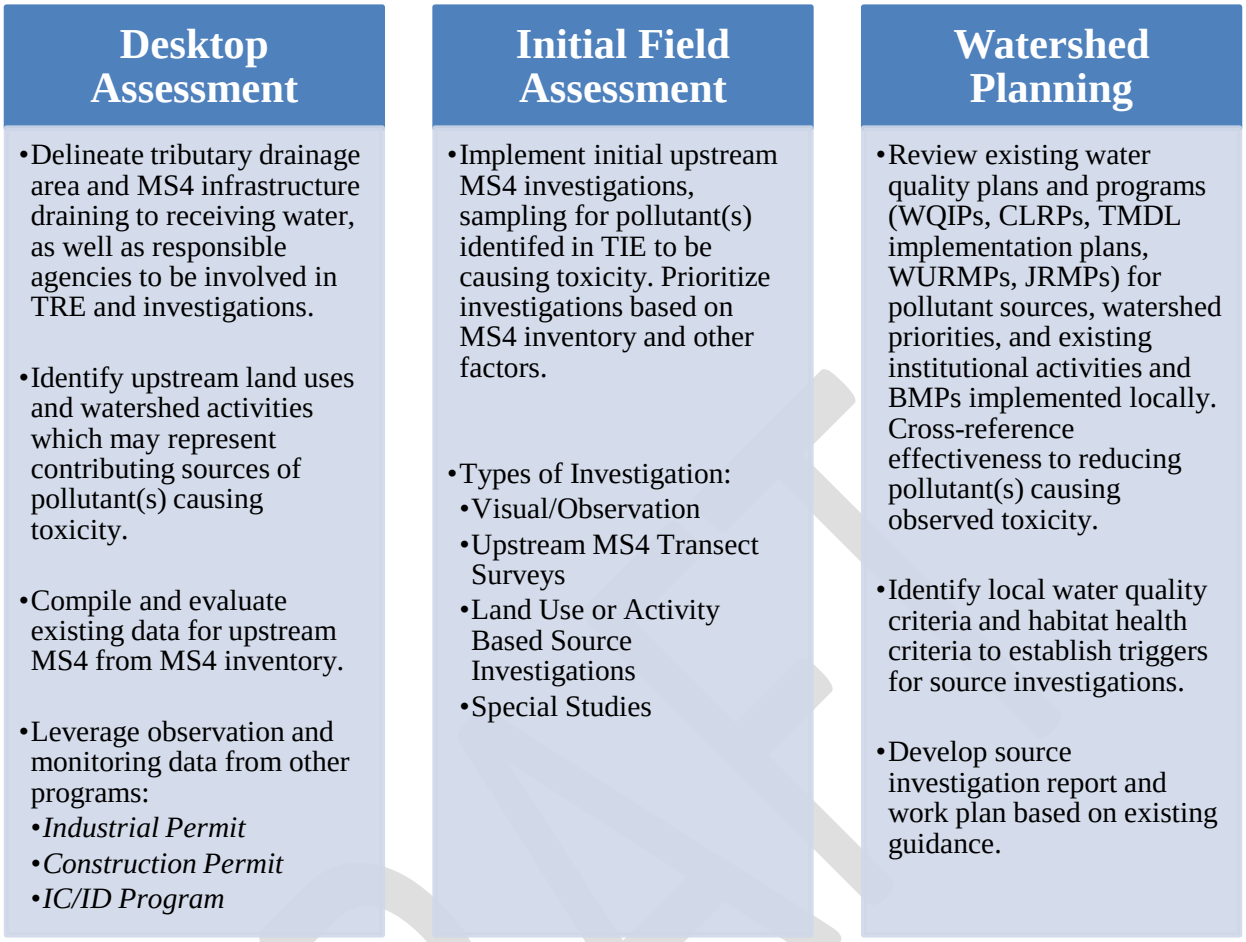

Figure 3-1. The Toxicity Source Evaluation Approach

Source identification efforts may coordinate with monitoring necessary for compliance with the following Provisions:

- Provision A.4.a.(2) – If it is determined that discharges from the multiple separate storm sewer system (MS4) are causing or contributing to a new exceedance of an applicable water quality standard not addressed by the WQIP, Copermittees are required to update the WQIP with the water quality improvement strategies implemented or to be implemented, the implementation schedule, and the monitoring and assessment program updates intended to track progress toward achieving compliance.
- Provision B.2.d – Requires Copermittees to identify and prioritize known and suspected sources of stormwater and non-stormwater pollutants from MS4 outfalls that contribute to the highest priority water quality conditions, as identified in the WQIP.
- Provision B.3 – Requires Copermittees to identify water quality improvement goals and strategies to address the highest priority water quality conditions, as identified in the WQIP.

- Provision D.2.b – Requires Copermittees to perform dry weather MS4 outfall monitoring to identify non-storm water and illicit discharges within its jurisdiction and to prioritize these discharges for investigation and elimination.
- Provision D.2.c – Requires Copermittees to perform wet weather MS4 outfall monitoring to identify pollutants in storm water discharges from the MS4, guide pollutant source identification efforts, and determine compliance with applicable Total Maximum Daily Loads (TMDLs).
- Provision D.3 – Requires Copermittees to conduct special studies related to the highest priority water quality conditions. Provision D.3.c specifies that special studies related to pollutant and/or stressor source identification should include a compilation of known information on the pollutant and/or stressor, an identification of data gaps intended to be filled by the studies, and a monitoring plan which includes, among other required elements, a prioritization of sources of the pollutant and/or stressor.
- Provision E.2 – Requires Copermittees to implement a program to detect and eliminate illegal discharges and improper disposal into the MS4.

If no source can be identified as a major contributor to receiving water toxicity, more intensive follow-up studies may be required.

3.4 Toxicity Control Evaluation

Using the results from the TRE elements conducted to this point, alternatives for reducing receiving water toxicity may be identified and the most feasible approach(es) may be selected. Pollution Prevention measures are designed to target pollutants and wastes before they are generated, while Source Controls are designed to reduce or eliminate pollutants before entering the MS4. These measures may include outreach, incentive programs, regulatory controls, and enforcement activities, as well as broader "true source controls" that must be implemented at a national or state level (e.g., product regulation). Institutional Programs, such as street sweeping, MS4 cleaning and repair, and other institutional services are typically maintenance activities implemented by agencies at various targeted frequencies to meet pollutant load reduction goals and minimum National Pollutant Discharge Elimination System (NPDES) Permit compliance criteria. Treatment Controls include structural systems designed to remove pollutants from stormwater and non-stormwater flows and may include a variety of low impact development (LID) and best management practices (BMPs) (e.g., infiltration-type, bioremediation, treatment trains, etc.). These BMPs are intended to protect receiving waters by eliminating or reducing the discharge of pollutants to the maximum extent practicable (MEP). Advantages and disadvantages of BMP alternatives should be considered, and appropriate BMPs should be selected based on site-specific conditions and pollutant(s) of concern. An integrated approach using a combination of Pollution Prevention measures, Institutional Programs, and Treatment Controls may be appropriate if more than one pollutant is identified to be causing or contributing to toxicity, or if the source is unknown. These three components of the toxicity control evaluation are shown in Figure 3-2.



Figure 3-2. Components of Toxicity Control Evaluation

3.5 Toxicity Control Implementation

Once the selected toxicity control method(s) are implemented, monitoring may be continued and possibly accelerated to confirm that toxicity reduction objectives are being met. Depending on the location and pollutant(s) being evaluated, some of this monitoring may be satisfied by Permit-required monitoring of receiving water and outfall locations (see Section 3.3).

Compliance with the monitoring and assessment requirements of the 2013 Permit, including Provision D.1.c.(4)(f) which requires the implementation of the TIE/TRE process described in this Work Plan, is intended to meet the discharge and receiving water limitations outlined in the 2013 Permit to the MEP. Updates to the monitoring programs developed to comply with these provisions will be incorporated into the WQIP through the adaptive management process outlined in Provisions B.4 and B.5 in order to continually monitor effectiveness and re-evaluate the programs.

3.6 Quality Assurance/Quality Control

A quality assurance/quality control (QA/QC) program for the TIE/TRE should be developed in order to ensure reliability of data collected throughout the process. The QA/QC program should include the QA/QC objectives, sample collection and preservation techniques, chain of custody procedures, analytical QA/QC, laboratory equipment maintenance, QA/QC training requirements, documentation and reporting procedures, and corrective action protocols (USEPA, 1993c). In addition, toxicology and analytical laboratories should be experienced and qualified to conduct the TIE/TRE.

3.7 TIE/TRE Limitations

There are inherent limitations associated with the TIE/TRE process summarized in this Work Plan, including the difficulty of characterizing intermittent toxicity (USEPA, 1993c) and/or toxicity resulting from multiple toxicants (USEPA, 2001). In addition, existing TRE guidance was

developed primarily for point source discharges from wastewater treatment plants whereas receiving waters potentially capture pollutants from many sources and contain contaminants at more variable concentrations than those from a wastewater treatment facility, especially during a storm event.

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Appendix 5F – San Diego County Municipal Copermittees Sediment Monitoring Plan

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San Diego County Municipal Copermittees
Sediment Monitoring Plan-Final

Prepared For:

County of San Diego Municipal Copermittees

November 2014

San Diego County Municipal Copermittees Sediment Monitoring Plan-Final

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ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
AVS:SEM	acid-volatile sulfides and simultaneously extracted metals
Bight	Southern California Bight Regional Monitoring Program
BRI	Benthic Response Index
CA EPA	California Environmental Protection Agency
CA LRM	California Logistic Regression Model
CEDEN	California Environmental Data Exchange Network
CDFW	California Department of Fish and Wildlife
COC	chain-of-custody
Copermittees	San Diego Regional Copermittees
CSI	Chemical Score Index
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DGPS	Differential Global Positioning System
DO	dissolved oxygen
DTCS	Department of Toxic Substances Control
EC_{50}	median effective concentration
IBI	Index of Biotic Integrity
ID	inner diameter
LC_{50}	median lethal concentration
LOE	line of evidence
$MgSO_4$	magnesium sulfate
MLOE	multiple lines of evidence
MS4	Municipal Separate Storm Sewer System
MW	molecular weight
NPDES	National Pollutant Discharge Elimination System
OEHHA	Office of Environmental Health Hazard Assessment
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
pH	hydrogen ion concentration
P_{MAX}	maximum probability model
QA	quality assurance
QA/QC	quality assurance/quality control
QAMP	Quality Assurance Management Plan
QAPP	Quality Assurance Project Plan
QC	quality control
RBI	Relative Benthic Index
RIVPACS	River Invertebrate Prediction and Classification System
RL	Reporting Limit
RWQCB	Regional Water Quality Control Board
SCAMIT	Southern California Association of Marine Invertebrate Taxonomists
SDRWQCB	San Diego Regional Water Quality Control Board
SOPs	Standard Operating Procedures
SPME	solid phase microextraction
SQOs	Sediment Quality Objectives

SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TIE	toxicity identification evaluation
TMDL	Total Maximum Daily Load
TOC	total organic carbon
USEPA	United States Environmental Protection Agency
WQIP	Water Quality Improvement Plan

UNITS OF MEASURE

cm	centimeter
°C	degrees Celsius
ft	feet or foot
L	liter
m^2	square meters
µg/kg	microgram per kilogram
mg	milligram
mg/kg	milligram per kilogram
mg/L	milligram per liter
mL	milliliter
mm	millimeter
ppt	parts per thousand
%	percent

1.0 INTRODUCTION

The San Diego County Regional Copermittees (Copermittees) are required to conduct sediment quality monitoring in accordance with the requirements of the San Diego Regional Water Quality Control Board (RWQCB) Order No. R9-2013-0001 (Permit), effective June 27, 2013. The Copermittees are required either individually, in association with multiple Copermittees, or through participation in a water body monitoring coalition to perform sediment quality monitoring to assess compliance with the sediment quality receiving water limits applicable to MS4 discharges to enclosed bays and estuaries. Provision D.1.e.(2) of the Permit requires the Copermittees to develop a Sediment Monitoring Plan for incorporation into the Water Quality Improvement Plan (WQIP) which satisfies the requirements of the *Water Quality Control Plan for Enclosed Bays and Estuaries of California – Part I Sediment Quality* (Sediment Control Plan; State Water Quality Control Board [SWRCB] and California Environmental Protection Agency [CA EPA], 2009; see Appendix A).

Provision D.1.e.(1)(b) of the Permit also requires the Copermittees to participate in the Southern California Bight Regional Monitoring Program (Bight). The Bight Program occurs every five years and consists of a partnership of multiple local, state, and federal agencies collaborating to address management questions of regional importance regarding offshore, nearshore, and estuarine habitats from Point Conception to the US-Mexican border. The Bight Program, which is overseen by the Southern California Coastal Water Research Program (SCCWRP) and reports to the State Water Quality Control Board (SWQCB), focuses on water quality, coastal ecology, sediment quality, and shoreline microbiology. Participation in the Bight Program can be used to simultaneously fulfill all or part of the sediment quality monitoring requirement (Provision D.1.e[2]) because sediment monitoring and sediment quality objectives (SQO) analyses are incorporated into the Bight Program to regionally assess the sediment quality of Southern California's enclosed bays, lagoons, and estuaries (herein referred to as waterbodies), including those waterbodies in San Diego County. The Copermittees can also decide to conduct the initial sediment quality monitoring of San Diego County's water bodies independently of the Bight Program. Depending upon the outcome of the initial SQO assessments, the Copermittees may need to perform follow-up monitoring to meet all of the Permit requirements.

The following Sediment Monitoring Plan describes the sediment quality sample collection and analysis activities that will be implemented by the Copermittees during the Permit term. As required by the Permit, this Sediment Monitoring Plan includes the elements listed in Sections VII.D and VII.E of the Sediment Control Plan (Receiving Water Limits Monitoring Frequency and Sediment Monitoring, respectively), a Sediment Monitoring Quality Assurance Project Plan (QAPP) (Appendix B), and a schedule for completion of monitoring and submission of the Sediment Monitoring Report. Once the sediment quality monitoring is complete, the Copermittees will incorporate a Sediment Monitoring Report into the WQIP Annual Report.

1.1 Background

In 2003, the SWRCB initiated a program to develop SQOs for enclosed bays and estuaries. The primary objective is to protect benthic communities and aquatic life from exposure to contaminants in sediment that have been directly discharged into the water body or indirectly discharged into waters draining into the water body. The SQOs, which are outlined in the Sediment Control Plan,

are based on a multiple lines of evidence (MLOE) approach in which the lines of evidence (LOE) are sediment toxicity, sediment chemistry, and benthic community condition, as described in the Sediment Control Plan (see Appendix A) and in Section 3.2. The MLOE approach evaluates the severity of biological effects and the potential for chemically mediated effects to provide a final station level assessment. The Sediment Control Plan was approved by the SWRCB and the Office of Administrative Law on September 16, 2008, and on January 5, 2009, respectively, and was subsequently approved by the United States Environmental Protection Agency (USEPA) on August 25, 2009.

1.2 Monitoring Objective

The primary objective of the sediment monitoring program is to assess compliance with the sediment quality receiving water limits applicable to MS4 discharges to enclosed bays and estuaries of San Diego County. Sediment toxicity, chemistry, and benthic community condition will be assessed using SQOs as described in the Sediment Control Plan (Appendix A). The goals of the SQOs are to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in marine organisms to levels that may be harmful.

The goal of the Sediment Monitoring Plan is to provide the key elements that are required to successfully conduct field sediment sampling, processing, testing, and analysis of the results. Analyses of chemistry, toxicity, and benthic community condition require that samples be collected, preserved, processed, and analyzed using proper field and laboratory equipment, methods, and techniques. Additionally, the selection of representative station locations is necessary to ensure proper characterization of benthic conditions. The Sediment Monitoring Plan and Sediment Monitoring QAPP (Appendix B) describe the collection and analysis of surface sediment samples necessary to provide representative assessments of in situ conditions for the enclosed bays and estuaries of San Diego County.

2.0 MATERIALS AND METHODS

The materials and methods described in this section are designed to meet the requirements of the Sediment Control Plan, Sections VII.D and VII.E, as required by Permit Provision D.1.e.(2)(a). The methodology is outlined in Section V of the Sediment Control Plan. If sediment quality monitoring is conducted as part of the Bight Program, the work plans and associated QA/QC documents pertaining to the Bight Program should be followed.

Quality assurance methods and procedures needed to maintain consistency in sample collection, processing, and analysis to produce scientifically defensible data are provided in the Sediment Monitoring Quality Assurance Project Plan (QAPP) (Appendix B). The QAPP provides acceptability criteria for the collection and analysis of duplicate field samples, field or equipment rinse blanks, laboratory methods, and laboratory spikes. The QAPP should be used as a reference to ensure proper methods are used consistently throughout the monitoring program.

2.1 Field Collection Program

2.1.1 Station Selection

The Sediment Control Plan applies to subtidal surficial sediments located seaward of the intertidal zone in enclosed bays and estuaries. It does not apply to ocean waters, inland surface waters, sediments consisting of less than 5 percent (%) fines or substrates composed of gravel, cobble, or consolidated rock, or to sediment classified as a pollutant due to physical processes such as burial or sedimentation. SQOs have been fully developed for only two of California's six enclosed bay habitats: euhaline (salinity = 25 to 32 parts per thousand [ppt]) bays and estuaries south of Point Conception and polyhaline (18 to 25 ppt) central San Francisco Bay. The benthic species assemblage used to calculate the benthic LOE in San Diego bays and estuaries is Habitat C- Southern California Marine Bays, which requires a salinity greater than 27 ppt (Bay et al 2014; Ranasinghe et al 2008). In order to select a sampling station applicable to the SQQ assessment using Habitat C for the benthic LOE, it is recommended to verify that a proposed sampling station is both subtidal and has salinity greater than 27 ppt. Salinity measurements should be taken near the sediment-water interface at a spring high and low tide to get an estimate of the salinity range for a proposed station. If feasible, it is recommended that salinity should be monitored throughout an entire spring tidal cycle to ensure it meets the salinity criteria prior to sampling, since it is likely that some areas of the enclosed bays and estuaries in San Diego will not meet the criteria under certain conditions. This monitoring can be accomplished by deploying a continuous monitoring device such as an YSI water quality data sonde. Water depth should also be measured when visiting the station at a spring low tide or deploying a continuous monitoring device over a spring tidal cycle to ensure the station is subtidal.

The Sediment Control Plan does not give guidance as to how many stations should be sampled in each waterbody. The number of sampling stations will vary within each San Diego County waterbody based on the spatial extent of the area likely to be impacted. If the Bight Program is utilized to fulfill the Sediment Quality Monitoring requirement of the Permit, then the number of stations within each San Diego County waterbody will be dictated by the Bight Program. For example, in the 2008 Bight Program, five stations were analyzed per lagoon; however, in the 2013 Bight Program the number of stations per lagoon varied from one to three stations. If a stressor

identification study becomes necessary following the original SQO assessment of a waterbody (see Section 4.0), then the number of stations will be based on what suspected pollutants are driving the impacted scores (e.g. algae, physical factors, or chemical factors) and to have enough samples to statistically support meaningful findings.

2.1.2 Permitting

Scientific collecting permits from the California Department of Fish and Wildlife will need to be obtained in order to collect benthic infaunal samples containing invertebrate specimens. At a minimum, it can take up to three weeks to obtain the permit; however, at times it can take several months to receive a scientific collecting permit so applications should be submitted well in advance of the desired sampling dates. A minimum of 24 hours (business day only) prior to collecting benthic infaunal samples in the field, a copy of the Notification of Intent to Collect for Scientific Purposes form should be faxed or emailed to the Marine Region (Monterey, CA) office of the CDFW. Additionally, written authorization may be required from state agencies or private landowners in order to gain access to water bodies that are surrounded by private land, have locked fences or gates, contain threatened or endangered species, or require the use of a private boat launch. Nesting seasons of threatened and endangered bird species may prevent sampling from being conducted or may restrict access around nesting areas during certain times of year, typically mid to late summer months.

2.1.3 Monitoring Season and Frequency

Section VII.E.6 of the Sediment Control Plan requires that samples for SQO programs be collected during the "index period" occurring between June and September. Physical environments and benthic community composition and abundance within enclosed bays and estuaries are generally stable and most similar from year to year during this time (Bay et al., 2014).

According to Section VII.D of the Sediment Control Plan, sediment monitoring associated with Phase I stormwater discharges and major discharges shall be conducted at least twice during the Permit cycle except at stations that have consistently been classified as Unimpacted or Likely Unimpacted using the MLOE approach described in Section 3.2. At the Unimpacted or Likely Unimpacted stations, monitoring may be reduced to a frequency of once during the Permit cycle. The San Diego RWQCB may also limit receiving water monitoring to a subset of outfalls to focus where the risk to sediment quality is greatest.

2.1.4 Sampling Vessels

Vessels used to collect sediment samples will be both stable and maneuverable and will have a sufficiently shallow draft to navigate into shallow waters (e.g. large inflatable boat). The vessels will be equipped with a side or rear davit from which to deploy and retrieve surface sampling equipment, and will accommodate a minimum of two persons in addition to all appropriate sampling and safety equipment. The vessel should be anchored in one or more directions with the motor turned off during sampling.

2.1.5 Navigation

All station locations will be selected using a stratified random design approach (where possible) and pre-plotted prior to sampling activities. Stations will be identified using a Differential Global Positioning System (DGPS). The system uses U.S. Coast Guard differential correction data, and is accurate within 10 feet (ft). Pre-plotted stations are defined by a specific latitude and longitude; however, occupation within a radius limit of 100 m of the target coordinate will be considered acceptable. This site acceptability criteria is similar to the criteria adhered to in the Bight Program. If a pre-plotted sample station is deemed to be unsuitable for collecting sediment (due to factors such as inaccessibility, salinity does not meet the SQO criteria, disturbance to wildlife, or safety considerations), the station may be abandoned and an alternate station may be selected. Reasons for abandonment will be recorded on field data sheets. All final station locations will be recorded in the field using positions from the DGPS.

2.1.6 Sediment Sampling and Handling

Benthic sediments will be collected as surface grabs using an appropriate sampler, such as a stainless steel Van Veen grab sampler. The size of the grab sampler to be used for sediment programs in Southern California should be 0.1 square meter (m^2) across the top of the sampler. An appropriate sampler for the collection of benthic sediments will have the following characteristics:

- Constructed of a material that does not introduce contaminants.
- Causes minimal surface sediment disturbance.
- Does not leak or mix during sample retrieval.
- Has a design that enables safe/easy sample verification that samples meet all applicable sampling criteria (e.g., collects sediments to at least 5 centimeters (cm) below the sediment surface, has access doors allowing visual inspection and removal of undisturbed surface sediment).

Sediment grabs will be collected for the following analyses: benthic infauna, chemistry, grain size, and toxicity. A sample will be considered acceptable if the surface of the grab is even, there is minimal surface disturbance, and there is a penetration depth of at least 7 cm. Rejected grabs will be discarded, and the station will be re-sampled. Acceptable sediment grabs to be utilized for chemistry, grain size, and toxicity analyses will have the overlying water carefully drained from the sediment surface prior to removing the sediment to be placed in the appropriate sample containers. Overlying water will not be drained from sediment samples collected for benthic infaunal analysis. Station location and grab event data will be recorded on pre-formatted field data sheets (hard copies or via computer). At a minimum, field data will include station identification, station location, date, time of sample collection, depth of water, depth of penetration of grab in sediment (e.g. 5 cm), sediment composition, sediment odor and color, and sample type (e.g. sediment chemistry). It is recommended that photographs of each sediment sample be taken and stored.

The entire contents of one grab sample will be utilized for benthic community analyses with a minimum penetration depth of 7 cm. Samples collected for benthic infaunal analysis will be rinsed through a 1.0-millimeter (mm) mesh screen. The material retained on the screen will be transferred to a labeled glass or plastic sample container. A 7% magnesium sulfate ($MgSO_4$) seawater solution

will be added to the sample container to 85-90% of its volume to relax the collected specimens. The sample container will be inverted several times to distribute the relaxant solution. After 30 minutes, add enough sodium borate buffered formaldehyde to top off the sample container and gently invert the container several times to ensure the sample is mixed. This will make a 10% formalin solution.

Sediment samples for chemistry and toxicity testing will be collected from the top 5 cm of a grab sample using a pre-cleaned stainless steel scoop. Sediment within 1 cm of the sides of the grab will be avoided to prevent interaction of any contaminants and the steel sampling device. For chemistry and grain size analysis, equal portions of sediment will be aliquoted from a single grab and placed into the appropriate samples containers. The sediment aliquots will be representative of the entire 5 cm depth of the surface sediment. According to the Sediment Control Plan, the preferred method of collection for sediment-water interface toxicity tests (see Section 2.2.2.2) is to collect intact cores directly from the sediment sampler by pressing polycarbonate core tubes (7.3-cm inner diameter [ID] and 16 cm in length) into the top 5 cm of sediment. However, homogenizing sediment for sediment-water interface testing is also acceptable according to the Sediment Control Plan. This method is more practical to implement in the field and is consistent with previous sediment quality objective methodology (e.g., Bight protocols and previous lagoon monitoring implemented by the Copermittees). A stainless steel scoop will be used to remove aliquots of the top 5 cm of surface sediment from two grab samples and evenly distributed into the appropriate toxicity sample container(s) until the necessary volume is reached. Minimum sample volumes and types of sample containers to be used in the sediment collection are provided in the Sediment Monitoring QAPP (see Appendix B).

All sampling equipment will be cleaned prior to sampling. Between sampling stations, the grab sampler will be rinsed with station water. Stainless steel scoops will be rinsed with seawater and rinsed with de-ionized water between stations. All sediment samples will be logged on a chain-of-custody (COC) form (see Section 2.1.7). Sediment chemistry and toxicity samples will be placed in a cooler on ice until delivered or shipped to the appropriate laboratories. Prior to shipping, sample containers will be placed in sealable plastic bags and securely packed inside the cooler with ice. The original signed COC forms will remain with the samples during shipment. Sediment samples will be shipped or delivered to the analytical laboratory within appropriate holding times (refer to Sediment Monitoring QAPP in Appendix B).

2.1.7 Documentation of Chain-of-Custody

This section describes the program requirements for sample handling and COC procedures. Samples are considered to be in custody if they are: (1) in the custodian's possession or view, (2) retained in a secured place (under lock) with restricted access, or (3) placed in a secured container. The principal documents used to identify samples and to document possession are COC records, field log books, and field tracking forms. COC procedures will be used for all samples throughout the collection, transport, and analytical process, and for all data and data documentation, whether in hard copy or electronic format.

COC procedures will be initiated during sample collection. A COC record will be provided with each sample or sample group. Each person who has custody of the samples will sign the form and

ensure that the samples are not left unattended unless properly secured. Minimum documentation of sample handling and custody will include the following:

- Sample identification.
- Sample collection date and time.
- Any special notations on sample characteristics.
- Initials of the person collecting the sample.
- Date the sample was sent to the laboratory.
- Shipping company and waybill information.

The completed COC form will be placed in a sealable plastic envelope that will travel inside the ice chest containing the listed samples. The COC form will be signed by the person transferring custody of the samples. The condition of the samples will be recorded by the receiver. COC records will be included in the final analytical report prepared by the laboratory and will be considered an integral part of the report.

2.2 Laboratory Testing

All samples will be tested in accordance with USEPA or American Society for Testing and Materials (ASTM) protocols. If appropriate protocols do not exist, the Copermittees should use other methods approved by the SWRCB or San Diego RWQCB. Analytical laboratories will be certified by the California Department of Health Services in accordance with Water Code 13176. Additional information pertaining to laboratory testing is presented in the Sediment Monitoring QAPP (see Appendix B).

2.2.1 Physical and Chemical Analysis

Physical and chemical measurements of sediment were selected to comply with the Sediment Control Plan and to provide data on chemicals of potential concern in bays and estuaries located in San Diego County. In accordance with the Sediment Control Plan, the physical and chemical analyses of sediments will include, at a minimum, the constituents outlined in Table 2-1. If sediment quality monitoring is conducted as part of the Bight Program, additional chemical analyses may be included and will be provided in Bight Workplans. Reporting limits (RLs) must be equal to or less than those listed in Table 2-1 in order to generate the chemistry LOE outlined in Section 2.3.3.1. Concentrations associated with the RLs in Table 2-1 are expressed in dry-weight. Physical analyses of sediment will include grain size and percent solids. Grain size will be analyzed to determine the general size classes that make up the sediment (e.g., gravel, sand, silt, and clay), whereas percent solids will be measured to convert chemical concentrations from a wet-weight to a dry-weight basis. Chemical analyses of sediment will include total organic carbon (TOC), and the select trace metals, chlorinated pesticides, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) shown in Table 2-1.

Table 2-1. Chemical and Physical Parameters for Sediment Samples

Parameter	Reporting Limit
Physical/Conventional Tests	
Grain Size	1.00 %
Percent Solids	0.10 %
Total Organic Carbon (TOC)	0.01 %
Metals	
Cadmium (Cd)	0.09 mg/kg
Copper (Cu)	52.8 mg/kg
Lead (Pb)	25.0 mg/kg
Mercury (Hg)	0.09 mg/kg
Zinc (Zn)	60.0 mg/kg
Organochlorine Pesticides	
2,4′-DDD	0.50 µg/kg
2,4′-DDE	0.50 µg/kg
2,4′-DDT	0.50 µg/kg
4,4′-DDD	0.50 µg/kg
4,4′-DDE	0.50 µg/kg
4,4′-DDT	0.50 µg/kg
Chlordane-alpha	0.50 µg/kg
Chlordane-gamma	0.54 µg/kg
Dieldrin	2.5 µg/kg
trans-Nonachlor	4.6 µg/kg
PCB Congeners	
2,4'-Dichlorobiphenyl	3.0 µg/kg
2,2',5-Trichlorobiphenyl	3.0 µg/kg
2,4,4'-Trichlorobiphenyl	3.0 µg/kg
2,2',3,5'-Tetrachlorobiphenyl	3.0 µg/kg
2,2',5,5'-Tetrachlorobiphenyl	3.0 µg/kg
2,3',4,4'-Tetrachlorobiphenyl	3.0 µg/kg
2,2',4,5,5'-Pentachlorobiphenyl	3.0 µg/kg
2,3,3',4,4'-Pentachlorobiphenyl	3.0 µg/kg
2,3',4,4',5-Pentachlorobiphenyl	3.0 µg/kg
2,2',3,3',4,4'-Hexachlorobiphenyl	3.0 µg/kg
2,2',3,4,4',5'-Hexachlorobiphenyl	3.0 µg/kg
2,2',4,4',5,5'-Hexachlorobiphenyl	3.0 µg/kg
2,2',3,3',4,4',5-Heptachlorobiphenyl	3.0 µg/kg
2,2',3,4,4',5,5'-Heptachlorobiphenyl	3.0 µg/kg
2,2',3,4',5,5',6-Heptachlorobiphenyl	3.0 µg/kg
2,2',3,3',4,4',5,6-Octachlorobiphenyl	3.0 µg/kg
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	3.0 µg/kg
Decachlorobiphenyl	3.0 µg/kg
PAHs (low molecular weight)	
Acenaphthene	20.0 µg/kg
Anthracene	20.0 µg/kg
Phenanthrene	20.0 µg/kg
Biphenyl	20.0 µg/kg
Naphthalene	20.0 µg/kg
2,6-Dimethylnaphthalene	20.0 µg/kg

Parameter	Reporting Limit
Fluorene	20.0 µg/kg
1-Methylnaphthalene	20.0 µg/kg
2-Methylnaphthalene	20.0 µg/kg
1-Methylphenanthrene	20.0 µg/kg
PAHs (high molecular weight)	
Benzo(a)anthracene	80.0 µg/kg
Benzo(a)pyrene	80.0 µg/kg
Benzo(e)pyrene	80.0 µg/kg
Chrysene	80.0 µg/kg
Dibenzo(a,h)anthracene	80.0 µg/kg
Fluoranthene	80.0 µg/kg
Perylene	80.0 µg/kg
Pyrene	80.0 µg/kg

DDD Dichlorodiphenyldichloroethane
DDE dichlorodiphenyldichloroethylene
DDT dichlorodiphenyltrichloroethane
mg/kg milligrams per kilogram
µg/kg micrograms per kilogram

2.2.2 Toxicity Testing

To evaluate the benthic condition of San Diego County's waterbodies, sediment toxicity testing will be conducted in accordance with ASTM and USEPA methods. Toxicity testing involves a short-term survival test, a sublethal endpoint test, and an assessment of sediment toxicity. For each test type, more than one specific test is acceptable. The appropriate species tested for a sample will depend on the characteristics of the sample such as grain size, salinity, and suspected toxic constituents, if any. When historical data are available for a sample location, it is recommended that the same species be used in order to make comparisons and to conduct trend analysis. In addition, if sediment monitoring is conducted as part of the Bight Program, the species selection will be listed in the Bight Workplans. If significant toxicity is observed in the solid phase or sediment-water interface test, a toxicity identification evaluation (TIE) may be conducted as part of stressor identification studies described in Section 4.0. Further descriptions of the test species used in both the short-term survival test and the sublethal endpoint test are provided below.

2.2.2.1 Short-Term Survival Testing

SQO analysis requires that at least one short-term survival test be conducted. There are three acceptable short-term survival tests, each of which is a 10-day test exposing amphipods to whole sediment. The three acceptable test organisms are *Eohaustorius estuarius*, *Leptocheirus plumulosus*, and *Rhepoxynius abronius*. The *E. estuarius* short-term survival test has been the 10-day test method used in previous San Diego County bay and lagoon monitoring programs, including the Bight Program, where the SQO analytical tool was used to assess aquatic health. These amphipod bioassays will be conducted in accordance with procedures outlined in *Methods for Assessing Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods* (USEPA, 1994) and ASTM method E1367-03 (ASTM, 2006). Test conditions are summarized in Table 2-2. If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans.

A water-only reference toxicity test should be conducted concurrently with the whole sediment amphipod test to assess the relative sensitivity of test organisms used in the evaluation of project sediments. Amphipod reference toxicant tests are typically conducted using cadmium. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

Table 2-2. Summary of Conditions for 10-Day Whole Sediment Amphipod Bioassay

Test Conditions 10-Day Whole Sediment Bioassay				
	Test Species	***E. estuarius***	***L. plumulosus***	***R. abronius***
	Test Procedures	USEPA (1994); ASTM E1367-03 (2006)		
	Test Type/Duration	Static - Acute Whole Sediment/10 days		
	Sample Storage Conditions	4 °C, dark, minimal head space		
	Age/Size Class	3-5 mm	2-4 mm; immature	3-5 mm
	Grain Size Tolerance	0.6-100% sand	0-100% sand	10-100% sand
Recommended Water Quality Parameters	Temperature	15 ± 1 °C	25 ± 1 °C	15 ± 1 °C
	Salinity	20 ± 2 ppt	20 ± 2 ppt	28 ± 2 ppt
	Dissolved Oxygen	Maintaining 90% saturation		
	Total Ammonia	< 60 mg/L	< 60 mg/L	< 30 mg/L
	Test Chamber	1 L glass		
	Exposure Volume	2 cm sediment, 800 mL seawater		
	Replicates/Sample	5		
	No. of Organisms/Replicate	20		
	Photoperiod	Continuous light		
	Feeding	None		
	Water Renewal	None		
	Aeration	Constant gentle aeration		
	Acceptability Criteria	Mean control survival ≥ 90%; ≥80% survival in each replicate		

mg/L milligram per liter

2.2.2.2 Sublethal Testing

The second type of testing required for SQO analysis is a sublethal test. Either a 48-hour development test exposing embryos of the bivalve *Mytilus galloprovincialis* to the sediment-water interface may be conducted or a 28-day survival and growth test exposing the polychaete worm *Neanthes arenaceodentata* to whole sediment. Test condition summaries for the bivalve and polychaete tests are presented in Table 2-3 and Table 2-4, respectively. The *M. galloprovincialis* sediment-water interface test has been the sublethal test method used in previous San Diego County bay and lagoon monitoring programs, including the Bight Program, where the SQO analytical tool was used to assess aquatic health.

Mytilus galloprovincialis Sediment-Water Interface Development Sublethal Test

Sediment-water interface bioassays are performed to estimate the potential toxicity of contaminants fluxing from test sediments into the overlying water. The sediments will be tested in a 48-hour sediment-water interface test using the bivalve *M. galloprovincialis* in accordance with procedures outlined in *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms* (USEPA, 1995) and Assessment of Sediment Toxicity at the Sediment-Water Interface (Anderson et al., 1996). If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans. Sediment-water interface bioassays will be tested on intact cores collected in the field or on homogenized sediment samples as described in Section 2.1.6.

A water-only reference toxicity test should be conducted concurrently with the sediment-water interface bivalve test to assess the relative sensitivity of test organisms used in the evaluation of the project sediments. Bivalve reference toxicant tests are typically conducted using copper. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

Table 2-3. Test Conditions for the 48-Hour *M. galloprovincialis* Sediment-Water Interface Bioassay

Test Conditions 10-Day Whole Sediment Bioassay		
	Test Species	***M. galloprovincialis***
	Test Procedures	USEPA (1995), Anderson et al. (1996)
	Test Type/Duration	Static - Acute sediment-water interface/48 hours
	Sample Storage Conditions	4 °C, dark, minimal head space
	Age/Size Class	< 4 hour old larvae
Recommended Water Quality Parameters	Temperature	15 ± 1 °C
	Salinity	32 ± 2 ppt
	Dissolved Oxygen	Maintaining 90% saturation
	Total Ammonia	< 4 mg/L
	Test Chamber	Polycarbonate core tube 7.3-cm inner diameter, 16 cm high
	Exposure Volume	5 cm sediment, 300 mL water
	Replicates/Sample	4
	No. of Organisms/Replicate	Approximately 250 larvae
	Photoperiod	16 hours light: 8 hours dark
	Feeding	None
	Water Renewal	None
	Aeration	Constant gentle aeration
	Acceptability Criteria	Mean control normal-alive ≥ 80%

<u>*Neanthes arenaceodentata* Whole Sediment Survival and Growth Sublethal Test</u>

The *N. arenaceodentata* test will be conducted in accordance with ASTM method E1562 (ASTM, 2002) with modifications described in Farrar and Bridges (2011) that have been found to contribute manageability and precision to the ASTM procedure. If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans. A water-only reference toxicity test should be conducted concurrently with the whole sediment polychaete test to assess the relative sensitivity of test organisms used in the evaluation

of the project sediments. Polychaete reference toxicant tests are typically conducted using cadmium. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

Table 2-4. Test Conditions for the 28-Day Whole Sediment *N. arenaceodentata* Bioassay

Test Conditions 10-Day Whole Sediment Bioassay		
	Test Species	***N. arenaceodentata***
	Test Procedures	ASTM E1562 (2002), Farrar and Bridges (2011)
	Test Type/Duration	Static - Acute Whole Sediment/28 days
	Sample Storage Conditions	4 °C, dark, minimal head space
	Age/Size Class	≤ 7 days post-emergence
	Grain Size Tolerance	5-100% sand
Recommended Water Quality Parameters	Temperature	20 ± 1 °C
	Salinity	30 ± 2 ppt
	Dissolved Oxygen	Maintaining 90% saturation
	Total Ammonia	< 20 mg/L
	Test Chamber	300 mL glass
	Exposure Volume	2 cm sediment, 125 mL seawater
	Replicates/Sample	10
	No. of Organisms/Replicate	1
	Photoperiod	12 hours light: 12 hours dark
	Feeding	Twice per week
	Water Renewal	Weekly
	Aeration	Constant gentle aeration
	Acceptability Criteria	Mean control survival ≥ 80%; positive growth in controls

2.2.3 Benthic Infauna Analysis

The benthic infaunal samples will be transported from the field to the laboratory and stored in a formalin solution for a minimum of 48 hours and no longer than 5 days. The samples will then be transferred from formalin to 70% ethanol for laboratory processing. The organisms will initially be sorted using a dissecting microscope into five major phyletic groups: polychaetes, crustaceans, molluscs, echinoderms, and miscellaneous minor phyla. While sorting, technicians will keep a count for quality control purposes, as described in the following paragraph. After initial sorting, samples will be distributed to qualified taxonomists who will identify each organism to species or to the lowest possible taxon. Taxonomists will use the most recent version of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) taxonomic listing for nomenclature and orthography. If sediment monitoring is conducted as part of the Bight Program, then procedures should be in accordance with Bight Workplans.

A QA/QC procedure will be performed on each of the sorted samples to ensure a 95% sorting efficiency. A 10% aliquot of a sample will be re-sorted by a senior technician trained in the QA/QC procedure. The number of organisms found in the aliquot will be divided by 10% and added to the total number found in the sample. The original total will be divided by the new total to calculate

the percent sorting efficiency. When the sorting efficiency of the sample is below 95%, the remainder of the sample (90%) will be re-sorted.

2.2.3.1 Quality Assurance/Quality Control

All quality assurance/quality control (QA/QC) samples must be conducted in accordance with the Quality Assurance Management Plan (QAMP) for the State of California's Surface Water Ambient Monitoring Program (SWAMP). The data quality objectives for all analyses conducted by the participating analytical laboratories will be detailed in the Sediment Monitoring QAPP (see Appendix B). The results of the laboratory quality control (QC) analyses will be reported with the final data. Any QC samples that fail to meet the specified QC criteria in the methodology or the Sediment Monitoring QAPP will be identified, and the corresponding data will be appropriately qualified in the final report. All QA/QC records for the various testing programs will be kept on file for review by regulatory agency personnel.

3.0 DATA REVIEW, MANAGEMENT, AND ANALYSIS

3.1 Data Review and Management

All QA/QC data must be conducted in accordance with the QAMP for the State of California's SWAMP and the data quality objectives as outlined in the Sediment Monitoring QAPP (see Appendix B). Data will be reviewed to determine if appropriate corrective actions have been taken, when necessary. Corrective actions taken by the laboratories will be noted in the laboratory report and affected data will be flagged or qualified as appropriate. The laboratories will supply analytical results in both hard copy and electronic formats. Laboratories will have the responsibility of ensuring that both formats are accurate. Monitoring data and analytical results will be uploaded into California Environmental Data Exchange Network (CEDEN).

3.2 Data Analysis

Sediment toxicity, chemistry, and benthic community condition will be assessed using California's SQOs as described in the Sediment Control Plan (Appendix A). The goals of the SQOs are to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in marine organisms to levels that may be harmful to humans. SQOs have been fully developed for only one of Southern California's enclosed bay habitats: euhaline (salinity = 25 to 32 ppt) bays and estuaries south of Point Conception. The benthic species assemblage used to calculate the benthic LOE in San Diego bays and estuaries is Habitat C- Southern California Marine Bays, which requires a salinity greater than 27 ppt (Bay et al 2014; Ranasinghe et al 2008). The data analysis methods described below should be limited to the subtidal areas of the waterbodies where the SQO salinity criteria can be met.

The SQOs are based on a MLOE approach in which sediment toxicity, sediment chemistry, and benthic community condition are the LOE. The MLOE approach evaluates the severity of biological effects and the potential for chemically mediated effects to provide a final station level assessment. Brief descriptions of the specific methods associated with each LOE are described below. Detailed calculations and descriptions of each LOE are provided in the Sediment Control Plan (SWRCB and CA EPA, 2009) (see Appendix A).

3.2.1 Sediment Toxicity

Sediment toxicity will be assessed using two tests: a short-term survival test using one of three species of marine amphipods (*E. estuarius*, *L. plumulosus*, or *R. abronius*) and a sublethal test using either *N. arenaceodentata* (a species of polychaete worm) or *M. galloprovincialis* (a species of marine bivalve). Sediment toxicity test results from each station will be statistically compared to control test results; normalized to the control survival; and categorized as nontoxic, low, moderate, or high toxicity according to Table 3-1. The average of the two test response categories (nontoxic, low toxicity, moderate toxicity, and high toxicity) will be calculated to determine the final toxicity LOE category. If the average falls midway between the two categories, it will be rounded up to the higher of the two. For example, if the test response category for the short-term survival test is low toxicity, and the test response category for the sublethal test is moderate toxicity, the final category for sediment toxicity would be moderate toxicity.

Table 3-1. Sediment Toxicity Categorization Values

Test Type	Endpoint	Statistical Significance	Nontoxic[1]	Low Toxicity[2]	Moderate Toxicity[2]	High Toxicity[2]
Short-Term Survival Tests	*E. estuarius* Survival	Significant	90 to 100	82 to 89	59 to 81	<59
		Not significant	82 to 100	59 to 81	-	<59
	L. plumulosus Survival	Significant	90 to 100	78 to 89	56 to 77	<56
		Not significant	78 to 100	56 to 77	-	<56
	R. abronius Survival	Significant	90 to 100	83 to 89	70 to 82	<70
		Not significant	83 to 100	70 to 82	-	<70
Sublethal Tests	*N. arenaceodentata* Growth	Significant	90 to 100[2]	68 to 90	46 to 67	<46
		Not significant	68 to 100	46 to 67	-	<46
	M. galloprovincialis Normal-Alive	Significant	80 to 100	77 to 79	42 to 76	<42
		Not significant	77 to 79	72 to 76	-	<42

[1] Expressed as percent.
[2] Expressed as percent of control.

3.2.2 Sediment Chemistry

Sediment chemistry will be assessed using the analyte list presented in Table 2-1. Concentrations of chemicals detected in sediments will be compared to the California Logistic Regression Model (CA LRM) and the Chemical Score Index (CSI). The CA LRM is a maximum probability model (P_{max}) that uses logistic regression to predict the probability of sediment toxicity. The CSI is calculated independently of the CA LRM and is a predictive index that relates sediment chemical concentration to benthic community disturbance. Sediment chemistry results according to CA LRM and CSI are categorized as having minimal, low, moderate, and high exposure to pollutants (Table 3-2). The final sediment LOE category is the average of the two chemistry exposure categories. If the average falls midway between the two categories, it is rounded up to the higher of the two. For example, if the CA LRM is low exposure and the CSI is moderate exposure, then the final sediment LOE category is moderate exposure.

Table 3-2. Sediment Chemistry Guideline Categorization

Sediment Chemistry Guideline		Sediment LOE Category
CA LRM	CSI	
<0.33	<1.69	**Minimal Exposure**
0.33 - 0.49	1.69 - 2.33	**Low Exposure**
0.50 - 0.66	2.34 - 2.99	**Moderate Exposure**
>0.66	>2.99	**High Exposure**

3.2.3 Benthic Community Condition

Benthic community condition will be assessed using a combination of four benthic indices: the Benthic Response Index (BRI; abundance-weighted average pollution tolerance of sample organisms), the Relative Benthic Index (RBI; the weighted sum of community parameters and abundance of indicator species), the Index of Biotic Integrity (IBI; a measure that identifies benthic community characteristics outside of reference ranges), and a predictive model based on the River Invertebrate Prediction and Classification System (RIVPACS; a comparison of assemblages in a

sample to expected species composition). The four indices will be calculated following the January 21, 2008, guidance provided by Southern California Coastal Water Research Project (SCCWRP) entitled *Determining Benthic Invertebrate Community Condition in Embayments* for Southern California marine bays. Each benthic index result is categorized according to four levels of disturbance, including reference, low, moderate, and high disturbance.

- Reference: Equivalent to a least affected or unaffected station.
- Low Disturbance: Some indication of stress is present, but is within measurement error of unaffected condition.
- Moderate Disturbance: Clear evidence of physical, chemical, natural, or anthropogenic stress.
- High Disturbance: High magnitude of stress.

Specific categorization values, which are tailored to southern California marine bays, are assigned for each index (Table 3-3), and are based on the specific taxa found within a given sample. To determine the benthic community condition, the four indices will be integrated into a single category. The median of the four benthic index response categories are computed to determine the benthic condition. If the median falls between two categories, the value is rounded to the next higher category to provide the most conservative estimate of benthic community condition.

Table 3-3. Benthic Index Categorization Values for Southern California Marine Bays

Benthic Community Guideline				Index
BRI	**IBI**	**RBI**	**RIVPACS**	
<39.96	0	>0.27	>0.90 to <1.10	**Reference**
39.96 - 49.14	1	0.17 - 0.27	0.75 - 0.90 or 1.10 - 1.25	**Low Disturbance**
49.15 - 73.26	2	0.09 - 0.16	0.33 - 0.74 or >1.25	**Moderate Disturbance**
>73.26	3 or 4	<0.09	<0.33	**High Disturbance**

3.2.4 Integration of Multiple Lines of Evidence

The station level assessment that indicates whether the aquatic life SQO at a station has been met will be determined by the combination of the three LOE categories to assess the severity of biological effects and the potential for chemically mediated effects. The severity of biological effects will be determined by combining the toxicity and benthic community condition LOEs (Table 3-4). The potential for chemically mediated effects will be determined by combining the toxicity and chemistry LOEs (Table 3-5).

Table 3-4. Determination of Severity of Biological Effects

Combination of Toxicity LOE and Benthic Condition LOE		Toxicity LOE			
		Non-toxic	Low Toxicity	Moderate Toxicity	High Toxicity
Benthic Community Condition LOE	Reference	Unaffected	Unaffected	Unaffected	Low Effect
	Low Disturbance	Unaffected	Low Effect	Low Effect	Low Effect
	Moderate Disturbance	Moderate Effect	Moderate Effect	Moderate Effect	Moderate Effect
	High Disturbance	Moderate Effect	High Effect	High Effect	High Effect

Table 3-5. Determination of Potential for Chemically Mediated Effects

Combination of Toxicity LOE and Sediment Chemistry LOE		Toxicity LOE			
		Non-toxic	Low Toxicity	Moderate Toxicity	High Toxicity
Sediment Chemistry LOE	Minimal Exposure	Minimum Potential	Minimum Potential	Low Potential	Moderate Potential
	Low Exposure	Minimum Potential	Low Potential	Moderate Potential	Moderate Potential
	Moderate Exposure	Low Potential	Moderate Potential	Moderate Potential	Moderate Potential
	High Exposure	Moderate Potential	Moderate Potential	High Potential	High Potential

Based on the determinations of the severity of biological effects and the potential for chemically mediated effects, a station level assessment (Table 3-6) will be made that categorizes the station as one of the following:

- Unimpacted: Confident that sediment contamination is not causing significant adverse impacts to aquatic life living in station sediments.
- Likely Unimpacted: Sediment contamination at the station is not expected to cause adverse impacts to aquatic life, but some disagreement among the LOE reduces the certainty that the station is unimpacted.
- Possibly Impacted: Sediment contamination at the station may be causing adverse impacts to aquatic life, but the impacts are either small or uncertain due to disagreement among the LOE.
- Likely Impacted: Evidence for a contaminant-related impact to aquatic life at the station is persuasive, even if there is some disagreement among the LOE.
- Clearly Impacted: Sediment contamination at the station is causing clear and severe adverse impacts to aquatic life.
- Inconclusive: Disagreement among the LOE suggests that either the data are suspect or additional information is needed before a determination can be made.

Table 3-6. Determination of Final Station Assessment

Combination of Severity of Biological Effects and Potential for Chemically-Mediated Effects		Severity of Biological Effects			
		Unaffected	**Low Effect**	**Moderate Effect**	**High Effect**
Potential for Chemically-Mediated Effects	**Minimal Potential**	Unimpacted	Likely Unimpacted	Likely Unimpacted	Inconclusive
	Low Potential	Unimpacted	Likely Unimpacted	Possibly Impacted	Possibly Impacted
	Moderate Potential	Likely Unimpacted	Possibly Impacted or Inconclusive[1]	Likely Impacted	Likely Impacted
	High Potential	Inconclusive	Likely Impacted	Clearly Impacted	Clearly Impacted

[1] When chemistry classification is minimal exposure, benthic response is reference, and toxicity is high.

All 64 possible combinations are presented in Attachment B of the Sediment Control Plan. If a station is consistently classified as Unimpacted or Likely Unimpacted according to the SQO assessments, then the protective condition has been achieved. If the final station assessment result is Possibly Impacted, Likely Impacted or Clearly Impacted, the station is considered degraded and the Copermittees will need to coordinate with the San Diego RWQCB to determine if a stressor identification study will need to be conducted. Stations categorized as Inconclusive should not be used to evaluate whether the protective condition at a station has been met. Additional information should be gathered at stations classified as Inconclusive in order to understand why the LOE results show a level of disagreement.

If stations are categorized as Possibly Impacted within a monitored segment, reach, or water body that also contain stations that are not categorized as Clearly or Likely Impacted, then confirmation monitoring will be conducted in order to confirm the level of impact at these stations prior to initiating a stressor identification study. As stated in the *Sediment Quality Assessment Technical Support Manual* (Bay et al., 2014), "the *Possibly Impacted* station assessment is the least certain of all categorizations, and therefore requires the most caution during interpretation. Stations may be classified as *Possibly Impacted* due to low levels of effect for each LOE, indicating a low magnitude of impacts. Alternatively, a *Possibly Impacted* classification may be the result of a large disagreement between LOEs, potentially due to confounding factors or noncontaminant stressors." At a minimum, confirmation monitoring at a Possibly Impacted station will consist of re-sampling and recalculating the SQO to determine if the station results in the same SQO assessment (i.e. Possibly Impacted) or if the assessment is more conclusive as to whether the station is impacted or not (e.g. Unimpacted or Likely Impacted). If the results of the confirmation monitoring determine that the station is Unimpacted or Likely Unimpacted then the protective condition has been achieved at that location. If the station assessment is categorized as Possibly Impacted, Likely Impacted, or Clearly Impacted then the Copermittees will need to coordinate with the San Diego RWQCB to determine if a stressor identification study will need to be conducted. If additional monitoring or previous specialized studies at Possibly Impacted stations indicate that factors other than toxic pollutants in sediments are causing observed negative responses then it may be possible to coordinate with the RWQCB to designate the station as meeting the protective condition. A flow chart of actions to be taken following the initial station assessment is provided in Figure 3-1.

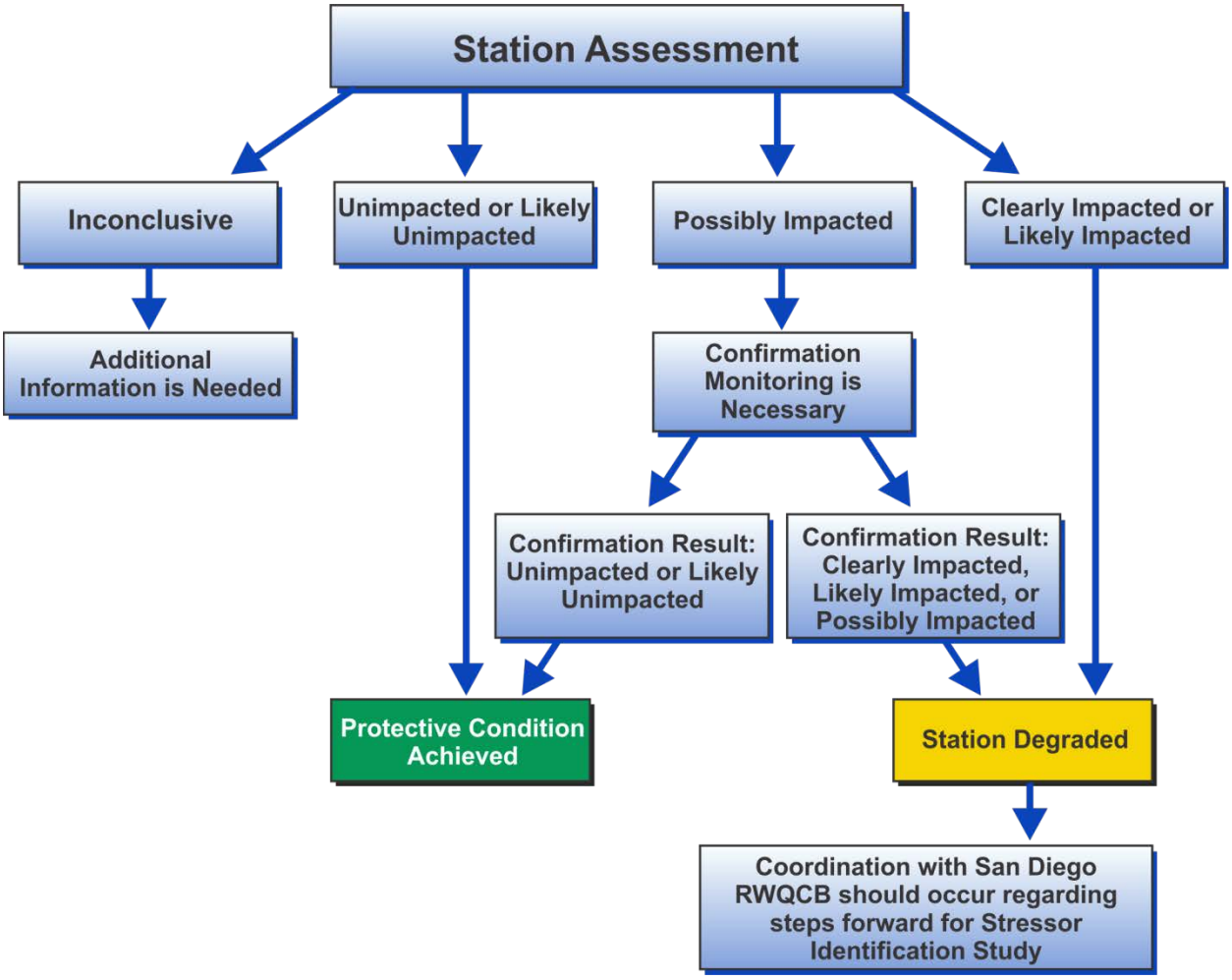

Figure 3-1. Flow Chart of Actions Following Station Assessment

4.0 STRESSOR IDENTIFICATION

The highest priority for stressor identification will be assigned to those water body segments with the highest percentage of Clearly Impacted or Likely Impacted stations. In cases where segments contain sediments categorized as Possibly Impacted but not Clearly Impacted or Likely Impacted, confirmation monitoring will be conducted prior to requiring stressor identification studies. By reviewing the available data sets, deductive reasoning can be used to narrow the focus of future actions. Based on the outcome of the additional data analysis, steps forward for stressor identification should be coordinated with the San Diego RWQCB. If a stressor identification study is required, the Copermittees will develop a clearly defined work plan that has met the approval of the San Diego RWQCB prior to beginning work. No formal guidance is given in the Sediment Control Plan on how to conduct a stressor identification study; however, the Sediment Control Plan does give some general guidance on types of stressor identification studies that can be implemented. These studies include confirmation and characterization of pollutant-related impacts, pollutant identification, and source identification and management actions. These types of studies are summarized in the following sections.

4.1.1 Pollutant Confirmation and Characterization

When the analyses described in Section 3.2 indicate that pollutants are a likely cause of an SQO exceedance at a station, a variety of tools can be used to determine whether the reason for the narrative objective not being met is due to generic stressors other than toxic pollutants, such as physical alterations or other pollutant-related stressors. Physical disturbances, such as decreased salinity, dredging impacts, and grain size, are confounding factors that may produce conditions mimicking the effects of pollutants. In these cases, the benthic community LOE will indicate degradation, but the toxicity and chemistry LOEs may not. Pollutant-related stressors, such as ammonia, TOC, nutrients, and pathogens, may also be confounding factors. In these cases, the benthic community LOE will indicate degradation, toxicity may be indicated, and chemical concentrations will be low. To determine whether a station is impacted from toxic pollutants, one or more of the following tools may be included in the stressor identification analysis as part of the confirmation:

- Evaluate the spatial extent of the area of concern in relation to anthropogenic sources.
- Evaluate the body burden of the pollutants accumulated in the animals used for exposure testing.
- Evaluate the chemical constituent results in relation to chemical benchmark values.
- Compare chemistry and biology LOE to determine whether correlations exist.
- Alternative biological assessment, such as bioaccumulation experiments, pore water toxicity, or pore water chemistry analyses, may be conducted.
- Phase I TIEs, which are often useful in determining the causative agent or class of compounds causing toxicity may be conducted.

According to the SQO guidelines, "If there is compelling evidence that the SQO exceedances contributing to a receiving water limit exceedance are not due to toxic pollutants, then the assessment area shall be designated as having achieved the receiving water limit."

4.1.2 Pollutant Identification

Pollutant identification investigations may be conducted using one or more of the following types of data: statistical, biological, or chemical investigation data. These investigations should be station-specific and should be based on:

- Correlations between individual chemicals and biological endpoints.
- Gradient analysis of chemical concentrations and the biological responses in comparison to distance from a chemical hotspot.
- Additional TIE procedures.
- Sediment pore water investigations into the bioavailability of pollutants (e.g., acid-volatile sulfides and simultaneously extracted metals [AVS:SEM] analysis, solid phase microextraction [SPME], and/or laboratory desorption studies.
- Verification studies such as spiking or in situ toxicity and bioaccumulation studies.

In cases where stressor identification studies conducted on stations categorized as Possibly Impacted are inconclusive, the Copermittees may iplement a one-time augmentation to the study or suspend stressor identification studies in favor of additional routine SQO monitoring.

4.1.3 Pollutant Source Identification and Management

Stressor identification studies should include determinations of whether sources are ongoing or legacy and determinations of the number and nature of ongoing sources. If a single or multiple dischargers are responsible for stressor pollutant discharges, the discharger(s) may need to address the SQO exceedance and to reduce the pollutant loading.

According to Section VII.H of the Sediment Control Plan, the San Diego RWQCB may develop station-specific sediment management guidelines to estimate the level of the stressor pollutant in order to meet the SQOs. Guideline development should be initiated only following identification of the stressor, and should have an overall goal of establishing a relationship between the organism's exposure and the biological effect. Upon establishing this relationship, a pollutant-specific guideline may be designated that corresponds with minimum biological effects. Approaches that can be used to establish relationships between exposure and biological effect include the following: correspondence with sediment chemistry, correspondence with bioavailable pollutant concentration, correspondence with tissue residue, and literature review. Additionally, the Sediment Control Plan states that the chemistry LOE, "including the threshold values (e.g. CSI and CALRM) shall not be used for setting cleanup levels or numeric values for technical TMDLs."

5.0 REPORTING

Provision D.1.e.(2)(c) of the Permit requires incorporation of Sediment Monitoring Report into the WQIP Annual Report. The Sediment Monitoring Report will contain an evaluation, interpretation, and tabulation of monitoring data, including an assessment of whether receiving water limits outlined in the Permit were attained; a sample location map; and a statement of certification that monitoring data and results have been uploaded into CEDEN.

Based on the conclusions of the Sediment Monitoring Report, a human health risk assessment may be required by the RWQCB. Provision A.2.a.(3)(b)(ii) states that "pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health." The potential risk assessments must consider any relevant information, such as guidelines set forth in the CA EPA's Office of Environmental Health Hazard Assessment (OEHHA) fish consumption policies, CA EPA's Department of Toxic Substances Control (DTSC) risk assessment, and the USEPA human health risk assessment policies.

Since the WQIPs are still in development and there will be no WQIP Annual Reports in 2015, the Copermittees will include the Sediment Monitoring Report with the Transitional Monitoring and Assessment Report due to the San Diego RWQCB on January 31, 2015. The Sediment Monitoring Report will include the results from the 2013 Bight Program and any follow-up monitoring collected in 2014 to satisfy Provisions D.1.e.(1)(b) and D.1.e.(2) of the Permit. Additional sediment quality monitoring or stressor identification studies conducted after 2014 will be included in the WQIP Annual Reports.

6.0 SCHEDULE

The schedule for completing the sediment quality monitoring requirements of the Permit and for submitting the Sediment Monitoring Report is shown in Table 6-1:

Table 6-1. Sediment Monitoring Plan Schedule

Activity/Deliverable	Dates(s)*
San Diego RWQCB Order No. R9-2013-0001	Adopted May 8, 2013 and effective June 27, 2013
Southern California Bight Regional Monitoring Program	August-September 2013
Follow-up confirmation monitoring	August-September 2014
Final Sediment Monitoring Plan and Sediment Monitoring QAPP incorporated into WQIPs	December 2014
Draft Sediment Monitoring Report	December 2014
Final Sediment Monitoring Report incorporated into Transitional Monitoring and Assessment Report	January 31, 2015
Potential Stressor ID Studies	TBD

*Table does not include future permit cycles

The Sediment Monitoring Plan and Sediment Monitoring QAPP (Appendix B) will be incorporated into the WQIPs in December of 2014. The San Diego County Regional Copermittees participated in the 2013 Bight Program and conducted follow-up monitoring in 2014 to satisfy

Provisions D.1.e.(1)(b) and D.1.e.(2) of the Permit prior to the development of the Sediment Monitoring Plan. Monitoring was conducted in accordance with the *San Diego County Municipal Copermittees Bight 2013 Workplan* (WESTON, 2013) and data were collected using methods consistent with previous Bight surveys and the current SQO guidelines as described in with Sediment Control Plan. Follow-up confirmation monitoring was conducted in 2014 in accordance with the *San Diego County Municipal Copermittees 2014 Sampling and Analysis Plan for Bight '13 Follow-up Investigations* (WESTON, 2014). Since the WQIPs are still in development and there will be no WQIP Annual Reports in 2015, the Copermittees will include the Sediment Monitoring Report with the Transitional Monitoring and Assessment Report due to the San Diego RWQCB on January 31, 2015. The Sediment Monitoring Report will include the results from the 2013 Bight Program and any follow-up monitoring collected in 2014. Additional sediment quality monitoring or stressor identification studies conducted after 2014 will be included in the WQIP Annual Reports.

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Appendix A

Water Quality Control Plan for Enclosed Bays and Estuaries - Part 1 Sediment Quality



WATER QUALITY CONTROL PLAN FOR ENCLOSED BAYS AND ESTUARIES - PART 1 SEDIMENT QUALITY

Effective August 25, 2009

STATE WATER RESOURCES CONTROL BOARD

California Environmental Protection Agency



State of California
Arnold Schwarzenegger, Governor

California Environmental Protection Agency
Linda S. Adams, Secretary

State Water Resources Control Board
http://www.waterboards.ca.gov

Charles R. Hoppin, Chair

Francis Spivy-Weber, Vice Chair

Tam M. Doduc, Member

Arthur G. Baggett, Jr., Member

Dorothy Rice, Executive Director

Jonathan Bishop, Chief Deputy Director

Thomas Howard, Chief Deputy Director

History of Plan
Adopted by the State Water Resources Control Board on September 16, 2008
Approved by the Office of Administrative Law on January 5, 2009
Approved by the U. S. Environmental Protection Agency on August 25, 2009

Prepared by
Chris Beegan, Ocean Unit, Division of Water Quality

STATE WATER RESOURCES CONTROL BOARD
RESOLUTION NO. 2008-0070

ADOPTION OF A WATER QUALITY CONTROL PLAN FOR
ENCLOSED BAYS AND ESTUARIES – PART 1 SEDIMENT QUALITY

WHEREAS:

1. California Water Code section 13393 requires the State Water Resources Control Board (State Water Board) to develop sediment quality objectives for toxic pollutants for California's enclosed bays and estuaries.

2. In 1991, the State Water Board adopted a workplan for the development of sediment quality objectives for California's enclosed bays and estuaries (1991 Workplan).

3. Due to funding constraints, the State Water Board did not implement the 1991 Workplan; consequently, litigation by environmental interests against the State Water Board ensued.

4. In August 2001, the Sacramento County Superior Court ruled against the state and ordered the State Water Board to initiate development of sediment quality objectives. On May 21, 2003, the State Water Board adopted a revised workplan.

5. Based upon the scope of work in the revised workplan, staff developed narrative sediment quality objectives to protect benthic communities, which utilize an approach based upon multiple lines of evidence.

6. Narrative sediment quality objectives have also been developed to protect human health from exposure to contaminants in fish tissue.

7. Staff also developed an implementation program for the narrative sediment quality objectives based upon input from the Scientific Steering Committee, Sediment Quality Advisory Committee, and staff of the State Water Board and the Regional Water Quality Control Boards (Regional Water Boards), and staff from other state and federal agencies. The work that has been completed, to date, is Phase 1 of the sediment quality objectives program.

8. The State Water Board recognizes this effort is an iterative process. Staff additionally have initiated a second phase of the sediment quality objectives program (Phase 2), which includes extensive sediment sampling in the Delta; further development of the estuarine chemistry, sediment toxicity, and benthic community indicators; and completion of a more prescriptive framework to address human health and exposure to contaminants in fish tissue. The tools, indicators, and framework developed under Phase 2 will be adopted into the draft plan in 2010. Phase 3 is proposed as the development, within available resources, of a

framework to protect fish and/or wildlife from the effects of pollutants in sediment. During Phases 2 and 3, staff would continue to evaluate the tools developed during the initial phase and the implementation language. As the Water Boards experience grows, the draft plan would be updated and amended as necessary to more effectively interpret and implement the narrative objectives.

9. In the process of developing SQOs, the State Water Board has identified the need to address statewide consistency in the regulation of dredging activities under the water quality certification program. While this issue is outside the scope of this plan, the State Water Board will consider initiating policy development in the future to address regulation of dredging activities under the water quality certification program.

10. The State Water Board's Clean Water Act section 303(d) listing policy was adopted prior to the development of SQOs and without the benefit of the scientific evidence supporting their development. The State Water Board recognizes the need to ensure that the listing policy and this plan are consistent. The State Water Board will, therefore, consider amending the 303(d) listing policy in the future to ensure consistency with this plan.

11. Staff has responded to significant verbal and written comments received from the public and made minor revisions to the draft plan in response to the comments.

12. In adopting this draft plan, the State Water Board has considered the requirements in Water Code section 13393. In particular, the sediment quality objectives are based on scientific information, including chemical monitoring, bioassays, and established modeling procedures; and the objectives provide adequate protection for the most sensitive aquatic organisms. In addition, sediment quality objectives for the protection of human health from contaminants in fish tissue are based on a health risk assessment.

13. As required by Water Code section 13393, the State Water Board has followed the procedures for adoption of water quality control plans in Water Code sections 13240 through 13247, in adopting this draft plan. In addition to the procedural requirements, the State Water Board has considered the substantive requirements in Water Code sections 13241 and 13242. The State Water Board has considered the past, present, and probable future beneficial uses of estuarine and bay waters that can be impacted by toxic pollutants in sediments; environmental characteristics of these waters; water quality conditions that can reasonably be achieved through the control of all factors affecting sediment quality; and economic considerations. Adoption of this draft plan is unlikely to affect housing needs or the development or use of recycled water. Further, the State Water Board has developed an implementation program to achieve the sediment quality objectives, which describes actions to be taken to achieve the objectives and monitoring to determine compliance with the objectives. Time schedules to achieve the objectives will be developed on a case-by-case basis by the appropriate Regional Water Board.

14. This draft plan is consistent with the state and federal antidegradation policies (State Water Board Resolution No. 68-16 and 40 C.F.R. Section 131.12, respectively). No lowering of water quality is anticipated to result from adoption of the draft plan. The draft plan contains scientifically-defensible sediment quality objectives for bays and estuaries, which can be consistently applied statewide to assess sediment quality, regulate waste discharges that can impact sediment quality, and provide the basis for appropriate remediation activities, where necessary. Adoption of the draft plan should result in improved sediment quality.

15. The Resources Agency has approved the State and Regional Water Boards' planning process as a "certified regulatory program" that adequately satisfies the California Environmental Quality Act (CEQA) requirements for preparing environmental documents. State Water Board staff has prepared a "substitute environmental document" for this project that contains the required environmental documentation under the State Water Board's CEQA regulations. (California Code of Regulations, title 23, section 3777.) The substitute environmental documents include the "Draft Staff Report – Water Quality Control Plan for Enclosed Bays and Estuaries, Part 1. Sediment Quality," the environmental checklist, the comments and responses to comments, the plan itself, and this resolution. The project is the adoption of sediment quality objectives and an implementation program, as Part 1 of the Water Quality Control Plan for Enclosed Bays and Estuaries.

16. CEQA scoping hearings were conducted on October 23, 2006 in San Diego, California, on November 8, 2006 in Oakland, California, and on November 28, 2006 in Rancho Cordova, California.

17. On September 26, 2007, staff circulated the draft plan – Part 1 Sediment Quality for public comment.

18. On November 19, 2007, the State Water Board conducted a public hearing on the draft plan and supporting Draft Staff Report and Substitute Environmental Document. Written comments were received through November 30, 2007.

19. The State Water Board adopted the Plan on February 19, 2008, and submitted it to the Office of Administrative Law (OAL) on February 29, 2008. Review by OAL revealed that the statutorily-required newspaper notification of the November 2007 hearing had not occurred. The State Water Board has, therefore, noticed and conducted a new public hearing for the draft plan on September 16, 2008.

20. In preparing the substitute environmental documents, the State Water Board has considered the requirements of Public Resources Code section 21159 and California Code of Regulations, title 14, section 15187, and intends these documents to serve as a Tier 1 environmental review. The State Water Board has considered the reasonably foreseeable consequences of adoption of the draft plan; however, project level impacts may need to be considered in any subsequent environmental analysis performed by lead agencies, pursuant to Public Resources Code section 21159.1.

21. Consistent with CEQA, the substitute environmental documents do not engage in speculation or conjecture but, rather, analyze the reasonably foreseeable environmental impacts related to methods of compliance with the draft plan, reasonably foreseeable mitigation measures to reduce those impacts, and reasonably feasible alternatives means of compliance that would avoid or reduce the identified impacts.

22. The draft plan could have a potentially significant adverse effect on the environment. However, there are feasible alternatives or feasible mitigation measures that, if employed, would reduce the potentially significant adverse impacts identified in the substitute environmental documents to less than significant levels. These alternatives or mitigation measures are within the responsibility and jurisdiction of other public agencies. When the sediment quality objectives are implemented on a project-specific basis, the agencies responsible for the project can and should incorporate the alternatives or mitigation measures into any subsequent project or project approvals.

23. From a program-level perspective, incorporation of the mitigation measures described in the substitute environmental documents will foreseeably reduce impacts to less than significant levels.

24. The substitute environmental documents for this draft plan identify broad mitigation approaches that should be considered at the project level.

25. Pursuant to Health and Safety Code section 57400, the draft Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality has undergone external peer review through an interagency agreement with the University of California.

26. This draft plan must be submitted for review and approval to the State Office of Administrative Law (OAL) and the United States Environmental Protection Agency (USEPA). The draft plan will become effective upon approval by OAL and USEPA.

27. If, during the OAL approval process, OAL determines that minor, non-substantive modifications to the language of the draft plan are needed for clarity or consistency, the Executive Director or designee may make such changes consistent with the State Water Board's intent in adopting this draft plan, and shall inform the State Water Board of any such changes.

THEREFORE BE IT RESOLVED THAT:

The State Water Board:

1. Approves and adopts the CEQA substitute environmental documentation, including all findings contained in the documentation, which was prepared in accordance with Public Resources Code section 21159 and California Code of

Regulations, Title 14, section 15187, and directs the Executive Director or designee to sign the environmental checklist;

2. After considering the entire record, including oral testimony at the public hearing, hereby adopts the proposed Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality;

3. Directs staff to submit the administrative record to OAL for review and approval; and

4. If, during the OAL approval process, OAL determines that minor, non-substantive modifications to the language of the draft plan are needed for clarity or consistency, directs the Executive Director or designee to make such changes and inform the State Water Board of any such changes.

5. Directs staff to initiate appropriate proceedings to amend the section 303(d) listing policy by February 2009.

CERTIFICATION

The undersigned Acting Clerk to the Board does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the State Water Resources Control Board held on September 16, 2008.

AYE:	Chair Tam M. Doduc Arthur G. Baggett, Jr. Charles R. Hoppin Frances Spivy-Weber
NAY:	None
ABSENT:	Vice Chair Gary Wolff, P.E., Ph.D
ABSTAIN:	None

Jeanine Townsend
Clerk to the Board

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I. INTENT AND SUMMARY

A. INTENT OF PART 1 OF THE WATER QUALITY CONTROL PLAN FOR ENCLOSED BAYS AND ESTUARIES (PART 1)

It is the goal of the State Water Resources Control Board (State Water Board) to comply with the legislative directive in Water Code §13393 to adopt sediment quality objectives (SQOs). Part 1 integrates chemical and biological measures to determine if the sediment dependent biota are protected or degraded as a result of exposure to toxic pollutants* in sediment and to protect human health. Part 1 is not intended to address low dissolved oxygen, pathogens or nutrients including ammonia. Part 1 represents the first phase of the State Water Board's SQO development effort and focuses primarily on the protection of benthic* communities in enclosed bays* and estuaries*. The State Water Board has committed in the second phase to the refinement of benthic community protection indicators for estuarine waters and the development of an improved approach to address sediment quality related human health risk associated with consumption of fish tissue.

B. SUMMARY OF PART 1

Part 1 includes**:**

1. Narrative SQOs for the protection of aquatic life and human health;
2. Identification of the beneficial uses that these objectives are intended to protect;
3. A program of implementation that contains:
   a. Specific indicators, tools and implementation provisions to determine if the sediment quality at a station or multiple stations meets the narrative objectives;
   b. A description of appropriate monitoring programs; and
   c. A sequential series of actions that shall be initiated when a sediment quality objective is not met including stressor identification and evaluation of appropriate targets.
4. A glossary that defines all terms denoted by an asterisk

II. USE AND APPLICABILITY OF SQOS

A. AMBIENT SEDIMENT QUALITY

The SQOs and supporting tools shall be utilized to assess ambient sediment quality.

B. RELATIONSHIP TO OTHER NARRATIVE OBJECTIVES

1. Except as provided in 2 below, Part 1 supersedes all applicable narrative water quality objectives and related implementation provisions in water quality control plans (basin plans) to the extent that the objectives and provisions are applied to protect bay or estuarine benthic communities from toxic pollutants in sediments.
2. The supersession provision in 1. above does not apply to existing sediment cleanup activities where a site assessment was completed and submitted to the Regional Water Board by February 19, 2008.

C. APPLICABLE WATERS

Part 1 applies to enclosed bays[1] and estuaries[2] only. Part 1 does not apply to ocean waters* including Monterey Bay and Santa Monica Bay, or inland surface waters*.

D. APPLICABLE SEDIMENTS

Part 1 applies to subtidal surficial sediments* that have been deposited or emplaced seaward of the intertidal zone. Part 1 does not apply to:

1. Sediments characterized by less than five percent of fines or substrates composed of gravels, cobbles, or consolidated rock.
2. Sediment as the physical pollutant that causes adverse biological response or community degradation related to burial, deposition, or sedimentation.

E. APPLICABLE DISCHARGES

Part 1 is applicable in its entirety to point source* discharges. Nonpoint sources* of toxic pollutants are subject to Sections II, III, IV, V, and VI of Part 1.

III. BENEFICIAL USES

Beneficial uses protected by Part 1 and corresponding target receptors are identified in Table 1.

Table 1. Beneficial Uses and Target Receptors

Beneficial Uses	Target Receptors
Estuarine Habitat	Benthic Community
Marine Habitat	Benthic Community
Commercial and Sport Fishing	Human Health
Aquaculture	Human Health
Shellfish Harvesting	Human Health

[1] ENCLOSED BAYS are indentations along the coast which enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. This definition includes, but is not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, San Francisco Bay, Morro Bay, Los Angeles Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.

[2] ESTUARIES AND COASTAL LAGOONS are waters at the mouths of streams that serve as mixing zones for fresh and ocean waters during a major portion of the year. Mouths of streams that are temporarily separated from the ocean by sandbars shall be considered as estuaries. Estuarine waters will generally be considered to extend from a bay or the open ocean to the upstream limit of tidal action but may be considered to extend seaward if significant mixing of fresh and salt water occurs in the open coastal waters. The waters described by this definition include, but are not limited to, the Sacramento-San Joaquin Delta as defined by Section 12220 of CWC, Suisun Bay, Carquinez Strait downstream to Carquinez Bridge, and appropriate areas of the Smith, Klamath, Mad, Eel, Noyo, and Russian Rivers.

IV. SEDIMENT QUALITY OBJECTIVES

A. AQUATIC LIFE – BENTHIC COMMUNITY PROTECTION

Pollutants in sediments shall not be present in quantities that, alone or in combination, are toxic to benthic communities in bays and estuaries of California. This narrative objective shall be implemented using the integration of multiple lines of evidence (MLOE) as described in Section V of Part 1.

B. HUMAN HEALTH

Pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health. This narrative objective shall be implemented as described in Section VI of Part 1.

V. BENTHIC COMMUNITY PROTECTION

A. MLOE APPROACH TO INTERPRET THE NARRATIVE OBJECTIVE

The methods and procedures described below shall be used to interpret the Narrative Objective described in Section IV.A. These tools are intended to assess the condition of benthic communities relative to potential for exposure to toxic pollutants in sediments. Exposure to toxic pollutants at harmful levels will result in some combination of a degraded benthic community, presence of toxicity, and elevated concentrations of pollutants in sediment. The assessment of sediment quality shall consist of the measurement and integration of three lines of evidence (LOE). The LOE are:

- ***Sediment Toxicity***—Sediment toxicity is a measure of the response of invertebrates exposed to surficial sediments under controlled laboratory conditions. The sediment toxicity LOE is used to assess both pollutant related biological effects and exposure. Sediment toxicity tests are of short durations and may not duplicate exposure conditions in natural systems. This LOE provides a measure of exposure to all pollutants present, including non-traditional or unmeasured chemicals.
- ***Benthic Community Condition***—Benthic community condition is a measure of the species composition, abundance and diversity of the sediment-dwelling invertebrates inhabiting surficial sediments*. The benthic community LOE is used to assess impacts to the primary receptors targeted for protection under Section IV.A. Benthic community composition is a measure of the biological effects of both natural and anthropogenic stressors.
- ***Sediment Chemistry***—Sediment chemistry is the measurement of the concentration of chemicals of concern* in surficial sediments. The chemistry LOE is used to assess the potential risk to benthic organisms from toxic pollutants in surficial sediments. The sediment chemistry LOE is intended only to evaluate overall exposure risk from chemical pollutants. This LOE does not establish causality associated with specific chemicals.

B. LIMITATIONS

None of the individual LOE is sufficiently reliable when used alone to assess sediment quality impacts due to toxic pollutants. Within a given site, the LOEs applied to assess exposure as described in Section V.A. may underestimate or overestimate the risk to benthic

communities and do not indicate causality of specific chemicals. The LOEs applied to assess biological effects can respond to stresses associated with natural or physical factors, such as sediment grain size, physical disturbance, or organic enrichment.

Each LOE produces specific information that, when integrated with the other LOEs, provides a more confident assessment of sediment quality relative to the narrative objective. When the exposure and effects tools are integrated, the approach can quantify protection through effects measures and also provide predictive capability through the exposure assessment.

C. WATER BODIES

1. The tools described in the Sections V.D. through V.I. are applicable to Euhaline* Bays and Coastal Lagoons* south of Point Conception and Polyhaline* San Francisco Bay that includes the Central and South Bay Areas defined in general by waters south and west of the San Rafael Bridge and north of the Dumbarton Bridge.
2. For all other bays and estuaries where LOE measurement tools are unavailable, station assessment will follow the procedure described in Section V.J.

D. FIELD PROCEDURES

1. All samples shall be collected using a grab sampler.
2. Benthic samples shall be screened through:
   a. A 0.5 millimeter (mm)-mesh screen in San Francisco Bay and the Sacramento-San Joaquin Delta;
   b. A 1.0 mm-mesh screen in all other locations.
3. Surface sediment from within the upper 5 cm shall be collected for chemistry and toxicity analyses.
4. The entire contents of the grab sample, with a minimum penetration depth of 5 cm, shall be collected for benthic community analysis.
5. Bulk sediment chemical analysis will include at a minimum the pollutants identified in Attachment A.

E. LABORATORY TESTING

All samples will be tested in accordance with U.S. Environmental Protection Agency (USEPA) or American Society for Testing and Materials (ASTM) methodologies where such methods exist. Where no EPA or ASTM methods exist, the State Water Board or Regional Water Quality Control Boards (Regional Water Boards) (collectively Water Boards) shall approve the use of other methods. Analytical tests shall be conducted by laboratories certified by the California Department of Health Services in accordance with Water Code Section 13176.

F. SEDIMENT TOXICITY

1. Short Term Survival Tests—A minimum of one short-term survival test shall be performed on sediment collected from each station. Acceptable test organisms and methods are summarized in Table 2.

Table 2. Acceptable Short Term Survival Sediment Toxicity Test Methods

Test Organism	Exposure Type	Duration	Endpoint*
Eohaustorius estuarius	Whole Sediment	10 days	Survival
Leptocheirus plumulosus	Whole Sediment	10 days	Survival
Rhepoxynius abronius	Whole Sediment	10 days	Survival

2. Sublethal Tests—A minimum of one sublethal test shall be performed on sediment collected from each station. Acceptable test organisms and methods are summarized in Table 3.

Table 3. Acceptable Sublethal Sediment Toxicity Test Methods

Test Organism	Exposure Type	Duration	Endpoint
Neanthes arenaceodentata	Whole Sediment	28 days	Growth
Mytilus galloprovincialis	Sediment-water Interface	48 hour	Embryo Development

3. Assessment of Sediment Toxicity—Each sediment toxicity test result shall be compared and categorized according to responses in Table 4. The response categories are:
   a. Nontoxic—Response not substantially different from that expected in sediments that are uncontaminated and have optimum characteristics for the test species (e.g., control sediments).
   b. Low toxicity—A response that is of relatively low magnitude; the response may not be greater than test variability.
   c. Moderate toxicity—High confidence that a statistically significant toxic effect is present.
   d. High toxicity—High confidence that a toxic effect is present and the magnitude of response includes the strongest effects observed for the test.

Table 4. Sediment Toxicity Categorization Values

Test Species/ Endpoint	Statistical Significance	Nontoxic (Percent)	Low Toxicity (Percent of Control)	Moderate Toxicity (Percent of Control)	High Toxicity (Percent of Control)
Eohaustorius Survival	Significant	90 to 100	82 to 89	59 to 81	< 59
Eohaustorius Survival	Not Significant	82 to 100	59 to 81		<59
Leptocheirus Survival	Significant	90 to 100	78 to 89	56 to 77	<56
Leptocheirus Survival	Not Significant	78 to 100	56 to 77		<56
Rhepoxynius Survival	Significant	90 to 100	83 to 89	70 to 82	< 70
Rhepoxynius Survival	Not Significant	83 to 100	70 to 82		< 70
Neanthes Growth	Significant	90 to 100*	68 to 90	46 to 67	<46
Neanthes Growth	Not Significant	68 to 100	46 to 67		<46
Mytilus Normal	Significant	80 to 100	77 to 79	42 to 76	< 42
Mytilus Normal	Not Significant	77 to 79	42 to 76		< 42

* Expressed as a percentage of the control.

4. Integration of Sediment Toxicity Categories—The average of all test response categories shall determine the final toxicity LOE category. If the average falls midway between categories it shall be rounded up to the next higher response category.

G. BENTHIC COMMUNITY CONDITION

1. General Requirements.
   a. All benthic invertebrates in the screened sample shall be identified to the lowest possible taxon and counted.
   b. Taxonomic nomenclature shall follow current conventions established by local monitoring programs and professional organizations (e.g., master species list).
2. Benthic Indices—The benthic condition shall be assessed using the following methods:
   a. Benthic Response Index (BRI), which was originally developed for the southern California mainland shelf and extended into California's bays and estuaries. The BRI is the abundance-weighted average pollution* tolerance score of organisms occurring in a sample.
   b. Index of Biotic Integrity (IBI), which was developed for freshwater streams and adapted for California's bays and estuaries. The IBI identifies community measures that have values outside a reference range.
   c. Relative Benthic Index (RBI), which was developed for embayments in California's Bay Protection and Toxic Cleanup Program. The RBI is the weighted sum of: (a) several community parameters (total number of species, number of crustacean species, number of crustacean individuals, and number of mollusc species), and abundances of (b) three positive, and (c) two negative indicator species.
   d. River Invertebrate Prediction and Classification System (RIVPACS), which was originally developed for British freshwater streams and adapted for California's bays and estuaries. The approach compares the assemblage at a site with an expected species composition determined by a multivariate predictive model that is based on species relationships to habitat gradients.
3. Assessment of Benthic Community Condition—Each benthic index result shall be categorized according to disturbance as described in Table 5. The disturbance categories are:
   a. Reference—A community composition equivalent to a least affected or unaffected site.
   b. Low disturbance— A community that shows some indication of stress, but could be within measurement error of unaffected condition.
   c. Moderate disturbance—Confident that the community shows evidence of physical, chemical, natural, or anthropogenic stress.
   d. High disturbance—The magnitude of stress is high.
4. Integration of Benthic Community Categories—The median of all benthic index response categories shall determine the benthic condition LOE category. If the median falls between categories it shall be rounded up to the next higher effect category.

Table 5. Benthic Index Categorization Values

Index	Reference	Low Disturbance	Moderate Disturbance	High Disturbance
Southern California Marine Bays				
BRI	< 39.96	39.96 to 49.14	49.15 to 73.26	> 73.26
IBI	0	1	2	3 or 4
RBI	> 0.27	0.17 to 0.27	0.09 to 0.16	< 0.09
RIVPACS	> 0.90 to < 1.10	0.75 to 0.90 or 1.10 to 1.25	0.33 to 0.74 or > 1.25	< 0.33
Polyhaline Central San Francisco Bay				
BRI	< 22.28	22.28 to 33.37	33.38 to 82.08	> 82.08
IBI	0 or 1	2	3	4
RBI	> 0.43	0.30 to 0.43	0.20 to 0.29	< 0.20
RIVPACS	> 0.68 to < 1.32	0.33 to 0.68 or 1.32 to 1.67	0.16 to 0.32 or > 1.67	< 0.16

H. SEDIMENT CHEMISTRY

1. All samples shall be tested for the analytes identified in Attachment A—This list represents the minimum analytes required to assess exposure. In water bodies where other toxic pollutants are believed to pose risk to benthic communities, those toxic pollutants shall be included in the analysis. Inclusion of additional analytes cannot be used in the exposure assessment described below. However, the data can be used to conduct more effective stressor identification studies as described in Section VII. F.
2. Sediment Chemistry Guidelines—The sediment chemistry exposure shall be assessed using the following two methods:
   a. Chemical Score Index (CSI), that uses a series of empirical thresholds to predict the benthic community disturbance category (score) associated with the concentration of various chemicals (Table 6). The CSI is the weighted sum of the individual scores (Equation 1).

      Equation 1. $CSI = \Sigma(w_i \times cat_i)/\Sigma w$

      Where: cat_i = predicted benthic disturbance category for chemical I;
      w_i = weight factor for chemical I;
      Σw = sum of all weights.

   b. California Logistic Regression Model (CA LRM), that uses logistic regression models to predict the probability of sediment toxicity associated with the concentration of various chemicals (Table 7 and Equation 2). The CA LRM exposure value is the maximum probability of toxicity from the individual models (P_{max})

      Equation 2. $p = e^{B0+B1\,(x)} / (1 + e^{B0+B1\,(x)})$

      Where: p = probability of observing a toxic effect;
      B0 = intercept parameter;
      B1 = slope parameter; and
      x = concentration the chemical.

Table 6. Category Score Concentration Ranges and Weighting Factors for the CSI

Chemical	Units	Weight	Score (Disturbance Category)			
			1 Reference	2 Low	3 Moderate	4 High
Copper	mg/kg	100	≤52.8	> 52.8 to 96.5	> 96.5 to 406	> 406
Lead	mg/kg	88	≤ 26.4	> 26.4 to 60.8	> 60.8 to 154	> 154
Mercury	mg/kg	30	≤ 0.09	> 0.09 to 0.45	> 0.45 to 2.18	> 2.18
Zinc	mg/kg	98	≤ 112	> 112 to 200	> 200 to 629	> 629
PAHs, total high MW	µg/kg	16	≤ 312	> 312 to 1325	> 1325 to 9320	>9320
PAHs, total low MW	µg/kg	5	≤ 85.4	> 85.4 to 312	> 312 to 2471	> 2471
Chlordane, alpha-	µg/kg	55	≤ 0.50	> 0.50 to 1.23	> 1.23 to 11.1	>11.1
Chlordane, gamma-	µg/kg	58	≤ 0.54	> 0.54 to 1.45	> 1.45 to 14.5	> 14.5
DDDs, total	µg/kg	46	≤ 0.50	> 0.50 to 2.69	> 2.69 to 117	> 117
DDEs, total	µg/kg	31	≤ 0.50	> 0.50 to 4.15	> 4.15 to 154	> 154
DDTs, total	µg/kg	16	≤ 0.50	> 0.50 to 1.52	> 1.52 to 89.3	> 89.3
PCBs, total	µg/kg	55	≤11.9	> 11.9 to 24.7	> 24.7 to 288	> 288

Table 7. CA LRM Regression Parameters

Chemical	Units	B0	B1
Cadmium	mg/kg	0.29	3.18
Copper	mg/kg	-5.59	2.59
Lead	mg/kg	-4.72	2.84
Mercury	mg/kg	-0.06	2.68
Zinc	mg/kg	-5.13	2.42
PAHs, total high MW	µg/kg	-8.19	2.00
PAHs, total low MW	µg/kg	-6.81	1.88
Chlordane, alpha	µg/kg	-3.41	4.46
Dieldrin	µg/kg	-1.83	2.59
Trans nonachlor	µg/kg	-4.26	5.31
PCBs, total	µg/kg	-4.41	1.48
p,p' DDT	µg/kg	-3.55	3.26

3. Assessment of Sediment Chemistry Exposure—Each sediment chemistry guideline result shall be categorized according to exposure as described in Table 8. The exposure categories are:
   a. Minimal exposure—Sediment-associated contamination* may be present, but exposure is unlikely to result in effects.
   b. Low exposure—Small increase in pollutant exposure that may be associated with increased effects, but magnitude or frequency of occurrence of biological impacts is low.
   c. Moderate exposure—Clear evidence of sediment pollutant exposure that is likely to result in biological effects; an intermediate category.
   d. High exposure—Pollutant exposure highly likely to result in possibly severe biological effects; generally present in a small percentage of the samples.

Table 8. Sediment Chemistry Guideline Categorization Values

Guideline	Minimal Exposure	Low Exposure	Moderate Exposure	High Exposure
CSI	< 1.69	1.69 to 2.33	2.34 to 2.99	>2.99
CA LRM	< 0.33	0.33 to 0.49	0.50 to 0.66	> 0.66

4. Integration of Sediment Chemistry Categories—The average of all chemistry exposure categories shall determine the final sediment chemistry LOE category. If the average falls midway between categories it shall be rounded up to the next higher exposure category.

I. INTERPRETATION AND INTEGRATION OF MLOE

Assessment as to whether the aquatic life sediment quality objective has been attained at a station is accomplished by the interpretation and integration of MLOE. The categories assigned to the three LOE, sediment toxicity, benthic community condition and sediment chemistry are evaluated to determine the station level assessment. The assessment category represented by each of the possible MLOE combinations reflects the presence and severity of two characteristics of the sample: severity of biological effects, and potential for chemically-mediated effects.

1. Severity of Biological Effects—The severity of biological effects present at a site shall be determined by the integration of the toxicity LOE and benthic condition LOE categories using the decision matrix presented in Table 9.
2. Potential for Chemically-Mediated Effects—The potential for effects to be chemically-mediated shall be determined by the integration of the toxicity LOE and chemistry LOE categories using the decision matrix presented in Table 10.

Table 9. Severity of Biological Effects Matrix

		Toxicity LOE Category			
		Nontoxic	Low Toxicity	Moderate Toxicity	High Toxicity
Benthic Condition LOE Category	Reference	Unaffected	Unaffected	Unaffected	Low Effect
	Low Disturbance	Unaffected	Low Effect	Low Effect	Low Effect
	Moderate Disturbance	Moderate Effect	Moderate Effect	Moderate Effect	Moderate Effect
	High Disturbance	Moderate Effect	High Effect	High Effect	High Effect

Table 10. Potential for Chemically Mediated Effects Matrix

		Toxicity LOE Category			
		Nontoxic	**Low Toxicity**	**Moderate Toxicity**	**High Toxicity**
Sediment Chemistry LOE Category	Minimal Exposure	Minimal Potential	Minimal Potential	Low Potential	Moderate Potential
	Low Exposure	Minimal Potential	Low Potential	Moderate Potential	Moderate Potential
	Moderate Exposure	Low Potential	Moderate Potential	Moderate Potential	Moderate Potential
	High Exposure	Moderate Potential	Moderate Potential	High Potential	High Potential

3. Station Level Assessment—The station level assessment shall be determined using the decision matrix presented in Table 11. This assessment combines the intermediate classifications for severity of biological effect and potential for chemically-mediated effect to result in six categories of impact at the station level:
   a. Unimpacted—Confident that sediment contamination is not causing significant adverse impacts to aquatic life living in the sediment at the site.
   b. Likely Unimpacted—Sediment contamination at the site is not expected to cause adverse impacts to aquatic life, but some disagreement among the LOE reduces certainty in classifying the site as unimpacted.
   c. Possibly Impacted—Sediment contamination at the site may be causing adverse impacts to aquatic life, but these impacts are either small or uncertain because of disagreement among LOE.
   d. Likely Impacted—Evidence for a contaminant-related impact to aquatic life at the site is persuasive, even if there is some disagreement among LOE.
   e. Clearly Impacted—Sediment contamination at the site is causing clear and severe adverse impacts to aquatic life.
   f. Inconclusive—Disagreement among the LOE suggests that either the data are suspect or that additional information is needed before a classification can be made.

Table 11. Station Assessment Matrix

		Severity of Effect			
		Unaffected	**Low Effect**	**Moderate Effect**	**High Effect**
Potential For Chemically-Mediated Effects	Minimal Potential	Unimpacted	Likely Unimpacted	Likely Unimpacted	Inconclusive
	Low Potential	Unimpacted	Likely Unimpacted	Possibly Impacted	Possibly Impacted
	Moderate Potential	Likely Unimpacted	Possibly Impacted or Inconclusive[1]	Likely Impacted	Likely Impacted
	High Potential	Inconclusive	Likely Impacted	Clearly Impacted	Clearly Impacted

[1] Inconclusive category when chemistry is classified as minimal exposure, benthic response is classified as reference, and toxicity response is classified as high.

The station assessment resulting from each possible combination of the three LOEs is shown in Attachment B. As an alternative to Tables 9, 10 and 11, each LOE

category can be applied to Attachment B to determine the overall condition of the station. The results will be the same regardless of the tables used.

4. Relationship to the Aquatic Life – Benthic Community Protection Narrative Objective.
   a. The categories designated as **Unimpacted** and **Likely Unimpacted** shall be considered as achieving the protective condition at the station. All other categories shall be considered as degraded except as provided in b. below.
   b. The Water Board shall designate the category **Possibly Impacted** as meeting the protective condition if the studies identified in Section VII.F demonstrate that the combination of effects and exposure measures are not responding to toxic pollutants in sediments and that other factors are causing these responses within a specific reach segment or waterbody. In this situation, the Water Board will consider only the Categories **Likely Impacted** and **Clearly Impacted** as degraded when making a determination on receiving water limits and impaired water bodies described in Section VII.

J. MLOE Approach to Interpret the Narrative Objective in Other Bays and Estuaries

Station assessments for waterbodies identified in Section V.C.2. will be conducted using the same conceptual approach and similar tools to those described in Sections V.D-H. Each LOE will be evaluated by measuring a set of readily available indicators in accordance with Tables 12 and 13.

1. Station assessment shall be consistent with the following key principles of the assessment approach described in Sections V.D. through V.I:
   a. Results for a single LOE shall not be used as the basis for an assessment.
   b. Evidence of both elevated chemical exposure and biological effects must be present to indicate pollutant-associated impacts.
   c. The categorization of each LOE shall be based on numeric values or a statistical comparison.
2. Lines of Evidence and Measurement Tools—Sediment chemistry, toxicity, and benthic community condition shall be measured at each station. Table 12 lists the required tools for evaluation of each LOE. Each measurement shall be conducted using standardized methods (e.g., EPA or ASTM guidance) where available.
3. Categorization of LOEs—Determination of the presence of an LOE effect (i.e., biologically significant chemical exposure, toxicity, or benthic community disturbance) shall be based on a comparison to a numeric response value or a statistical comparison to reference stations. The numeric values or statistical comparisons (e.g., confidence interval) used to classify a LOE as Effected shall be comparable to those specified in Sections V.F-H. to indicate High Chemical Exposure, High Toxicity, or High Disturbance. Reference stations shall be located in an area expected to be uninfluenced by the discharge or pollutants of concern in the assessment area and shall be representative of other habitat characteristics of the assessment area (e.g., salinity, grain size). Comparison to reference shall be accomplished by compiling data for appropriate regional reference sites and determining the reference envelope using statistical methods (e.g., tolerance interval).

Table 12. Tools for Use in Evaluation of LOEs

LOE	Tools	Metrics
Chemistry	Bulk sediment chemistry to include existing list (Attachment A) plus other chemicals of concern	CA LRM P_{max} Concentration on a dry weight basis
Sediment Toxicity	10-Day amphipod survival using a species tolerant of the sample salinity and grain size characteristics. e.g., *Hyalella azteca* or *Eohaustorius estuarius*	Percent of control survival
Benthic Community Condition	Invertebrate species identification and abundance	Species richness* Presence of sensitive indicator taxa Dominance by tolerant indicator taxa Presence of diverse functional and feeding groups Total abundance

Table 13. Numeric Values and Comparison Methods for LOE Categorization

Metric	Threshold value or Comparison
CA LRM	Pmax > 0.66
Chemical Concentration	Greater than reference range or interval
Percent of Control Survival	*E. estuarius*: < 59 *H. azteca*: < 62 or SWAMP criterion
Species Richness	Less than reference range or interval
Abundance of Sensitive Indicator Taxa	Less than reference range or interval
Abundance of Tolerant Indicator Taxa	Greater than reference range or interval
Total Abundance	Outside of reference range or interval

4. Station Level Assessment—The station level assessment shall be determined using the decision matrix presented in Table 14. This assessment combines the classifications for each LOE to result in two categories of impact at the station level:
   a. Unimpacted—No conclusive evidence of both high pollutant exposure and high biological effects present at the site. Evidence of chemical exposure and biological effects may be within natural variability or measurement error.
   b. Impacted—Confident that sediment contamination present at the site is causing adverse direct impacts to aquatic life.

Table 14. Station Assessment Matrix for Other Bays and Estuaries

Chemistry LOE Category	Toxicity LOE Category	Benthic Condition LOE Category	Station Assessment
No effect	No effect	No effect	Unimpacted
No effect	No effect	Effect	Unimpacted
No effect	Effect	No effect	Unimpacted
No effect	Effect	Effect	Impacted
Effect	No effect	No effect	Unimpacted
Effect	No effect	Effect	Impacted
Effect	Effect	No effect	Impacted
Effect	Effect	Effect	Impacted

5. Relationship to the Aquatic Life – Benthic Community Protection Narrative Objective— The category designated as **Unimpacted** shall be considered as achieving the protective condition at the station.

VI. HUMAN HEALTH

The narrative human health objective in Section IV. B. of this Part 1 shall be implemented on a case-by-case basis, based upon a human health risk assessment. In conducting a risk assessment, the Water Boards shall consider any applicable and relevant information, including California Environmental Protection Agency's (Cal/EPA) Office of Environmental Health Hazard Assessment (OEHHA) policies for fish consumption and risk assessment, Cal/EPA's Department of Toxic Substances Control (DTSC) Risk Assessment, and USEPA Human Health Risk Assessment policies.

VII. PROGRAM OF IMPLEMENTATION

Implementation of Part 1 shall be conducted in accordance with the following provisions and consistent with the process shown in Figures 1 and 2.

A. DREDGE MATERIALS

1. Part 1 shall not apply to dredge material suitability determinations.
2. The Water Boards shall not approve a dredging project that involves the dredging of sediment that exceeds the objectives in Part 1, unless the Water Boards determine that:
   a. The polluted sediment is removed in a manner that prevents or minimizes water quality degradation.
   b. The polluted sediment is not deposited in a location that may cause significant adverse effects to aquatic life, fish, shellfish, or wildlife or may harm the beneficial uses of the receiving waters, or does not create maximum benefit to the people of the State.
   c. The activity will not cause significant adverse impacts upon a federal sanctuary, recreational area, or other waters of significant national importance.

B. NPDES RECEIVING WATER AND EFFLUENT LIMITS

1. If a Water Board determines that discharge of a toxic pollutant to bay or estuarine waters has the reasonable potential to cause or contribute to an exceedance of the SQOs, the Water Board shall apply the objectives as receiving water limits.
2. The Permittee shall be in violation of such limits if it is demonstrated that the discharge is causing or contributing to the SQO exceedance as defined in Section VII.C.
3. Receiving water monitoring required by an NPDES permit may be satisfied by a Permitee's participation in a regional SQO monitoring program described in Section VII.E.
4. The sediment chemistry guidelines shall not be translated into or applied as effluent limits. Effluent limits established to protect or restore sediment quality shall be developed only after:
   a. A clear relationship has been established linking the discharge to the degradation,

b. The pollutants causing or contributing to the degradation have been identified, and

c. Appropriate loading studies have been completed to estimate the reductions in pollutant loading that will restore sediment quality.

These actions are described further in Sections VII.F and VII.G. Nothing in this section shall limit a Water Board's authority to develop and implement waste* load allocations* for Total Maximum Daily Loads. However, it is recommended that the Water Boards develop TMDL allocations using the methodology described herein, wherever possible.

C. EXCEEDANCE OF RECEIVING WATER LIMIT

Exceedance of a receiving water limit is demonstrated when:

1. Using a binomial distribution*, the total number of stations designated as not meeting the protective condition as defined in Sections V.I.4. or V.J.4. supports rejection of the null hypothesis* as presented in Table 15. The stations included in this analysis will be those located in the vicinity of the discharge and identified in the permit, and
2. It is demonstrated that the discharge is causing or contributing to the SQO exceedance, following the completion of the stressor identification studies described in Section VII.F.
3. If studies by the Permittee demonstrate that other sources may also be contributing to the degradation of sediment quality, the Regional Water Board shall, as appropriate, require the other sources to initiate studies to assess the extent to which these sources are a contributing factor.

Table 15. Minimum Number of Measured Exceedances Needed to Exceed the Direct Effects SQO as a Receiving Water Limit

Sample Size	List If the Number of Exceedances Equals or Is Greater Than
2 – 24	2*
25 – 36	3
37 – 47	4
48 – 59	5
60 – 71	6
72 – 82	7
83 – 94	8
95 – 106	9
107 – 117	10
118 – 129	11

Note: Null Hypothesis: Actual exceedance proportion $\leq$ 3 percent. Alternate Hypothesis: Actual exceedance proportion > 18 percent. The minimum effect size* is 15 percent.

*Application of the binomial test requires a minimum sample size of 16. The number of exceedances required using the binomial test at a sample size of 16 is extended to smaller sample sizes.

Exceedance will require the Permittee to perform additional studies as described in Sections VII.F and VII.G.

D. RECEIVING WATER LIMITS MONITORING FREQUENCY

1. Phase I Stormwater Discharges and Major Discharges—Sediment Monitoring shall not be required less frequently than twice per permit cycle. For Stations that are consistently classified as unimpacted or likely unimpacted the frequency may be reduced to once per permit cycle. The Water Board may limit receiving water monitoring to a subset of outfalls for Phase I Stormwater Permitees.
2. Phase II Stormwater and Minor Discharges—Sediment Monitoring shall not be required more often then twice per permit cycle or less then once per permit cycle. For stations that are consistently classified as unimpacted or likely unimpacted, the number of stations monitored may be reduced at the discretion of the Water Board. The Water Board may limit receiving water monitoring to a subset of outfalls for Phase II Stormwater Permitees.
3. Other Regulated Discharges and Waivers—The frequency of the monitoring for receiving water limits for other regulated discharges and waivers will be determined by the Water Board.

E. SEDIMENT MONITORING

1. Objective—Bedded sediments in bays contain an accumulation of pollutants from a wide variety of past and present sources discharged either directly into the bay or indirectly into waters draining into the bay. Embayments also represent highly disturbed or altered habitats as a result of dredging and physical disturbance caused by construction and maintenance of harbor works, boat and ship traffic, and development of adjacent lands. Due to the multitude of stressors and the complexity of the environment, a well-designed monitoring program is necessary to ensure that the data collected adequately characterizes the condition of sediment in these water bodies.
2. Permitted Discharges—Monitoring may be performed by individual Permitees to assess compliance with receiving water limits, or through participation in a regional or water body monitoring coalition as described under VII.E.3, or both as determined by the Water Board.
3. Monitoring Coalitions—To achieve maximum efficiency and economy of resources, the State Water Board encourages the regulated community in coordination with the Regional Water Boards to establish water body-monitoring coalitions. Monitoring coalitions enable the sharing of technical resources, trained personnel, and associated costs and create an integrated sediment-monitoring program within each major water body. Focusing resources on regional issues and developing a broader understanding of pollutants effects in these water bodies enables the development of more rapid and efficient response strategies and facilitates better management of sediment quality.
    a. If a regional monitoring coalition is established, the coalition shall be responsible for sediment quality assessment within the designated water body and for ensuring that appropriate studies are completed in a timely manner.
    b. The Water Board shall provide oversight to ensure that coalition participants are proactive and responsive to potential sediment quality related issues as they arise during monitoring and assessment.
    c. Each regional monitoring coalition shall prepare a workplan that describes the monitoring, a map of the stations, participants and a schedule that shall be submitted to the Water Board for approval.

4. Methods—Sediments collected from each station shall be tested or assessed using the methods and metrics described in Section V.
5. Design.
    a. The design of sediment monitoring programs, whether site-specific or region wide, shall be based upon a conceptual model. A conceptual model is useful for identifying the physical and chemical factors that control the fate and transport of pollutants and receptors that could be exposed to pollutants in the sediment. The conceptual model serves as the basis for assessing the appropriateness of a study design. The detail and complexity of the conceptual model is dependent upon the scope and scale of the monitoring program. A conceptual model shall consider:
        - Points of discharge into the segment of the waterbody or region of interest
        - Tidal flow and/or direction of predominant currents
        - Historic and or legacy conditions in the vicinity
        - Nearby land and marine uses or actions
        - Beneficial uses
        - Potential receptors of concern
        - Changes in grain size salinity water depth and organic matter
        - Other sources or discharges in the immediate vicinity.
    b. Sediment monitoring programs shall be designed to ensure that the aggregate stations are spatially representative of the sediment within the water body.
    c. The design shall take into consideration existing data and information of appropriate quality.
    d. Stratified random design shall be used where resources permit to assess conditions throughout a water body.
    3. Identification of appropriate strata shall consider characteristics of the water body including sediment transport, hydrodynamics, depth, salinity, land uses, inputs (both natural and anthropogenic) and other factors that could affect the physical, chemical, or biological condition of the sediment.
    f. Targeted designs shall be applied to those Permitees that are required to meet receiving water limits as described in Section VII. B.
6. Index Period—All stations shall be sampled between the months of June through September to be consistent with the benthic community condition index period.
7. Regional Monitoring Schedule and Frequency.
    a. Regional sediment quality monitoring will occur at a minimum of once every three years.
    b. Sediments identified as exceeding the narrative objective will be evaluated more frequently.
8. Evaluating Waters for placement on the Section 303(d) list —In California, water segments are placed on the section 303(d) list for sediment toxicity based either on toxicity alone or toxicity that is associated with a pollutant. The listing criteria are contained in the State Water Board's Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List (2004)(Listing Policy). Part 1 adds an additional listing criterion that applies only to listings for exceedances of the narrative sediment quality objective for aquatic life protection in Section IV.A. The criterion under Part 1 is described in subsection a. below and the relationship

between the sediment toxicity listing criteria under the Listing Policy and the criterion under Part 1 is described in subsections b. and c., below.

1. Water segments shall be placed on the section 303(d) list for exceedance of the narrative sediment quality objective for aquatic life protection in Section IV.A. of Part 1 only if the number of stations designated as not achieving the protective condition as defined in Sections V.I. and V.J. supports rejection of the null hypothesis, as provided in Table 3.1 of the State Water Board's Listing Policy.
2. Water segments that exhibit sediment toxicity but that are not listed for an exceedance of the narrative sediment quality objective for aquatic life protection in Section IV.A. shall continue to be listed in accordance with Section 3.6 of the Listing Policy.
3. If a water segment is listed under Section 3.6 of the Listing Policy and the Regional Water Board later determines that the applicable water quality standard that is impaired consists of the sediment quality objective in Section IV.A. of Part 1 and a bay or estuarine habitat beneficial use, the Regional Water Board shall reevaluate the listing in accordance with Sections V.I and V.J. If the Regional Water Board reevaluates the listing and determines that the water segment does not meet the criteria in subsection a. above, the Regional Water Board shall delist the water segment.

F. STRESSOR IDENTIFICATION

If sediments fail to meet the narrative SQOs in accordance with Sections V. and VI. the Water Boards shall direct the regional monitoring coalitions or Permittees to conduct stressor identification.

The Water Boards shall assign the highest priority for stressor identification to those segments or reaches with the highest percentage of sites designated as Clearly Impacted and Likely Impacted.

Where segments or reaches contain Possibly Impacted but no Clearly or Likely Impacted sites, confirmation monitoring shall be conducted prior to initiating stressor identification.

The stressor identification approach consists of development and implementation of a work plan to seek confirmation and characterization of pollutant-related impacts, pollutant identification and source identification. The workplan shall be submitted to the Water Board for approval. Stressor identification consists of the following studies:

1. Confirmation and Characterization of Pollutant Related Impacts—Exceedance of the direct effects SQO at a site indicates that pollutants in the sediment are the likely cause but does not identify the specific pollutant responsible. The MLOE assessment establishes a linkage to sediment pollutants; however, the lack of confounding factors (e.g., physical disturbance, non-pollutant constituents) must be confirmed. There are two generic stressors that are not related to toxic pollutants that may cause the narrative to be exceeded:
    a. Physical Alteration—Examples of physical stressors include reduced salinity, impacts from dredging, very fine or coarse grain size, and prop wash from passing ships. These types of stressors may produce a non-reference condition* in the benthic community that is similar to that caused by pollutants. If impacts to a site are purely due to physical disturbance, the LOE characteristics will likely show a degraded benthic community with little or no toxicity and low chemical concentrations.

b. Other Pollutant Related Stressors—These constituents, which include elevated total organic carbon, ammonia, nutrients and pathogens, may have sources similar to chemical pollutants. Chemical and microbiological analysis will be necessary to determine if these constituents are present. The LOE characteristics for this type of stressor would likely be a degraded benthic community with possibly an indication of toxicity, and low chemical concentrations.

To further assess a site that is impacted by toxic pollutants, there are several lines of investigation that may be pursued, depending on site-specific conditions. These studies may be considered and evaluated in the work plan for the confirmation effort:

a. Evaluate the spatial extent of the Area of Concern. This information can be used to evaluate the potential risk associated with the sediment, distinguish areas of known physical disturbance or pollution and evaluate the proximity to anthropogenic source gradient from such inputs as outfalls, storm drains, and industrial and agricultural activities.

b. Body burden data may be examined from animals exposed to the site's sediment to indicate if pollutants are being accumulated and to what degree.

c. Chemical specific mechanistic benchmarks* may be applied to interpret sediment chemistry concentrations.

d. Chemistry and biology data from the site should be examined to determine if there is a correlation between the two LOE.

e. Alternate biological effects data may be pursued, such as bioaccumulation* experiments and pore water toxicity or chemical analysis.

f. Other investigations that may commonly be performed as part of a Phase 1 Toxicity Identification Evaluation* (TIE).

If there is compelling evidence that the SQO exceedances contributing to a receiving water limit exceedance are not due to toxic pollutants, then the assessment area shall be designated as having achieved the receiving water limit.

2. Pollutant Identification—Methods to help determine cause may be statistical, biological, chemical or a combination. Pollutant identification studies should be structured to address site-specific conditions, and may be based upon the following:

a. Statistical methods—Correlations between individual chemicals and biological endpoints (toxicity and benthic community).

b. Gradient analysis—Comparisons are made between different samples taken at various distances from a chemical hotspot to examine patterns in chemical concentrations and biological responses. The concentrations of causative agents should decrease as biological effects decrease.

c. Additional Toxicity Identification Evaluation efforts—A toxicological method for determining the cause of impairments is the use of toxicity identification evaluations (TIE). Sediment samples are manipulated chemically or physically to remove classes of chemicals or render them biologically unavailable. Following the manipulations, biological tests are performed to determine if toxicity has been removed. TIEs should be conducted at a limited number of stations, preferably those with strong biological or toxicological effects.

d. Bioavailability*—Chemical pollutants may be present in the sediment but not biologically available to cause toxicity or degradation of the benthic community. There are several measures of bioavailability that can be made. Chemical and

toxicological measurements can be made on pore water to determine the availability of sediment pollutants. Metal compounds may be naturally bound up in the sediment and rendered unavailable by the presence of sulfides. Measurement of acid volatile sulfides and simultaneously extracted metals analysis can be conducted to determine if sufficient sulfides are present to bind the observed metals. Similarly, organic compounds can be tightly bound to sediments. Measurements of sediment organic carbon and other binding phases can be conducted to determine the bioavailable fraction of organic compounds. Solid phase microextraction (SPME) or laboratory desorption experiments can also be used to identify which organics are bioavailable to benthic organisms.

e. Verification—After specific chemicals are identified as likely causes of impairment, analysis should be performed to verify the results. Sediments can be spiked with the suspected chemicals to verify that they are indeed toxic at the concentrations observed in the field. Alternately, animals can be transplanted to suspected sites for *in situ* toxicity and bioaccumulation testing.

When stressor Identification yields inconclusive results for sites classified as Possibly Impacted, the Water Board shall require the Permittee or regional monitoring coalition to perform a one-time augmentation to that study or, alternatively, the Water Board may suspend further stressor identification studies pending the results of future routine SQO monitoring.

3. Sources Identification and Management Actions.
   a. Determine if the sources are ongoing or legacy sources.
   b. Determine the number and nature of ongoing sources.
   c. If a single discharger is found to be responsible for discharging the stressor pollutant at a loading rate that is significant, the Regional Water Board shall require the discharger to take all necessary and appropriate steps to address exceedance of the SQO, including but not limited to reducing the pollutant loading into the sediment.
   d. When multiple sources are present in the water body that discharge the stressor pollutant at a loading rate that is significant, the Regional Water Board shall require the sources to take all necessary and appropriate steps to address exceedance of the SQO. If appropriate, the Regional Water Board may adopt a TMDL to ensure attainment of the sediment standard.

G. CLEANUP AND ABATEMENT

Cleanup and abatement actions covered by Water Code section 13304 for sediments that exceed the objectives in Chapter IV shall comply with Resolution No. 92-49 (Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304), Cal. Code Regs., tit. 23, §§2907, 2911.

H. DEVELOPMENT OF SITE-SPECIFIC SEDIMENT MANAGEMENT GUIDELINES

The Regional Water Boards may develop site-specific sediment management guidelines where appropriate, for example, where toxic stressors have been identified and controllable sources of these stressors exist or remedial goals are desired.

Development of site-specific sediment management guidelines is the process to estimate the level of the stressor pollutant that will meet the narrative sediment quality objective. The guideline can serve as the basis for cleanup goals or revision of effluent limits described in B. 4

above, depending upon the situation or sources. All guidelines when applied for cleanup, must comply with 92-49.

Guideline development should only be initiated after the stressor has been identified. The goal is to establish a relationship between the organism's exposure and the biological effect. Once this relationship is established, a pollutant specific guideline may be designated that corresponds with minimum biological effects. The following approaches can be applied to establish these relationships:

1. Correspondence with sediment chemistry. An effective guideline can best be derived based upon the site-specific, or reach- specific relationship between the stressor pollutant exposure and biological response. Therefore the correspondence between the bulk sediment stressor concentration and biological effects should be examined.
2. Correspondence with bioavailable pollutant concentration. The concentration of the bioavailable fraction of the stressor pollutants is likely to show a less variable relationship to biological effects that bulk sediment chemistry. Interstitial water analysis, SPME, desorption experiments, selective extractions, or mechanistic models may indicate the bioavailable pollutant concentration. The correspondence between the bioavailable stressor concentration and biological effects should be examined.
3. Correspondence with tissue residue. The concentration of the stressor accumulated by a target organism may provide a measure of the stressor dose for some chemicals (e.g., those that are not rapidly metabolized). The tissue residue threshold concentration associated with unacceptable biological effects can be combined with a bioaccumulation factor or model to estimate the loading or sediment concentration guideline.
4. Literature review. If site-specific analyses are ambiguous or unable to determine a guideline, then the results of similar development efforts for other areas should be reviewed. Scientifically credible values from other studies can be combined with mechanistic or empirical models of bioavailability, toxic potency, and organism sensitivity to estimate guidelines for the area of interest.
5. The chemistry LOE of Section V.H.2, including the threshold values (e.g. CSI and CALRM), shall not be used for setting cleanup levels or numeric values for technical TMDLs.

VIII. GLOSSARY

BENTHIC: Living on or in bottom of the ocean, bays, and estuaries, or in the streambed.

BINOMIAL DISTRIBUTION: Mathematical distribution that describes the probabilities associated with the possible number of times particular outcomes will occur in series of observations (i.e., samples). Each observation may have only one of two possible results (e.g., standard exceeded or standard not exceeded).

BIOACCUMULATION: A process in which an organism's body burden of a pollutant exceeds that in its surrounding environment as a result of chemical uptake through all routes of chemical exposure; dietary and dermal absorption and transport across the respiratory surface.

BIOAVAILABILITY: The fraction of a pollutant that an organism is exposed to that is available for uptake through biological membranes (gut, gills).

CHEMICALS OF CONCERN (COCS): Pollutants that occur in environmental media at levels that pose a risk to ecological receptors or human health.

CONTAMINATION: An impairment of the quality of the waters of the State by waste to a degree that creates a hazard to the public health through poisoning or through the spread of disease. "Contamination" includes any equivalent effect resulting from the disposal of waste whether or not waters of the State are affected (CWC section 13050(k)).

EFFECT SIZE: The maximum magnitude of exceedance frequency that is tolerated.

ENCLOSED BAYS: Indentations along the coast that enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. This definition includes, but is not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, San Francisco Bay, Morro Bay, Los Angeles Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.

ENDPOINT: A measured response of a receptor to a stressor. An endpoint can be measured in a toxicity test or in a field survey.

ESTUARIES AND COASTAL LAGOONS: Waters at the mouths of streams that serve as mixing zones* for fresh and ocean waters during a major portion of the year. Mouths of streams that are temporarily separated from the ocean by sandbars shall be considered as estuaries. Estuarine waters will generally be considered to extend from a bay or the open ocean to the upstream limit of tidal action but may be considered to extend seaward if significant mixing of fresh and salt water occurs in the open coastal waters. The waters described by this definition include, but are not limited to, the Sacramento-San Joaquin Delta as defined by Section 12220 of the California Water Code, Suisun Bay, Carquinez Strait downstream to Carquinez Bridge, and appropriate areas of the Smith, Klamath, Mad, Eel, Noyo, and Russian Rivers.

EUHALINE: Waters ranging in salinity from 25–32 practical salinity units (psu).

INLAND SURFACE WATERS: All surface waters of the State that do not include the ocean, enclosed bays, or estuaries.

LOAD ALLOCATION (LA): The portion of a receiving water's total maximum daily load that is allocated to one of its nonpoint sources of pollution or to natural background sources.

MECHANISTIC BENCHMARKS: Chemical guidelines developed based upon theoretical processes governing bioavailability and the relationship to biological effects.

MIXING ZONE: A limited zone within a receiving water that is allocated for mixing with a wastewater discharge where water quality criteria can be exceeded without causing adverse effects to the overall water body.

NONPOINT SOURCES: Sources that do not meet the definition of a point source as defined below.

NULL HYPOTHESIS: A statement used in statistical testing that has been put forward either because it is believed to be true or because it is to be used as a basis for argument, but has not been proved.

OCEAN WATERS: Territorial marine waters of the State as defined by California law to the extent these waters are outside of enclosed bays, estuaries, and coastal lagoons. Discharges to ocean waters are regulated in accordance with the State Water Board's California Ocean Plan.

POINT SOURCE: Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock,

concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural stormwater discharges and return flows from irrigated agriculture.

POLLUTANT: Defined in section 502(6) of the CWA as "dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water."

POLLUTION: Defined in section 502(19) of the CWA as the "the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water." *Pollution* is also defined in CWC section 13050(1) as an alternation of the quality of the waters of the State by waste to a degree that unreasonably affects either the waters for beneficial uses or the facilities that serve these beneficial uses.

POLYHALINE: Waters ranging in salinity from 18–25 psu.

REFERENCE CONDITION: The characteristics of water body segments least impaired by human activities. As such, reference conditions can be used to describe attainable biological or habitat conditions for water body segments with common watershed/catchment characteristics within defined geographical regions.

SPECIES RICHNESS: The number of species in a sample.

SURFICIAL SEDIMENTS: Those sediments representing recent depositional materials and containing the majority of the benthic invertebrate community.

STATISTICAL SIGNIFICANCE: When it can be demonstrated that the probability of obtaining a difference by chance only is relatively low.

TOXICITY IDENTIFICATION EVALUATION (TIE): Techniques used to identify the unexplained cause(s) of toxic events. TIE involves selectively removing classes of chemicals through a series of sample manipulations, effectively reducing complex mixtures of chemicals in natural waters to simple components for analysis. Following each manipulation the toxicity of the sample is assessed to see whether the toxicant class removed was responsible for the toxicity.

WASTE: As used in this document, waste includes a discharger's total discharge, of whatever origin, i.e., gross, not net, discharge.

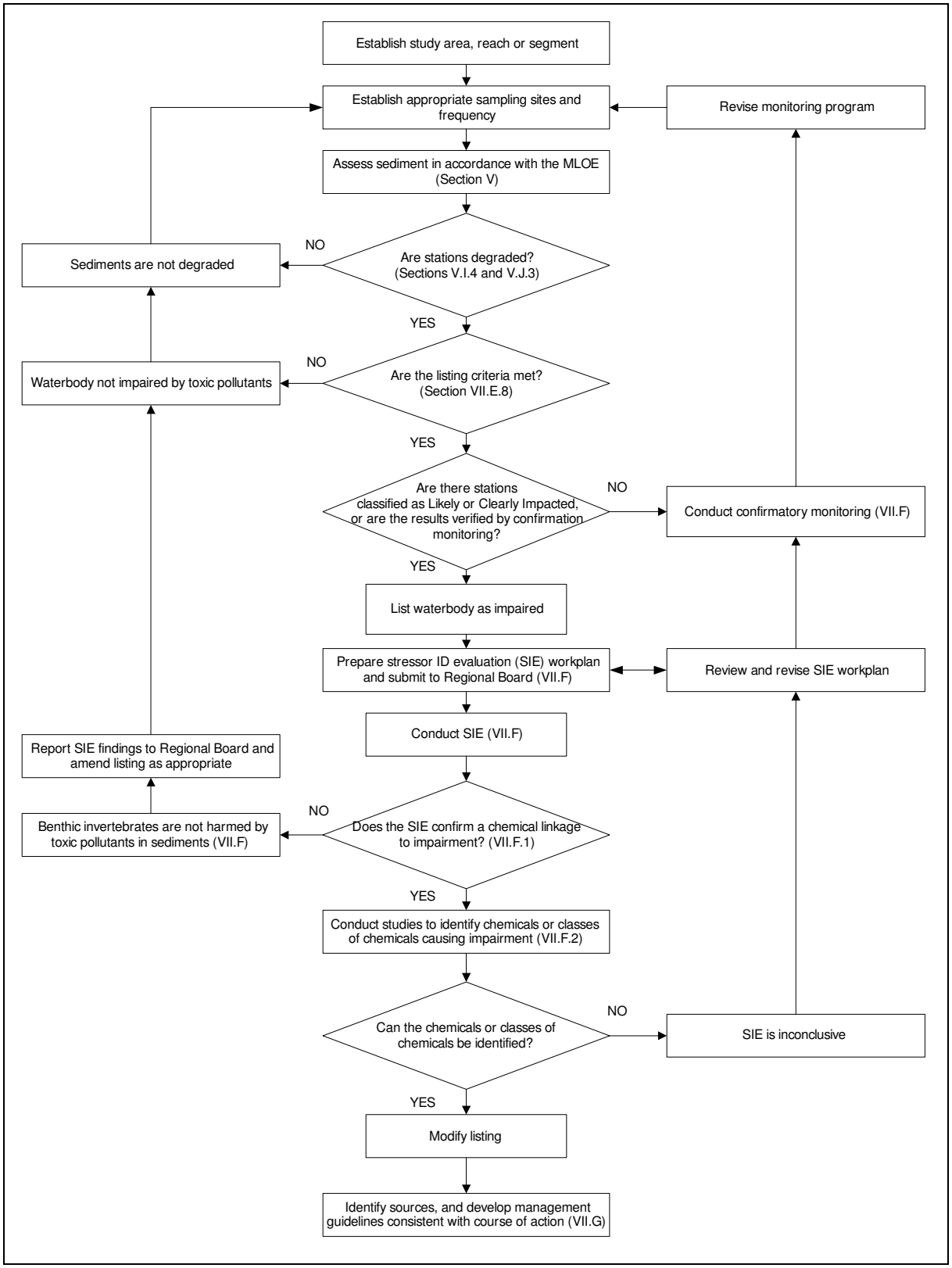

Figure 1. Waterbody Assessment Process



Figure 2. Point Source Assessment Process

Attachment A. List of chemical analytes needed to characterize sediment contamination exposure and effect.

Chemical Name	Chemical Group	Chemical Name	Chemical Group
Total Organic Carbon	General	Alpha Chlordane	Pesticide
Percent Fines	General	Gamma Chlordane	Pesticide
		Trans Nonachlor	Pesticide
Cadmium	Metal	Dieldrin	Pesticide
Copper	Metal	o,p'-DDE	Pesticide
Lead	Metal	o,p'-DDD	Pesticide
Mercury	Metal	o,p'-DDT	Pesticide
Zinc	Metal	p,p'-DDD	Pesticide
		p,p'-DDE	Pesticide
		p,p'-DDT	Pesticide
Acenaphthene	PAH	2,4'-Dichlorobiphenyl	PCB congener
Anthracene	PAH	2,2',5-Trichlorobiphenyl	PCB congener
Biphenyl	PAH	2,4,4'-Trichlorobiphenyl	PCB congener
Naphthalene	PAH	2,2',3,5'-Tetrachlorobiphenyl	PCB congener
2,6-dimethylnaphthalene	PAH	2,2',5,5'-Tetrachlorobiphenyl	PCB congener
Fuorene	PAH	2,3',4,4'-Tetrachlorobiphenyl	PCB congener
1-methylnaphthalene	PAH	2,2',4,5,5'-Pentachlorobiphenyl	PCB congener
2-methylnaphthalene	PAH	2,3,3',4,4'-Pentachlorobiphenyl	PCB congener
1-methylphenanthrene	PAH	2,3',4,4',5-Pentachlorobiphenyl	PCB congener
Phenanthrene	PAH	2,2',3,3',4,4'-Hexachlorobiphenyl	PCB congener
Benzo(a)anthracene	PAH	2,2',3,4,4',5'-Hexachlorobiphenyl	PCB congener
Benzo(a)pyrene	PAH	2,2',4,4',5,5'-Hexachlorobiphenyl	PCB congener
Benzo(e)pyrene	PAH	2,2',3,3',4,4',5-Heptachlorobiphenyl	PCB congener
Chrysene	PAH	2,2',3,4,4',5,5'-Heptachlorobiphenyl	PCB congener
Dibenz(a,h)anthracene	PAH	2,2',3,4',5,5',6-Heptachlorobiphenyl	PCB congener
Fluoranthene	PAH	2,2',3,3',4,4',5,6-Octachlorobiphenyl	PCB congener
Perylene	PAH	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	PCB congener
Pyrene	PAH	Decachlorobiphenyl	PCB congener

Attachment B. Station assessment category resulting from each possible MLOE combination

LOE Category Combination	Sediment Chemistry Exposure	Benthic Community Condition	Sediment Toxicity	Station Assessment
1	Minimal	Reference	Nontoxic	Unimpacted
2	Minimal	Reference	Low	Unimpacted
3	Minimal	Reference	Moderate	Unimpacted
4	Minimal	Reference	High	Inconclusive
5	Minimal	Low	Nontoxic	Unimpacted
6	Minimal	Low	Low	Likely unimpacted
7	Minimal	Low	Moderate	Likely unimpacted
8	Minimal	Low	High	Possibly impacted
9	Minimal	Moderate	Nontoxic	Likely unimpacted
10	Minimal	Moderate	Low	Likely unimpacted
11	Minimal	Moderate	Moderate	Possibly impacted
12	Minimal	Moderate	High	Likely impacted
13	Minimal	High	Nontoxic	Likely unimpacted
14	Minimal	High	Low	Inconclusive
15	Minimal	High	Moderate	Possibly impacted
16	Minimal	High	High	Likely impacted
17	Low	Reference	Nontoxic	Unimpacted
18	Low	Reference	Low	Unimpacted
19	Low	Reference	Moderate	Likely unimpacted
20	Low	Reference	High	Possibly impacted
21	Low	Low	Nontoxic	Unimpacted
22	Low	Low	Low	Likely unimpacted
23	Low	Low	Moderate	Possibly impacted
24	Low	Low	High	Possibly impacted
25	Low	Moderate	Nontoxic	Likely unimpacted
26	Low	Moderate	Low	Possibly impacted
27	Low	Moderate	Moderate	Likely impacted
28	Low	Moderate	High	Likely impacted
29	Low	High	Nontoxic	Likely unimpacted
30	Low	High	Low	Possibly impacted
31	Low	High	Moderate	Likely impacted
32	Low	High	High	Likely impacted
33	Moderate	Reference	Nontoxic	Unimpacted
34	Moderate	Reference	Low	Likely unimpacted
35	Moderate	Reference	Moderate	Likely unimpacted
36	Moderate	Reference	High	Possibly impacted
37	Moderate	Low	Nontoxic	Unimpacted
38	Moderate	Low	Low	Possibly impacted
39	Moderate	Low	Moderate	Possibly impacted
40	Moderate	Low	High	Possibly impacted
41	Moderate	Moderate	Nontoxic	Possibly impacted
42	Moderate	Moderate	Low	Likely impacted
43	Moderate	Moderate	Moderate	Likely impacted
44	Moderate	Moderate	High	Likely impacted

LOE Category Combination	Sediment Chemistry Exposure	Benthic Community Condition	Sediment Toxicity	Station Assessment
45	Moderate	High	Nontoxic	Possibly impacted
46	Moderate	High	Low	Likely impacted
47	Moderate	High	Moderate	Likely impacted
48	Moderate	High	High	Likely impacted
49	High	Reference	Nontoxic	Likely unimpacted
50	High	Reference	Low	Likely unimpacted
51	High	Reference	Moderate	Inconclusive
52	High	Reference	High	Likely impacted
53	High	Low	Nontoxic	Likely unimpacted
54	High	Low	Low	Possibly impacted
55	High	Low	Moderate	Likely impacted
56	High	Low	High	Likely impacted
57	High	Moderate	Nontoxic	Likely impacted
58	High	Moderate	Low	Likely impacted
59	High	Moderate	Moderate	Clearly impacted
60	High	Moderate	High	Clearly impacted
61	High	High	Nontoxic	Likely impacted
62	High	High	Low	Likely impacted
63	High	High	Moderate	Clearly impacted
64	High	High	High	Clearly impacted

CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

Office of Public Affairs: (916) 341-5254
Office of Legislative Affairs: (916) 341-5251
Office of the Ombudsman (916) 341-5254

P.O. Box 100, Sacramento, CA 95812-0100
www.waterboards.ca.gov

Water Quality information: (916) 341-5455
Water Rights information: (916) 341-5300
Financial Assistance information: (916) 341-5700

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARDS

NORTH COAST REGION (1)
www.waterboards.ca.gov/northcoast
5550 Skylane Blvd., Suite A
Santa Rosa, CA 95403
E-mail: info1@waterboards.ca.gov
(707) 576-2220 TEL • (707) 523-0135 FAX

SAN FRANCISCO BAY REGION (2)
www.waterboards.ca.gov/sanfranciscobay
1515 Clay Street, Suite 1400
Oakland, CA 94612
E-mail: info2@waterboards.ca.gov
(510) 622-2300 TEL • (510) 622-2460 FAX



CENTRAL COAST REGION (3)
www.waterboards.ca.gov/centralcoast
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San Luis Obispo, CA 93401
E-mail: info3@waterboards.ca.gov
(805) 549-3147 TEL • (805) 543-0397 FAX

LOS ANGELES REGION (4)
www.waterboards.ca.gov/losangeles
320 W. 4th Street, Suite 200
Los Angeles, CA 90013
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(213) 576-6600 TEL • (213) 576-6640 FAX

CENTRAL VALLEY REGION (5)
www.waterboards.ca.gov/centralvalley
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Redding, CA 96002
(530) 224-4845 TEL • (530) 224-4857 FAX

LAHONTAN REGION (6)
www.waterboards.ca.gov/lahontan
2501 Lake Tahoe Blvd.
South Lake Tahoe, CA 96150
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(530) 542-5400 TEL • (530) 544-2271 FAX

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COLORADO RIVER BASIN REGION (7)
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Palm Desert, CA 92260
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(760) 346-7491 TEL • (760) 341-6820 FAX

SANTA ANA REGION (8)
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3737 Main Street, Suite 500
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SAN DIEGO REGION (9)
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State of California
Arnold Schwarzenegger, Governor

California Environmental Protection Agency
Linda S. Adams, Secretary

State Water Resources Control Board
Charles R. Hoppin, Chair

Appendix B

Sediment Monitoring Plan QAPP

FINAL
APPENDIX B

SAN DIEGO COUNTY MUNICIPAL COPERMITTEES
SEDIMENT MONITORING
QUALITY ASSURANCE PROJECT PLAN

Prepared for:

County of San Diego Municipal Copermittees

Prepared by:

Weston Solutions, Inc.
5817 Dryden Place, Suite 101
Carlsbad, California 92008

November 2014

GROUP A:
PROJECT MANAGEMENT

ELEMENT 1 TITLE AND APPROVAL SHEET

Final

Appendix B

San Diego County Municipal Copermittees
Sediment Monitoring
Quality Assurance Project Plan

November 2014

APPROVAL SIGNATURES

San Diego County Copermittee:

Title	Name	Signature	Date
Senior Project Manager			
Project Manager			

Contractor:

Title	Name	Signature	Date
Contractor Sr. Project Manager			
Contractor Project Manager			
Contractor Quality Assurance Officer			

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LIST OF ACRONYMS

ASTM	American Society for Testing and Materials
Bight	Southern California Bight Regional Monitoring Program
BPJ	best professional judgement
CA EPA	California Environmental Protection Agency
CA LRM	California Logistic Regression Model
CEDEN	California Environmental Data Exchange Network
COC	chain of custody
Copermittees	San Diego County Regional Copermittees
CRM	certified reference materials
CSI	Chemical Score Index
CVAA	cold vapor atomic absorption
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DGPS	Differential Global Positioning System
DQO	data quality objective
DTSC	Department of Toxic Substances Control
EC_{50}	median effect concentration
EPA	Environmental Protection Agency
GC/ECD	gas chromatography/ electron capture detector
GC/MS	gas chromatography/ mass spectrometry
HDPE	high density polyethylene
ICP/MS	inductively coupled mass spectrometry
ID	inner diameter
LC_{50}	median lethal concentration
LCS	laboratory control sample
LOE	line(s) of evidence
$MgSO_4$	magnesium sulfate
MLOE	multiple lines of evidence
MS/MSD	matrix spike/matrix spike duplicate
MS4	municipal separate storm sewer system
OEHHA	Office of Environmental Health Hazard Assessment
PAHs	polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenyls
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RL	reporting limit
RPD	relative percent difference
RWQCB	Regional Water Quality Control Board
SCAMIT	Southern California Association of Marine Invertebrate Taxonomists
SRM	standard reference material
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
SIM	selective ion capture
SM	Standard Method

SOP	standard operating procedure
SP	solid phase
SQO	sediment quality objective
SWI	sediment water interface
TBD	to be determined
TOC	total organic carbon
USEPA	United States Environmental Protection Agency
WQIP	Water Quality Improvement Plan

Units of Measure

ppt	parts per thousand
ft	feet
m^2	square meters
L	liter
cm	centimeter
mm	millimeter
%	percent
mL	milliliter
^oC	degrees Celsius
kg	kilogram
mg	milligram
µg	microgram

ELEMENT 3 DISTRIBUTION LIST

Table 1 identifies those individuals who will receive one copy of the approved Sediment Monitoring Quality Assurance Project Plan (QAPP). (**NOTE:** This table should be completed by each San Diego County Regional Copermittee (Copermittee). The Titles and roles listed in the table can be expanded based on the monitoring and team assembled.)

Table 1. Quality Assurance Project Plan Distribution List

Title	Name (Affiliation)	Telephone No.	QAPP No.
San Diego County Copermittee Project Manager			01
Contractor Project Manager			02
Contractor Project Quality Assurance (QA) Officer			03
Contractor Field Task Manager			04
Laboratory Contractor Quality Assurance (QA) Officer			05

ELEMENT 4 PROJECT/TASK ORGANIZATION

Involved Parties and Roles

NOTE: This section detailing the specific roles of key individuals who will be conducting and managing the sediment monitoring project will have to be completed by each Copermittee. Text describing the roles played by key personnel should be followed by the contact information for these key individuals in a tabular format as shown in Table 2, and by an organizational chart. The Titles and roles listed in the table can be expanded based on the monitoring and team assembled.

Table 2. Key Personnel Responsibilities and Contact Information

Name	Organizational Affiliation	Title	Contact Information (telephone number, fax number and email address)
	San Diego County Copermittee	Project Manager	
	Contractor	Project Manager	
	Contractor	Field Task Manager	
	Contractor	QA Officer	
	Laboratory Contractor	QA Officer	

NOTE: Each Copermittee should complete an Organizational Chart to be placed here in Figure 1. An example is provided below. This chart should reflect the key individuals listed in Table 2.

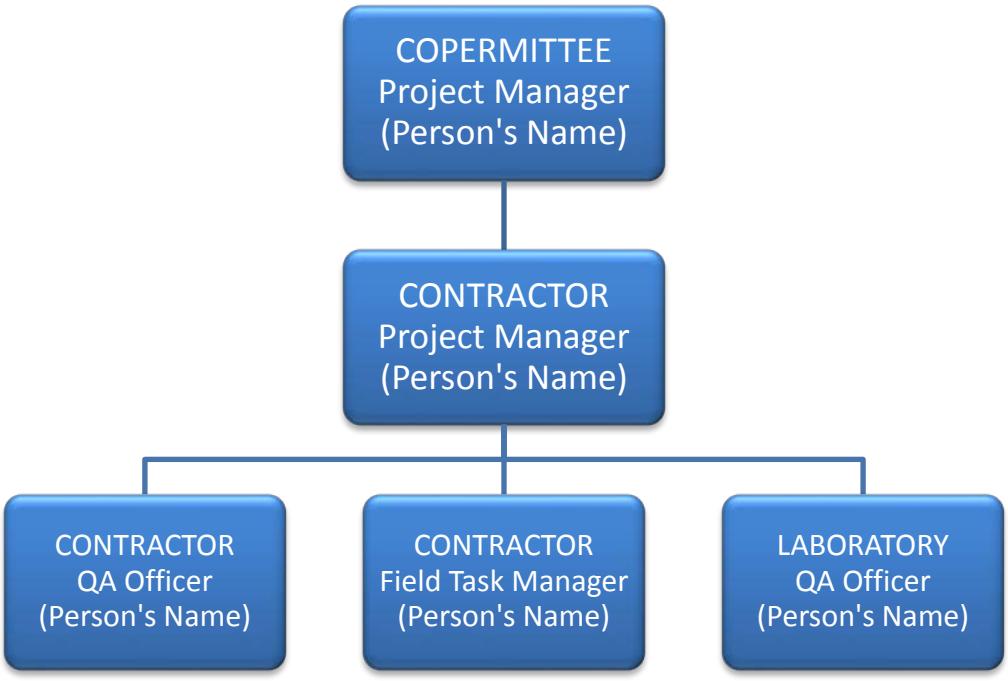

Figure 1. Organizational Chart

Quality Assurance Officer Role

The project Quality Assurance (QA) Officer will be responsible for the overall QA and quality control (QC) procedures found in this plan as part of the sampling and field analyses, laboratory analysis, and the overall quality of the data.

Persons Responsible for QAPP Update and Maintenance

Changes and updates to this QAPP may be made after a review of the evidence for change by the Contractor Project Manager and QA Officer with the concurrence of Copermittee Project Manager. The Contractor Project Manager, with input from the QA Officer, will be responsible for making the changes, submitting drafts for review by the Copermittee Project Manager, preparing a final amended copy, and submitting the final for signature. Project work must be halted while revisions to the QAPP are made, unless authorized by the Copermittee Project Manager.

ELEMENT 5 PROBLEM DEFINITION/BACKGROUND

Problem Statement

The Copermittees are required to conduct sediment quality monitoring in accordance with the requirements of the San Diego Regional Water Quality Control Board (RWQCB) Order No. R9-2013-0001 (Permit), effective June 27, 2013. The Copermittees are required, either individually, in association with multiple Copermittees, or through participation in a water body monitoring coalition to perform sediment quality monitoring to assess compliance with the sediment quality receiving water limits applicable to municipal separate storm sewer system (MS4) discharges to enclosed bays and estuaries. Urban runoff from the MS4 poses a risk to beneficial uses in receiving waterbodies. An understanding of the quality of sediments in relation to MS4 discharges is needed to direct and prioritize management actions.

Provision D.1.e.(2) of the Permit requires the Copermittees to develop a Sediment Monitoring Plan for incorporation into the Water Quality Improvement Plan (WQIP) which satisfies the requirements of the *Water Quality Control Plan for Enclosed Bays and Estuaries of California – Part I Sediment Quality* (Sediment Control Plan; State Water Quality Control Board [SWRCB] and California Environmental Protection Agency [CA EPA], 2009; see Appendix A). This QAPP supports the Sediment Monitoring Plan by describing the sampling, analysis, and quality assurance procedures that are needed to comply with Permit-required sediment quality monitoring.

Decisions or Outcomes

The primary objective of the sediment monitoring program is to assess compliance with the sediment quality receiving water limits applicable to MS4 discharges to enclosed bays and estuaries of San Diego County. Sediment toxicity, chemistry, and benthic community condition will be assessed using SQOs as described in the Sediment Monitoring Plan. The goals of the SQOs are to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in marine organisms to levels that may be harmful.

The goal of the Sediment Monitoring Plan and Sediment Monitoring QAPP is to provide the key elements that are required to successfully conduct field sediment sampling, processing, testing, and analysis of the results in accordance with SQO guidelines. Analyses of chemistry, toxicity, and benthic community condition require that samples be collected, preserved, processed, and analyzed using proper field and laboratory equipment, methods, and techniques. The Sediment Monitoring Plan and Sediment Monitoring QAPP describe the collection and analysis of surface sediment samples necessary to provide representative assessments of in-situ conditions for the enclosed bays and estuaries of San Diego County. By adhering to SQO protocols, sediment quality in subtidal marine and estuarine habitats can be assessed as to whether it is protective of aquatic life and human health.

ELEMENT 6 PROJECT/TASK DESCRIPTION

Work Statement and Produced Products

The San Diego County Regional Copermittees (Copermittees) are required to conduct sediment quality monitoring in accordance with the requirements of the *Water Quality Control Plan for Enclosed Bays and Estuaries of California – Part I Sediment Quality* (Sediment Control Plan; SWRCB and CA EPA, 2009; see Appendix A). The Sediment Control Plan outlines a multiple lines of evidence (MLOE) approach to determine whether pollutants in sediments are present in quantities that are toxic to benthic organisms and/or will bioaccumulate in marine organisms to levels that may be harmful to humans. Sediment monitoring will be conducted at least twice during the Permit cycle except at stations that have consistently been classified as Unimpacted or Likely Unimpacted using the MLOE approach. At the Unimpacted or Likely Unimpacted stations, monitoring may be reduced to a frequency of once during the Permit cycle. Sediment samples will be analyzed for toxicity, chemistry, and benthic infauna at a designated number of stations (station selection is outlined in ELEMENT 10) within a waterbody. An SQO analysis will be conducted on each station to determine a final station assessment that indicates whether the aquatic life SQO has been met. Depending on the outcome of the SQO assessments at the designated stations located in San Diego County waterbodies, follow-up monitoring may be necessary to meet all of the Permit requirements. Upon completion of the sediment quality monitoring, a Sediment Monitoring Report will be incorporated into the WQIP Annual Report. An additional stressor identification study may be required by the San Diego RWQCB for stations not meeting SQOs.

Provision D.1.e.(1)(a) of the Permit also requires the Copermittees to participate in the Southern California Bight Regional Monitoring Program. Participation in the Bight Program can be used to simultaneously fulfill all or part of the sediment quality monitoring requirement (Provision D.1.e[2]) because sediment monitoring and SQO analyses are incorporated into the Bight Program to regionally assess the sediment quality of Southern California's waterbodies. The Copermittees can also decide to conduct the initial sediment quality monitoring of San Diego County's water bodies independently of the Bight Program. Depending upon the outcome of the initial SQO assessments, the Copermittees may need to perform follow-up monitoring to meet all of the Permit requirements.

Constituents to be Monitored and Measurement Techniques

Chemical and toxicity analyses of all sediment samples collected as part of the SQO assessment must be tested in accordance with United States Environmental Protection Agency (USEPA) or American Society for Testing and Materials (ASTM) protocols. If appropriate protocols do not exist, the SWRCB or San Diego RWQCB may approve the use of other methods. All analytical laboratories must be certified by the California Department of Health Services in accordance with Water Code 13176.

Physical and chemical measurements of sediment were selected to comply with the Sediment Control Plan and to provide data on chemicals of potential concern in bays and estuaries located in San Diego County. The physical and chemical analyses of sediments will include, at a minimum, grain size, percent solids, total organic carbon (TOC), trace metals, organochlorine pesticides,

polychlorinated biphenyl (PCBs) congeners, and polynuclear aromatic hydrocarbons (PAHs). Chemical analyses of these constituents are necessary in order to compare to the California Logistic Regression Model (CA LRM) and the Chemical Score Index (CSI) for SQO analyses. Additional physical or chemical analyses may be included in order to aid in the interpretation of the individual lines of evidence (LOEs) (e.g. pyrethroids or ammonia).

Sediment toxicity testing will be performed for each station using a minimum of one short-term survival toxicity test and one sublethal toxicity test. Acceptable short-term sediment survival tests include the *Eohaustorius estuarius* 10-day survival test, the *Leptocheirus plumulosus* 10-day survival test, or the *Rhepoxynius abronius* 10-day survival test. Acceptable sublethal sediment toxicity tests include the the *Mytilus galloprovincialis* sediment-water interface (SWI) 48-hour embryo development test or the *Neanthes arenaceodentata* whole sediment 28-day growth test. The *E. estuarius* short-term survival test and the *M. galloprovincialis* sublethal toxicity test have been the test methods used in previous San Diego County bay and estuary monitoring programs including the Bight program where the SQO analytical tool was used to assess aquatic health.

Benthic community condition samples will be screened by field personnel and then sorted and identified to the lowest possible taxon by qualified taxonomists in accordance with the most recent version of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) taxonomic listing for nomenclature and orthography.

For the purposes of this QAPP, the constituent list for chemical analyses includes only those analytes that are required for compliance with SQO analyses and physical analyses that will aid in the interpretation of the SQO data. Analytical physical and chemistry methods provided in Table 3 are suggested methods that have been used in previous sediment monitoring programs within San Diego County's waterbodies (e.g. Bight), but are not the only acceptable methods. A detailed list of individual analytes is provided in Element 13.

Table 3. Analyte list and Suggested Testing Methods for SQO analyses

Analyte/ Test	Method
Physical Analyses	
Grain size	Plumb 1981 or use of a Horiba LA920 (Laser Particle Analyzer)
Percent solids	SM 2540B
TOC	USEPA 9060A
Chemical Analyses	
Trace Metals	USEPA 6020A (Mercury- 7471B)
Oganochlorine pesticides	USEPA 8081B
PCB congeners	USEPA 8082A
PAHs	USEPA 8270D
Toxicity	
Short-term amphipod survival using *Eohaustorius estuarius*	USEPA (1994) *Methods for Assessing Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods,* ASTM E1367-03
Sublethal testing using *Mytilus galloprovincialis*	USEPA (1995) *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms;* Anderson et al. (1996) *Assessment of Sediment Toxicity at the Sediment-Water Interface*
Sublethal testing using *Neanthes arenaceodentata*	ASTM E1562 with modifications described in Farrar and Bridges (2011)
Benthic Infauna	
Benthic Community Condition	See Element 13

Short-term survival toxicity testing will be performed in accordance with procedures for amphipod testing outlined in *Methods for Assessing Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods* (USEPA, 1994) and ASTM method E1367-03 (ASTM, 2006). Sublethal sediment toxicity testing for *Mytilus galloprovincialis* should follow procedures outlined in *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms* (USEPA, 1995) and *Assessment of Sediment Toxicity at the Sediment-Water Interface* (Anderson et al., 1996), whereas sublethal sediment toxicity testing for *Neanthes arenaceodentata* should follow ASTM method E1562 (ASTM, 2002) with modifications described in Farrar and Bridges (2011) that have been found to contribute manageability and precision to the ASTM procedure.

SQO Analyses

Protocols for assessing sediment chemistry, toxicity, and benthic community conditions for San Diego County waterbodies using California's SQOs are described in Section 3.2 of the Sediment Monitoring Plan.

Project Schedule

The schedule for completing the sediment quality monitoring requirements of the Permit and for submitting the Sediment Monitoring Report is shown in Table 4.

Table 4. Sediment Monitoring Program Schedule

Activity/Deliverable	Dates(s)*
San Diego RWQCB Order No. R9-2013-0001	Adopted May 8, 2013 and effective June 27, 2013
Southern California Bight Regional Monitoring Program	August-September 2013
Follow-up confirmation monitoring	August-September 2014
Final Sediment Monitoring Plan and Sediment Monitoring QAPP incorporated into WQIPs	December 2014
Draft Sediment Monitoring Report	December 2014
Final Sediment Monitoring Report incorporated into Transitional Monitoring and Assessment Report	January 31, 2015
Potential Stressor ID Studies	TBD

*Table does not include future permit cycles

The Sediment Monitoring Plan and Sediment Monitoring QAPP will be incorporated into the WQIPs in December of 2014. The San Diego County Regional Copermittees participated in the 2013 Bight Program and conducted follow-up monitoring in 2014 to satisfy Provisions D.1.e.(1)(b) and D.1.e.(2) of the Permit prior to the Sediment Monitoring Plan. Monitoring was conducted in accordance with *San Diego County Municipal Copermittees Bight 2013 Workplan* (WESTON, 2013) and data were collected using methods consistent with previous Bight surveys and the current SQO guidelines as described in with Sediment Control Plan. Follow-up confirmation monitoring was conducted in 2014 in accordance with the *San Diego County Municipal Copermittees 2014 Sampling and Analysis Plan for Bight '13 Follow-up Investigations* (WESTON, 2014). Since the WQIPs are still in development and there will be no WQIP Annual Reports in 2015, the Copermittees will include the Sediment Monitoring Report with the Transitional Monitoring and Assessment Report due to the San Diego RWQCB on January 31, 2015. The Sediment Monitoring Report will include the results from the 2013 Bight Program and any follow-up monitoring collected in 2014. Additional sediment quality monitoring or stressor identification studies conducted after 2014 will be included in the WQIP Annual Reports.

Constraints

Sediment monitoring must occur in subtidal areas located within a waterbody between the months of June through September. SQOs have been fully developed for only two of California's six enclosed bay habitats: euhaline (salinity = 25 to 32 parts per thousand [ppt]) bays and estuaries south of Point Conception and polyhaline (18 to 25 ppt) central San Francisco Bay. The benthic species assemblage used to calculate the benthic LOE in San Diego bays and estuaries is Habitat C-Southern California Marine Bays, which requires a salinity greater than 27 ppt (Bay et al 2014; Ranasinghe et al 2008). In order to select a sampling station applicable to the SQO assessment using Habitat C for the benthic LOE, it is recommended to verify that a proposed sampling station is both subtidal and has salinity greater than 27 ppt. Salinity measurements should be taken near the sediment-water interface. Sediment samples will be collected with a 0.1 m^2 Van Veen grab sampler or other similar device. Certain types of benthic habitat such as hard clay, cobble, coarse sand, and areas with thick eel grass may be difficult to sample using this type of device. A slight relocation of the target sampling location may be necessary to avoid areas in which obtaining acceptable grab samples is not achievable.

Nesting periods for threatened or endangered bird species inhabiting coastal water bodies may prevent or delay sampling during certain summer months. Species of particular concern include least terns, snowy plovers, California clapper rails, and Belding's savannah sparrows. Permission from California Fish and Wildlife may be required to enter restricted areas that are known to contain these species. Additionally permission from private land owners may be necessary to gain access to private property and/or private boat launches.

ELEMENT 7 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

All quality assurance/quality control (QA/QC) data for chemistry and toxicity samples must be conducted in accordance with the QAPP for the State of California's Surface Water Ambient Monitoring Program (SWAMP) (SWAMP Quality Assurance Team, 2008). The data quality objectives (DQOs) are summarized by category in Table 5. If sediment quality monitoring is conducted as part of the Bight Program (i.e. SQO analysis as stated in the Sediment Control Plan), the work plans and associated QA/QC documents pertaining to the Bight Program should be followed in conjunction with this QAPP.

Table 5. Summary of Data Quality Objectives

Measurement or Analysis Type	Applicable Data Quality Objective
Chemistry Laboratory Analyses	Accuracy, precision, and completeness
Toxicity Laboratory Analyses	Precision and completeness
Benthic Infauna Analyses	Accuracy and completeness

Acceptance criteria will be based on the implementation of acceptable and recognized QA/QC procedures. Acceptable data must have proper sample collection and handling methods, sample preparation and analytical procedures, holding times, stability issues, and QA protocols.

Accuracy is a measure of how closely the analytical result or field measurement represents the true quantity found in the sample. Evaluation of the accuracy of laboratory samples will be achieved through the preparation and analysis of either reference materials (e.g. certified or standard reference materials [CRM/SRM]) or laboratory control samples [LCS]) with each analytical batch. For sediment toxicity samples, the accuracy of sediment toxicity tests cannot be determined since a reference material of known toxicity is not available. The accuracy of benthic infaunal sorting will be evaluated via a QA/QC procedure that ensures a 95% sorting efficiency of each sample.

Precision is the measure of agreement among repeated measurements of the same property under identical or substantially similar conditions calculated as either the range or as the standard deviation. The precision of chemistry laboratory measurements will be controlled by comparison of the sample to either a laboratory duplicate or a laboratory matrix spike/matrix spike duplicate (MS/MSD). For toxicity samples, a water only reference toxicant test will be run with every batch of test samples in order to document organism relative sensitivity and test precision. Reference toxicant test results that fall outside of control chart limits (2 standard deviations of the mean) will trigger a review of test procedures and a possible retest of the corresponding sediment samples. A negative control will be run with each test batch for both the short term survival and sublethal toxicity tests.

Completeness is a measure of the percentage of sample results that are collected and analyzed and determined to be valid. A goal of 90% completeness exists for each measurement process. Completeness will be assessed in all chemistry samples with qualifiers indicating the reasons for any samples that did not meet acceptance criteria. All toxicity tests will be run with toxicity control

tests to assess validity of the toxicity test results. Benthic infauna samples that do not meet acceptance criteria will be re-sorted.

"Representative" is a qualitative term that expresses "the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition" (ANSI/ASQC, 1994). Best professional judgement (BPJ) will be used in the field to evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied. Sample selection and use of approved/documented analytical methods will control to the best extent possible that the measurement data represent the conditions at the investigation site.

Quality control samples and data quality objectives for analyzing chemistry and toxicity samples collected as part of the sediment monitoring program must be conducted in accordance with the QAPP for the State of California's SWAMP (SWAMP Quality Assurance Team, 2008) if SWAMP quality objectives are available. The quality objectives are outlined in Table 6 through Table 8. Depending on the physical or chemical analysis of the sediment samples, the following QA/QC sample types may be required to be included in the analytical run:

- A laboratory blank to determine the likelihood of contamination in the samples.
- A laboratory duplicate sample to estimate the precision of the results through the calculation of the relative percent difference (RPD) between the sample and the duplicate sample.
- A certified or standard reference material to determine the accuracy of the analyses.
- A matrix spike to determine if interference has occurred between the sample matrix and the analysis of the target analyte.
- A surrogate compound to estimate losses of the target analyte during the sample extraction phase and analysis of the sample (for organic measurements only).

SWAMP quality control measurements for toxicity testing of marine sediments are provided in Table 7. It should be noted that these SWAMP measurements currently only apply for the short term 10-day survival test using *Eohaustorius estuariu*s. SWAMP is developing quality guidelines for *Mytilus galloprovincialis*; however, they are not currently available. It is recommended that quality control measurements for the other test species use the same guidelines listed in Table 7. For the SQO analysis, quality assurance recommendations for toxicity testing are also provided in the Sediment Quality Assessment Technical Support Manual (Bay et al., 2014).

Table 6. Frequency of Chemistry Analysis for Laboratory Quality Assurance/Quality Control Samples

Analysis Type	Laboratory Blanks	Laboratory Duplicate	SRM or LCS[1]	Matrix Spikes	Matrix Spike Duplicates	Surrogate
Total solids	1 per analytical batch	1 per analytical batch	N/A	N/A	N/A	N/A
Total organic carbon	1 per analytical batch	1 per analytical batch	1 per 20 samples or 1 per analytical batch, whichever is more frequent	N/A	N/A	N/A
Grain size	N/A	1 per analytical batch	N/A	N/A	N/A	N/A
Trace Metals	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	N/A
Organochlorine Pesticides	1 per 20 samples or 1 per analytical batch, whichever is more frequent	N/A	1 per 20 samples or 1 per analytical batch	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	Included in all samples and all QC samples
PCB Congeners	1 per 20 samples or 1 per analytical batch, whichever is more frequent	N/A	1 per 20 samples or 1 per analytical batch	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	Included in all samples and all QC samples
PAHs	1 per 20 samples or 1 per analytical batch, whichever is more frequent	N/A	1 per 20 samples or 1 per analytical batch	1 per 20 samples or 1 per analytical batch, whichever is more frequent	1 per 20 samples or 1 per analytical batch, whichever is more frequent	Included in all samples and all QC samples

LCS = Laboratory control sample

N/A = not applicable

SRM = standard reference material

[1] When a Standard Reference Material is not available, an LCS will be analyzed.

Table 7. Quality Control Measurements for Sediment Toxicity Testing

QC Control	Frequency of Analysis and Control Limits
Negative Controls Laboratory Control Water	Laboratory Control water consistent with Section 7 of appropriate EPA method/manual must be tested with each analytical batch/ Laboratory control water must meet all test acceptability criteria for the species of interest.
Negative Controls Conductivity/Salinity Control Water	A conductivity or salinity control must be tested when these parameters are above or below the species tolerance/ Follow EPA guidance on interpreting data.
Negative Controls Additional Control Water	Additional method blanks are required whenever manipulations are performed on one or more of the ambient samples within each analytical batch/ There must be no statistical difference between the laboratory control water and each additional control water within an analytical batch.
Negative Controls Sediment Control	Sediment control consistent with Section 7 of the appropriate EPA method/manual must be tested with each analytical batch of sediment toxicity tests/ Sediment control must meet all data acceptability criteria for the species of interest.
Positive Controls Reference Toxicant Tests	Reference toxicant tests must be conducted monthly for species that are raised within a laboratory, or per analytical batch for commercially-supplied or field-collected species/ Last plotted data point (LC50 or EC50) must be within 2 SD of the cumulative mean (n=20). Reference toxicant tests that fall outside of recommended control chart limits are evaluated to determine the validity of associated tests. An out of control reference toxicant test result does not necessarily invalidate associated test results. More frequent and/or concurrent reference toxicant testing may be advantageous if recent problems have been identified in testing.
Sample Duplicate	5% of total project sample count/ Recommended acceptable RPD<20%

[1] SWAMP quality control measurements currently only apply for marine sediment toxicity testing for the 10-day survival *Eohaustorius estuarius* test. SWAMP is in the process of developing guidelines for the *Mytilus galloprovincialis* 48-hr SWI test.

Table 8. Data Quality Objectives for Laboratory Measurements

Group	Parameter	Accuracy	Precision	Completeness
Sediment Samples				
Laboratory analyses	Total Solids	N/A	Laboratory duplicate RPD < 25%	90%
Laboratory analyses	TOC	Laboratory Blank <RL or <30% of lowest sample; SRM or LCS with 80–120% recovery of true value	Laboratory duplicate RPD < 25%	90%
Laboratory analyses	Grain Size	N/A	Laboratory duplicate RPD < 25%	90%
Laboratory Analyses	Trace Metals	Laboratory Blank< RL for target analyte; SRM or LCS 75-125% recovery	Laboratory duplicate, MSD RPD < 25%; MS/MSD 75-125% recovery	90%
Laboratory Analyses	Organochlorine Pesticides	Laboratory Blank< RL for target analyte; SRM 70-130% recovery if certified, otherwise 50-150% recovery; if using LCS 70-130% recovery	MSD RPD < 25%; MS/MSD 50-150% recovery or based on historical laboratory control limits (average ±3SD); surrogates based on historical lab control limits (50-150% or better)	90%
Laboratory Analyses	PCB Congeners	Laboratory Blank< RL for target analyte; SRM 70-130% recovery if certified, otherwise 50-150% recovery; if using LCS 70-130% recovery	MSD RPD < 25%; MS/MSD 50-150% recovery or based on historical laboratory control limits (average ±3SD); surrogates based on historical lab control limits (50-150% or better)	90%
Laboratory Analyses	PAHs	Laboratory Blank< RL for target analyte; SRM 70-130% recovery if certified, otherwise 50-150% recovery; if using LCS 70-130% recovery	MSD RPD < 25%; MS/MSD 50-150% recovery or based on historical laboratory control limits (average ±3SD); surrogates based on historical lab control limits (50-150% or better)	90%

Table 8. Data Quality Objectives for Laboratory Measurements

Group	Parameter	Accuracy	Precision	Completeness
Toxicity Samples				
Toxcity Testing	Short-term 10-day Amphipod Survival Tests	N/A	Reference toxicity testing; test results within 2 standard deviations of the mean are re-evaluated.	90%
Toxicity Testing	Sublethal Sediment Toxicity Tests	N/A	Reference toxicity testing; test results within 2 standard deviations of the mean are re-evaluated.	90%
Benthic Infauna Samples				
Benthic Infauna	Benthic Infaunal Sorting	95% sorting efficiency	N/A	90%

ELEMENT 8 SPECIAL TRAINING NEEDS/CERTIFICATION

Specialized Training or Certifications

Field Sampling

Field personnel will have current and relevant experience in the aspects of standard field monitoring, including use of relevant field equipment such as boats, field instruments, and monitoring equipment. Field personnel will also have been trained and have experience in the collection and handling of samples, and chain-of-custody (COC) procedures. Training will be reviewed in proper field sampling and sample-handling techniques prior to sampling and only those staff with proficiency will be permitted to conduct field work.

Analytical Laboratory

All analytical tests including chemistry and toxicity will be conducted by laboratories certified by the California Department of Health Services in accordance with Water Code Section 13176.

Training and Certification Documentation

Personnel are responsible for complying with QA/QC requirements that pertain to their organizational/technical function. Each technical staff member must have a combination of experience and education to adequately demonstrate a specific knowledge of their particular function and a general knowledge of laboratory operations, test methods, QA/QC procedures, and records management.

Field Sampling

Field personnel training will be documented and records kept in the project files at each organization's offices.

Analytical Laboratory

Training documents for each subcontracting laboratory will be detailed in the individual QAPPs for each laboratory.

Training Personnel

The Project Manager and/or Field Task Manager will provide training for field personnel in proper field sampling techniques prior to work initiation to ensure consistent and appropriate sampling, sample handling/storage, and COC procedures.

ELEMENT 9 DOCUMENTS AND RECORDS

Each Copermittee or their subcontractor(s) will document and track the aspects of the sample collection process, including generating field logs at each site and COC forms for the samples collected. COC forms will accompany samples to the appropriate laboratory for analysis. Each laboratory will document and track the aspects of receipt and storage, analyses, and reporting related to their respective samples.

A database of information collected during the sediment monitoring will be maintained by each Copermittee or their subcontractor(s). The database will include field observations, data sheets, COC records, and analytical results. The original data sheets, statistical worksheets, and reports produced will be accumulated into project-specific files maintained in file cabinets following submittal of the draft report. Data from outside contractors will be kept exactly as received. Monitoring data and analytical results will be uploaded into California Environmental Data Exchange Network (CEDEN).

Persons responsible for maintaining records for this project will be specified by the project manager and will be tasked with overseeing the operations of the project, and maintaining the sample collection, sample transport, COC, field analysis forms, and laboratory data. They will also be responsible for arbitrating any issues relative to records retention and any decisions to discard records.

Copies of this QAPP will be distributed to all parties identified previously in Element 3. Updates to this QAPP will be distributed in like manner, and previous versions will be discarded from the project file. The Project Manager under the direction, supervision, and review of the QA Officer, will be responsible for distributing an updated version of the QAPP.

Copies of the final report, including laboratory results and field records, will be maintained for a minimum of five years after project completion.

GROUP B:
DATA GENERATION AND ACQUISITION

ELEMENT 10 SAMPLE PROCESS DESIGN

Station Selection

NOTE: It is recommended that each Copermittee list under this section the waterbodies they are responsible for by WMA.

The selection of suitable station locations is critical to assessing benthic conditions. Justification for selecting locations for sediment sampling is provided in Section 2.1.1 of the Sediment Monitoring Plan. The Sediment Control Plan does not give guidance as to how many stations should be sampled in each waterbody. The number of sampling stations will vary within each San Diego County waterbody based on the spatial extent of the area likely to be impacted. If the Bight Program is utilized to fulfill the Sediment Quality Monitoring requirement of the Permit, then the number of stations within each San Diego County waterbody will be dictated by the Bight Program. If a stressor identification study becomes necessary following the original SQO assessment of a waterbody, then the number of stations will be based upon the drivers of the impacted scores (e.g. algae, physical factors, or chemical factors) and statistical power (i.e., having enough samples to statistically support meaningful findings).

All station locations will be pre-plotted prior to sampling activities. Locations will be identified in the field using a Differential Global Positioning System (DGPS). The system uses U.S. Coast Guard differential correction data, and is accurate within 10 feet (ft). All final station locations will be recorded in the field using positions from the DGPS.

In the event that a pre-plotted sample location is found to be unsuitable for collecting sediment, because of factors such as inaccessibility, the salinity does not meet the SQO criteria, disturbance to wildlife, or safety considerations, the station may be abandoned and an alternate station may be selected. Reasons for abandonment should be recorded on field data sheets.

Monitoring Season and Frequency

Sediment for SQO programs must be collected between June and September. Physical environments and benthic community composition and abundance within enclosed bays and estuaries are generally most stable during this time of year (Bay et al., 2014).

According to Section VII.D of the Sediment Control Plan, sediment monitoring associated with Phase I stormwater discharges and major discharges shall be conducted at least twice during the Permit cycle except at stations that have consistently been classified as Unimpacted or Likely Unimpacted using the MLOE approach described in Section 3.2 of the Sediment Monitoring Plan. At the Unimpacted or Likely Unimpacted stations, monitoring may be reduced to a frequency of once during the Permit cycle. The San Diego RWQCB may also limit receiving water monitoring to a subset of outfalls to focus where the risk to sediment quality is greatest.

ELEMENT 11 SAMPLING METHODS

Sediment Sampling

Information regarding the sampling vessel and site acceptability are provided in Sections 2.1.4 and 2.1.5 of the Sediment Monitoring Plan. Benthic sediments will be collected as surface grabs using an appropriate sampler, such as a stainless steel Van Veen grab sampler. The size of the grab sampler to be used for sediment programs in Southern California should be 0.1 m^2 across the top of the sampler. An appropriate sampler for the collection of benthic sediments will have the following characteristics:

- Constructed of a material that does not introduce contaminants.
- Causes minimal surface sediment disturbance.
- Does not leak or mix during sample retrieval.
- Has a design that enables safe/easy sample verification that samples meet all applicable sampling criteria (e.g., collects sediments to at least 5 centimeters (cm) below the sediment surface, has access doors allowing visual inspection and removal of undisturbed surface sediment).

Sediment grabs will be collected for the following analyses: benthic infauna, chemistry, grain size, and toxicity. A sample will be considered acceptable if the surface of the grab is even, there is minimal surface disturbance, and there is a penetration depth of at least 7 cm. Rejected grabs will be discarded, and the station will be re-sampled. Acceptable sediment grabs to be utilized for chemistry, grain size, and toxicity analyses will have the overlying water carefully drained from the sediment surface prior to removing the sediment to be placed in the appropriate sample containers. Overlying water will not be drained from sediment samples collected for benthic infaunal analysis. Station location and grab event data will be recorded on pre-formatted field data sheets (hard copies or via computer). At a minimum, field data will include station identification, station location, date, time of sample collection, depth of water, depth of penetration of grab in sediment (e.g. 5 cm), sediment composition, sediment odor and color, and sample type (e.g. sediment chemistry). It is recommended that photographs of each sediment sample be taken and stored.

The entire contents of one grab sample will be utilized for benthic community analyses with a minimum penetration depth of 7 cm. Samples collected for benthic infaunal analysis will be rinsed through a 1.0-millimeter (mm) mesh screen. The material retained on the screen will be transferred to a labeled glass or plastic sample container. A 7% magnesium sulfate ($MgSO_4$) seawater solution will be added to the sample container to 85-90% of its volume to relax the collected specimens. The sample container will be inverted several times to distribute the relaxant solution. After 30 minutes, add enough sodium borate buffered formaldehyde to top off the sample container and gently invert the container several times to ensure the sample is mixed. This will make a 10% formalin solution.

Sediment samples for chemistry and toxicity testing will be collected from the top 5 cm of a grab sample using a pre-cleaned stainless steel scoop. Sediment within 1 cm of the sides of the grab

will be avoided to prevent interaction of any contaminants and the steel sampling device. For chemistry and grain size analysis, equal portions of sediment will be aliquoted from a single grab and placed into the appropriate samples containers. The sediment aliquots will be representative of the entire 5 cm depth of the surface sediment. According to the Sediment Control Plan, the preferred method of collection for SWI toxicity tests is to collect intact cores directly from the sediment sampler by pressing polycarbonate core tubes (7.3-cm inner diameter [ID] and 16 cm in length) into the top 5 cm of sediment. However, homogenizing sediment for SWI testing is also acceptable according to the Sediment Control Plan. This method is more practical to implement in the field and is consistent with previous sediment quality objective methodology (e.g., Bight protocols and previous lagoon monitoring implemented by the Copermittees). A stainless steel scoop will be used to remove aliquots of the top 5 cm of surface sediment from two grab samples and evenly distributed into the appropriate toxicity sample container(s) until the necessary volume is reached.

All sampling equipment will be cleaned prior to sampling. Between sampling locations, grab sampling equipment will be scrubbed with a brush and rinsed with site water. Stainless steel scoops will be rinsed with seawater and rinsed with de-ionized water between stations. Clean gloves will be worn by sampling personnel at each new station.

ELEMENT 12 SAMPLE HANDLING CUSTODY

Sediment samples will be uniquely identified with sample labels in indelible ink. All sample containers will be identified with the project title, appropriate identification number, date and time of sample collection, and preservation method. All samples will be kept on wet ice from the time of sample collection until delivery or transport to the analytical laboratory. All samples will be transferred to the appropriate laboratory and analyses initiated within the method specified holding time (Table 9). Sample volumes required for each analysis will be dictated by the analytical laboratory conducting the analyses.

Table 9. List of Analytes with Container Type, Holding Time, and Preservation Method

Analyte	Recommended Container Type	Required Holding Time	Recommended Preservation
Field Measurements			
Salinity (conductivity & temperature if using a YSI sonde)	*In situ*		
Depth			
Sediment Chemistry			
Total Solids	Glass jar	7 days	Cool to ≤6 °C
Total Organic Carbon	Glass jar	28 days at ≤6 °C; 1 year at ≤- 20°C	Cool to ≤6 °C or freeze to ≤ -20°C
Grain Size	HDPE, Glass jar, or plastic bag	1 year	Wet ice to ≤6 °C in the field, then refrigerate at ≤6 °C
Trace Metals	Glass jar	1 year; samples must be analyzed within 14 days of collection or thawing	Cool to ≤6 °C within 24 hours, then freeze to ≤-20°C
Organochlorine Pesticides	Glass jar	1 year; samples must be extracted within 14 days of collection or thawing and analyzed within 40 days of extraction	Cool to ≤6 °C within 24 hours, then freeze to ≤-20°C
PCB Congeners	Glass jar	None	Cool to ≤6 °C within 24 hours, then freeze to ≤-20°C
PAHs	Glass jar	1 year; samples must be extracted within 14 days of collection or thawing and analyzed within 40 days of extraction	Cool to ≤6 °C within 24 hours, then freeze to ≤-20°C
Sediment Toxicity			
Toxicity Testing	10L Polyethylene bag or 1-L glass jar	1 month	Wet ice then 4°C for transport; 4°C for storage
Benthic Infauna			
Benthic Community Condition	1-L HDPE or 1-L Glass jar – sample volume will vary so may need multiple jars per sample	Formalin: 2-5 days 70% Ethanol: Indefinite-sample jars should be periodically checked for evaporation of ethanol	Initially samples are placed in 10% Buffered Formalin for 2-5 days; samples are then transferred to 70% ethanol

Chain-of-Custody Procedures

Samples will be considered to be in custody if they are (1) in the custodian's possession or view, (2) retained in a secured place (under lock) with restricted access, or (3) placed in a container and secured with an official seal such that the sample could not be reached without breaking the seal. The principal documents used to identify samples and to document possession will be COC records, field logbooks, and field tracking forms. COC procedures will be used for samples throughout the collection, transport, and analytical process.

COC procedures will be initiated during sample collection. A COC record will be provided with each sample or group of samples. Each person who will have custody of the samples will sign the form and ensure the samples will not be left unattended unless properly secured. Documentation of sample handling and custody includes the following:

- Sample identifier.
- Sample collection date and time.
- Any special notations on sample characteristics or analysis.
- Initials of the person collecting the sample.
- Date the sample was sent to the analytical laboratory.
- Shipping company and waybill information.

Completed COC forms will be placed in a plastic envelope and kept inside the cooler containing the samples. Once delivered to the analytical laboratory, the COC form will be signed by the person receiving the samples. The condition of the samples will be noted and recorded by the receiver. COC records will be included in the final reports prepared by the analytical laboratories and are considered an integral part of the report.

Sampling Transport, Shipping, and Storage Procedures

Sediment samples collected in the field for chemistry and toxicity analyses will initially be placed on ice and stored in the dark. Prior to shipping or transport, sample containers will be packed inside coolers with ice. COC forms will be filled out, and the original signed COC forms will be inserted in a sealable plastic bag and placed inside the coolers. The cooler lids will be securely taped shut and then samples will be delivered or shipped on ice to the appropriate analytical laboratory for analysis. Sediment designated for benthic infauna analysis will be screened on location by field personnel. The material and organisms retained on the screen will be put into appropriate 1-L containers, treated with magnesium sulfate relaxant, and preserved with formalin. Once preserved, benthic infauna samples will be delivered with accompanying COC forms to the laboratory tasked with sorting macroinvertebrates into broad taxonomic groupings. Following sorting, taxonomic samples will be shipped/ delivered to specialized taxonomists who will identify benthic macroinvertebrates to the lowest possible taxon.

ELEMENT 13 ANALYTICAL METHODS

Field Analytical Methods

A YSI water quality data sonde (e.g. YSI 6600 Multiparameter Sonde) or similar device can be utilized to take salinity measurements at each station location. Salinity measurements should be taken approximately six inches above the SWI. At a minimum, it is recommended that salinity measurements should be taken at a spring high and low tide to get an estimate of the salinity range for a proposed station. If feasible, it is recommended that salinity should be monitored throughout an entire spring tidal cycle to ensure it meets the salinity criteria prior to sampling. Water depth should also be measured when visiting the station at a spring low tide or deploying a continuous monitoring device over a spring tidal cycle to ensure the station is subtidal. Operation of field equipment will be conducted as per manufacturer instructions. Calibrations will be performed and recorded to ensure accurate functionality.

Laboratory Analytical Methods

Chemistry Samples

A list of sediment chemical constituents and maxiumum reporting limits (RLs) for analytes that are required for SQO analysis are provided in Table 10. Additional physical parameters including grain size and TOC are also listed. While these physical parameters are not required to calculate the chemistry LOE, they should be analyzed in order to provide additional information to aid in the interpretation of the toxicity and benthic LOEs. Percent solids must be measured to convert concentrations of the chemical parameters from a wet-weight to a dry-weight basis.

Target RLs listed in Table 10 are those that are provided in the Sediment Quality Assessment Technical Support Manual (Bay et al., 2014) for SQO analyses. The maximum RLs provided in Table 10 are based on the CSI classification ranges and are expressed on a dry weight basis. Lower RLs may be achievable depending on available analytical methods. As stated in Element 6, the analytical methods listed in Table 8 are suggested methods that have been used in previous sediment monitoring programs within San Diego County's waterbodies (e.g. Bight), but are not the only acceptable methods. Chemical analyses of all sediment samples collected as part of the SQO assessment must be tested in accordance with USEPA or ASTM protocols. If appropriate protocols do not exist, the SWRCB or San Diego RWQCB may approve the use of other methods.

Table 10. Physical and Chemical Parameters, Suggested Methods, and Maximum Reporting Limits for SQO Analysis

Parameter	Method	Procedure	Maximum Reporting Limit (dry weight)
Physical/ Conventional			
Grain Size	Plumb 1981	Wet sieving	1.00 %
Percent Solids	SM 2540B	Gravimetric	0.10 %
Total Organic Carbon (TOC)	USEPA 9060A	Combustion/ oxidation	0.01 %
Chemistry			
Trace Metals			
Cadmium (Cd)	USEPA 6020A	ICP/MS	0.09 mg/kg
Copper (Cu)	USEPA 6020A	ICP/MS	52.8 mg/kg

Table 10. Physical and Chemical Parameters, Suggested Methods, and Maximum Reporting Limits for SQO Analysis

Parameter	Method	Procedure	Maximum Reporting Limit (dry weight)
Lead (Pb)	USEPA 6020A	ICP/MS	25.0 mg/kg
Mercury (Hg)	USEPA 7471B	CVAA	0.09 mg/kg
Zinc (Zn)	USEPA 6020A	ICP/MS	60.0 mg/kg
Organochlorine Pesticides			
2,4′-DDD	USEPA 8081B	GC/MS	0.50 µg/kg
2,4′-DDE	USEPA 8081B	GC/MS	0.50 µg/kg
2,4′-DDT	USEPA 8081B	GC/MS	0.50 µg/kg
4,4′-DDD	USEPA 8081B	GC/MS	0.50 µg/kg
4,4′-DDE	USEPA 8081B	GC/MS	0.50 µg/kg
4,4′-DDT	USEPA 8081B	GC/MS	0.50 µg/kg
Chlordane-alpha	USEPA 8081B	GC/MS	0.50 µg/kg
Chlordane-gamma	USEPA 8081B	GC/MS	0.54 µg/kg
Dieldrin	USEPA 8081B	GC/MS	2.5 µg/kg
trans-Nonachlor	USEPA 8081B	GC/MS	4.6 µg/kg
PCB Congeners			
2,4'-Dichlorobiphenyl (8)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',5-Trichlorobiphenyl (18)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,4,4'-Trichlorobiphenyl (28)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,5'-Tetrachlorobiphenyl (44)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',5,5'-Tetrachlorobiphenyl (52)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,3',4,4'-Tetrachlorobiphenyl (66)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',4,5,5'-Pentachlorobiphenyl (101)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,3,3',4,4'-Pentachlorobiphenyl (105)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,3',4,4',5-Pentachlorobiphenyl (118)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,3',4,4'-Hexachlorobiphenyl (128)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,4,4',5'-Hexachlorobiphenyl (138)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',4,4',5,5'-Hexachlorobiphenyl (153)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,3',4,4',5-Heptachlorobiphenyl (170)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,4,4',5,5'-Heptachlorobiphenyl (180)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,4',5,5',6-Heptachlorobiphenyl (187)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,3',4,4',5,6-Octachlorobiphenyl (195)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (206)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
Decachlorobiphenyl (209)	USEPA 8082A	GC/MS ECD	3.0 µg/kg
Low Molecular Weight PAHs			
Acenaphthene	USEPA 8270D	GC/MS SIM	20 µg/kg
Anthracene	USEPA 8270D	GC/MS SIM	20 µg/kg
Phenanthrene	USEPA 8270D	GC/MS SIM	20 µg/kg
Biphenyl	USEPA 8270D	GC/MS SIM	20 µg/kg

Table 10. Physical and Chemical Parameters, Suggested Methods, and Maximum Reporting Limits for SQO Analysis

Parameter	Method	Procedure	Maximum Reporting Limit (dry weight)
Naphthalene	USEPA 8270D	GC/MS SIM	20 µg/kg
2,6-Dimethylnaphthalene	USEPA 8270D	GC/MS SIM	20 µg/kg
Fluorene	USEPA 8270D	GC/MS SIM	20 µg/kg
1-Methylnaphthalene	USEPA 8270D	GC/MS SIM	20 µg/kg
2-Methylnaphthalene	USEPA 8270D	GC/MS SIM	20 µg/kg
1-Methylphenanthrene	USEPA 8270D	GC/MS SIM	20 µg/kg
High Molecular Weight PAHs			
Benzo(a)anthracene	USEPA 8270D	GC/MS SIM	80 µg/kg
Benzo(a)pyrene	USEPA 8270D	GC/MS SIM	80 µg/kg
Benzo(e)pyrene	USEPA 8270D	GC/MS SIM	80 µg/kg
Chrysene	USEPA 8270D	GC/MS SIM	80 µg/kg
Dibenzo(a,h)anthracene	USEPA 8270D	GC/MS SIM	80 µg/kg
Fluoranthene	USEPA 8270D	GC/MS SIM	80 µg/kg
Perylene	USEPA 8270D	GC/MS SIM	80 µg/kg
Pyrene	USEPA 8270D	GC/MS SIM	80 µg/kg

DDD Dichlorodiphenyldichloroethane
DDE dichlorodiphenyldichloroethylene
DDT dichlorodiphenyltrichloroethane
mg/kg milligrams per kilogram
µg/kg micrograms per kilogram

Toxicity Samples

To evaluate the benthic condition of San Diego County's waterbodies, sediment toxicity testing will be conducted in accordance with ASTM and USEPA methods. Toxicity testing involves a short-term survival test, a sublethal endpoint test, and an assessment of sediment toxicity. For each test type, more than one specific test is acceptable. The appropriate species tested for a sample will depend on the characteristics of the sample such as grain size, salinity, and suspected toxic constituents, if any. When historical data are available for a sample location, it is recommended that the same species be used in order to make comparisons and to conduct trend analysis. In addition, when testing is conducted as part of a regional monitoring program such as the Bight program, the species selection will be dictated by the program.

Short-Term Survival Testing

SQO analysis requires that at least one short-term survival test be conducted. There are three acceptable short-term survival tests, each of which is a 10-day test exposing amphipods to whole sediment. The three acceptable test organisms are *Eohaustorius estuarius*, *Leptocheirus plumulosus*, and *Rhepoxynius abronius*. The *E. estuarius* short-term survival test has been the 10-day test method used in previous San Diego County enclosed bay and estuary monitoring programs, including the Bight Program, where the SQO analytical tool was used to assess aquatic health. These amphipod bioassays will be conducted in accordance with procedures outlined in *Methods for Assessing Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods* (USEPA, 1994) and ASTM method E1367-03 (ASTM, 2006). Test conditions are

summarized in Table 11. If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans.

A water-only reference toxicity test should be conducted concurrently with the whole sediment amphipod test to assess the relative sensitivity of test organisms used in the evaluation of project sediments. Amphipod reference toxicant tests are typically conducted using cadmium. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

Table 11. Summary of Conditions for 10-Day Whole Sediment Amphipod Bioassay

Test Conditions 10-Day Whole Sediment Bioassay				
	Test Species	***E. estuarius***	***L. plumulosus***	***R. abronius***
	Test Procedures	USEPA (1994); ASTM E1367-03 (2006)		
	Test Type/Duration	Static - Acute Whole Sediment/10 days		
	Sample Storage Conditions	4 ºC, dark, minimal head space		
	Age/Size Class	3-5 mm	2-4 mm; immature	3-5 mm
	Grain Size Tolerance	0.6-100% sand	0-100% sand	10-100% sand
Recommended Water Quality Parameters	Temperature	15 ± 1 ºC	25 ± 1 ºC	15 ± 1 ºC
	Salinity	20 ± 2 ppt	20 ± 2 ppt	28 ± 2 ppt
	Dissolved Oxygen	Maintaining 90% saturation		
	Total Ammonia	< 60 mg/L	< 60 mg/L	< 30 mg/L
	Test Chamber	1 L glass		
	Exposure Volume	2 cm sediment, 800 mL seawater		
	Replicates/Sample	5		
	No. of Organisms/Replicate	20		
	Photoperiod	Continuous light		
	Feeding	None		
	Water Renewal	None		
	Aeration	Constant gentle aeration		
	Acceptability Criteria	Mean control survival ≥ 90%; ≥80% survival in each replicate		

mg/L milligram per liter

Sublethal Testing

The second type of testing required for SQO analysis is a sublethal test. Either a 48-hour development test exposing embryos of the bivalve *Mytilus galloprovincialis* to the sediment-water interface may be conducted or a 28-day survival and growth test exposing the polychaete worm *Neanthes arenaceodentata* to whole sediment. Test condition summaries for the bivalve and polychaete tests are presented in Table 12 and Table 13, respectively. The *M. galloprovincialis*

sediment-water interface test has been the sublethal test method used in previous San Diego County enclosed bay and estuary monitoring programs, including the Bight Program, where the SQO analytical tool was used to assess aquatic health.

Mytilus galloprovincialis Sediment-Water Interface Development Sublethal Test

Sediment-water interface bioassays are performed to estimate the potential toxicity of contaminants fluxing from test sediments into the overlying water. The sediments will be tested in a 48-hour sediment-water interface test using the bivalve *M. galloprovincialis* in accordance with procedures outlined in *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to West Coast Marine and Estuarine Organisms* (USEPA, 1995) and Assessment of Sediment Toxicity at the Sediment-Water Interface (Anderson et al., 1996). If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans. Sediment-water interface bioassays will be tested on intact cores collected in the field or on homogenized sediment samples as described in Section 2.1.6 of the Sediment Monitoring Plan.

A water-only reference toxicity test should be conducted concurrently with the sediment-water interface bivalve test to assess the relative sensitivity of test organisms used in the evaluation of the project sediments. Bivalve reference toxicant tests are typically conducted using copper. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

Table 12. Test Conditions for the 48-Hour *M. galloprovincialis* Sediment-Water Interface Bioassay

Test Conditions 10-Day Whole Sediment Bioassay		
	Test Species	***M. galloprovincialis***
	Test Procedures	USEPA (1995), Anderson et al. (1996)
	Test Type/Duration	Static - Acute sediment-water interface/48 hours
	Sample Storage Conditions	4 °C, dark, minimal head space
	Age/Size Class	< 4 hour old larvae
Recommended Water Quality Parameters	Temperature	15 ± 1 °C
	Salinity	32 ± 2 ppt
	Dissolved Oxygen	Maintaining 90% saturation
	Total Ammonia	< 4 mg/L
	Test Chamber	Polycarbonate core tube 7.3-cm inner diameter, 16 cm high
	Exposure Volume	5 cm sediment, 300 mL water
	Replicates/Sample	4
	No. of Organisms/Replicate	Approximately 250 larvae

Test Conditions 10-Day Whole Sediment Bioassay	
Photoperiod	16 hours light: 8 hours dark
Feeding	None
Water Renewal	None
Aeration	Constant gentle aeration
Acceptability Criteria	Mean control normal-alive ≥ 80%

Neanthes arenaceodentata Whole Sediment Survival and Growth Sublethal Test

The *N. arenaceodentata* test will be conducted in accordance with ASTM method E1562 (ASTM, 2002) with modifications described in Farrar and Bridges (2011) that have been found to contribute manageability and precision to the ASTM procedure. If sediment monitoring is conducted as part of the Bight Program, then procedures and test conditions should be in accordance with Bight Workplans. A water-only reference toxicity test should be conducted concurrently with the whole sediment polychaete test to assess the relative sensitivity of test organisms used in the evaluation of the project sediments. Polychaete reference toxicant tests are typically conducted using cadmium. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. If ammonia is selected as the reference toxicant, pore water ammonia will be measured between sample receipt and test set-up, and again at test initiation. If the un-ionized pore water ammonia concentration in the test initiation sample is 0.8 mg/L or greater, then the ammonia reference toxicant test will be extended from 4 days to 10 days for better comparison to 10-day test sample results.

Table 13. Test Conditions for the 28-Day Whole Sediment *N. arenaceodentata* Bioassay

Test Conditions 10-Day Whole Sediment Bioassay		
	Test Species	***N. arenaceodentata***
	Test Procedures	ASTM E1562 (2002), Farrar and Bridges (2011)
	Test Type/Duration	Static - Acute Whole Sediment/28 days
	Sample Storage Conditions	4 °C, dark, minimal head space
	Age/Size Class	≤ 7 days post-emergence
	Grain Size Tolerance	5-100% sand
Recommended Water Quality Parameters	Temperature	20 ± 1 °C
	Salinity	30 ± 2 ppt
	Dissolved Oxygen	Maintaining 90% saturation
	Total Ammonia	< 20 mg/L
	Test Chamber	300 mL glass
	Exposure Volume	2 cm sediment, 125 mL seawater
	Replicates/Sample	10
	No. of Organisms/Replicate	1
	Photoperiod	12 hours light: 12 hours dark
	Feeding	Twice per week
	Water Renewal	Weekly
	Aeration	Constant gentle aeration
	Acceptability Criteria	Mean control survival ≥ 80%; positive growth in controls

Benthic Infauna Samples

The benthic infaunal samples will be transported from the field to the laboratory and stored in a formalin solution for a minimum of 48 hours and no longer than 5 days. The samples will then be transferred from formalin to 70% ethanol for laboratory processing. The organisms will initially be sorted using a dissecting microscope into five major phyletic groups: polychaetes, crustaceans, molluscs, echinoderms, and miscellaneous minor phyla. While sorting, technicians will keep a count for quality control purposes. After initial sorting, samples will be distributed to qualified taxonomists who will identify each organism to species or to the lowest possible taxon. Taxonomists will use the most recent version of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT) taxonomic listing for nomenclature and orthography. If sediment monitoring is conducted as part of the Bight Program, then procedures should be in accordance with Bight Workplans.

ELEMENT 14 QUALITY CONTROL

QA/QC Field Procedures

Field measurements for salinity will be made using a water quality probe, such as a YSI data sonde, that has been calibrated according to manufacturer specifications. Operation of field equipment will be conducted as per manufacturer instructions. Calibrations will be performed and recorded to ensure accurate functionality. Proper storage and maintenance procedures will be followed.

QA/QC for sampling processes begins with proper collection of the samples to minimize the possibility of contamination. Sediment samples will be collected in appropriate containers, kept on wet ice during the sampling event, and placed into coolers along with completed COC for transfer to the analytical laboratory. Field crews will ensure that sampling containers are being filled properly and the requirement to avoid contamination of samples at all times is met. The field data log sheets will include empirical observations of the site and water quality characteristics. Field duplicates will be collected at a minimum of 5% of total project sample count. A minimum of one equipment blank will be collected during the monitoring event. The equipment blank will be analyzed for the same target SQO analytes specified for the sediment samples (excluding grain size and percent solid analyses).

QA/QC Laboratory Analyses

Chemistry Analyses

The chemistry analysis of the samples will be performed under the guidelines of the analytical laboratories respective standard operationg procedures (SOPs) and QAPPs as well as meet the DQOs and quality objectives set forth in this QAPP. This includes analyzing the appropriate QC laboratory controls for each analysis in accordance with SWAMP criteria such as laboratory blanks and duplicates, MS/MSDs, certified or standard reference materials, and surrogates (see Element 7 for frequency of analysis and DQOs for QC laboratory controls).

Toxicity Analyses

A water-only reference toxicity test will be conducted concurrently with each batch of sediment tests to establish the sensitivity of the test organisms used in the evaluation of the sediments and to evaluate the potential influence of ammonia toxicity on the test organisms. Typically, amphipod and polychaete reference toxicant tests are conducted using cadmium and bivalve reference toxicant tests are typically conducted using copper. However, using ammonia as the reference toxicant is preferable because the sensitivity of the test organisms to ammonia (often a confounding factor in sediment testing) can be evaluated along with the relative sensitivity of the batch of organisms used in testing. The LC_{50} and/or EC_{50} values of the reference toxicant test will be compared to historical laboratory data for each respective test species. The results of these reference toxicant tests will be used in combination with the control mortality to assess the health of the test organisms.

Benthic Infauna Analyses

A QA/QC procedure will be performed on each of the sorted samples to ensure a 95% sorting efficiency. This procedure is the same one followed in the Bight programs. A 10% aliquot of a sample will be re-sorted by a senior technician trained in the QA/QC procedure. The number of organisms found in the aliquot will be divided by 10% and added to the total number found in the sample. The original total will be divided by the new total to calculate the percent sorting efficiency. When the sorting efficiency of the sample is below 95%, the remainder of the sample (90%) will be re-sorted.

ELEMENT 15 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Field Sampling

Prior to conducting field sampling, field technicians will be responsible for preparing sampling kits that include field logs, COC forms, sample labels, sampling containers, decontamination equipment and tools. Field measurement equipment should be checked for operation in accordance with the manufacturer's specifications. Equipment should be inspected prior to use and when returned from use for damage.

Analytical Laboratories

All analytical laboratories including chemistry, toxicity, and benthic infaunal will maintain their equipment in accordance with their SOPs, which include those specified by the manufacturer and those specified by the method. Each laboratory's QAPP will specify equipment and system evaluations.

ELEMENT 16 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

The equipment and instruments used at each analytical laboratory will be operated and calibrated according to manufacturer recommendations as well as by criteria defined in each analytical laboratory's SOPs. Operation and calibration will be performed by properly trained personnel. Documentation of routine and special calibration information will be recorded in appropriate logbooks and reference files. If a critical measurement is found to be out of compliance during analysis, the results of that analysis will not be reported, corrective action will be taken and documented, and the analysis will be repeated.

Field Equipment

Water quality instruments used for salinity measurements will be calibrated per manufacturer's specifications prior to each monitoring event. Complete records of calibration will be maintained for each field instrument that requires periodic calibration.

Analytical Laboratories

All analytical labortatories including chemistry, toxicity, and benthic infaunal will calibrate their instrumentation at a frequency that ensures the validity of the results. Each laboratory's calibration procedures must follow EPA guidelines and the recommendations of the instrument manufacturer. Each laboratory's QAPP should provide detailed information on calibration procedures.

ELEMENT 17 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

It is the duty of each person who is responsible for equipment ordering to inspect equipment and materials for quality and report any equipment or materials that do not meet acceptance criteria to the Project Manager, Laboratory Manager, and/or QA Officer, as appropriate. Upon receipt of materials or equipment, a designated employee must receive and sign for the materials. The items will then be reviewed to ensure the shipment is complete, prior to delivery to the proper storage location. Chemicals must be dated upon receipt. Supplies will be stored appropriately and discarded on their expiration date. The equipment and supplies purchased for use in field sampling activities will be inspected for damage as they are received. Confirmation that sample bottles are laboratory-certified clean will be made when received.

Critical Supplies and Consumables

Chemistry Sample Bottles – Chemistry sample bottles will be provided by the analytical laboratory. They will be shipped from the laboratory and stored appropriately by the field sampling team prior to use in the field. Confirmation that sample bottles are laboratory-certified clean will be made when received from the analytical laboratories. Preservatives may be required for the analysis of certain analyte groups and the laboratory supplied bottles should already contain any required preservatives.

Toxicity Sample Containers – Clean, food-grade, heavy duty 0.004 gauge polyethylene bags capable of holding up to 20-L, or clean glass jars with Teflon-lined lids should be used as the sample container for sediment toxicity samples. If bags are used, samples should be double bagged, twisted at the top with excess air removed, and cable tied to ensure sample integrity.

Benthic Infauna Jars– Clean, 1-L HDPE or glass sample jars should be used as containers for benthic infauna samples following sediment processing in the field. Additionally, magnesium sulfate and 10% formalin solutions that are used for processing benthic infauna samples will need to be on hand during sampling events and should be provided by each Copermittee or their subcontractor(s).

ELEMENT 18 NON-DIRECT MEASUREMENTS

Data will be reviewed against DQOs in Section 7 prior to SQO analysis. Only data meeting the DQOs will be used in the SQO analysis.

ELEMENT 19 DATA MANAGEMENT

Data will be maintained as described in Element 9. The original data sheets and reports produced will be accumulated into project-specific files that are kept by either the Copermittee or Contractor Project Manager.

The Copermittee or Contractor Project Manager will document and track the aspects of the sample collection process, including generating field logs at each site and COC forms for the samples collected. COC forms will accompany samples to the appropriate laboratories for analysis. Each analytical laboratory will document and track the aspects of sample receipt and storage, analyses, and reporting. Each analytical laboratory's results will be stored in a database system at their office and will be provided to the Copermittee or Contractor Project Manager both electronically and by hard copy. Further details of each laboratory's data management protocols can be found in each laboratory's respective QAPP.

Field logs and analytical data will be entered into or transferred to the Copermittee or Contractor's database. After the data is added to the database, the Contractor Project QA Officer will validate the data by checking for errors and ensure the data is complete. The database will be updated with finalized data. The results of the laboratory QC analyses will be reported with the final data. Any QC samples that fail to meet the specified QC criteria in the methodology or the DQOs described in Element 7 will be identified, and the corresponding data will be appropriately qualified in the final report. All QA/QC records will be kept on file for review by regulatory agency personnel. Once data is finalized, all monitoring data and analytical results will be formatted and uploaded into CEDEN. All records should be maintained for at least five years.

GROUP C:
ASSESSMENT AND OVERSIGHT

ELEMENT 20 ASSESSMENTS AND RESPONSE ACTIONS

Corrective Actions

The following sections identify the responsibilities of key project members and corrective actions to be taken if issues arise during field sampling or laboratory analyses that may result in noncompliance with protocols established in the Sediment Monitoring Plan.

Field Sampling

The initial responsibility for monitoring the quality of field measurements lies with the field personnel. The Field Task Manager is responsible for verifying that QC procedures are followed. This requires that the Field Task Manager assess the accuracy of the field methods as well as the ability to meet QA objectives and make a value judgment regarding the impact a procedure has on field objectives and subsequent data quality. If a problem occurs that might jeopardize the integrity of the project, hinder a QA objective, or impact data quality, the Field Task Manager will immediately (within 24 hours) notify the Copermittee or Contractor Project Manager. Corrective action measures are then decided upon and implemented. The Field Task Manager documents the situation, the field objective affected, the corrective action taken, and the results of that action. Copies of the documentation are provided to the Copermittee or Contractor Project Manager and the QA Officer.

Laboratory

The need for corrective action comes from several sources, including equipment malfunction, failure of internal QA/QC checks or to follow-up on performance or system audit findings, and noncompliance with QA requirements. All laboratory personnel are responsible for documenting and correcting problems that might affect quality. When measurement equipment or analytical methods fail QA/QC requirements, the problem(s) will be brought immediately to the attention of the Laboratory Manager and QA Officer. Corrective measures will depend entirely on the type of analysis, the extent of the error, and whether or not the error is determinant. The corrective action is determined by either the Laboratory Manager, technicians, the Copermittee or Contractor Project Manager, the QA Officer, or by all of them in conference, if necessary, but final approval is the responsibility of the Copermittee or Contractor QA Officer and/or Project Manager.

If failure is due to equipment malfunction, the equipment will not be used until repaired. Precision and accuracy will be reassessed, and the analysis will be rerun. Attempts will be made to reanalyze the affected parts of the analysis so that in the end, the product is not affected by failure of QC requirements. When a result in a performance audit is unacceptable, the laboratory will identify the problem(s) and implement corrective actions immediately. A step-by-step analysis and investigation to determine the cause of the problem will take place as part of the corrective action program. If the problem cannot be controlled, the laboratory will analyze the impact on data. If the data is affected, the problem will be documented and the Copermittee or Contractor QA Officer and/or Project Manager will be notified. When a system audit reveals an unacceptable performance, work will be suspended until corrective action has been implemented and performance has been proven acceptable. If the problem is instrumental or specific only to

preparation of a sample batch, samples are reprocessed after the instrument is repaired and recalibrated. In the event that a QC measure is out-of-control and the data are to be reported, qualifiers are reported together with sample results.

ELEMENT 21 PROJECT REPORTS

The Project Manager is responsible for preparation and submittal of all project deliverables. Each analytical laboratory's QA Officer is responsible for the preparation of all data packages and laboratory reports originating from their laboratory. Provision D.1.e.(2)(c) of the Permit requires incorporation of a Sediment Monitoring Report into the WQIP Annual Report. The Sediment Monitoring Report will contain an evaluation, interpretation, and tabulation of monitoring data, including an assessment of whether receiving water limits outlined in the Permit were attained; a sample location map; and a statement of certification that monitoring data and results have been uploaded into CEDEN.

Based on the conclusions of the Sediment Monitoring Report, a human health risk assessment may be necessary in order to determine whether human health objectives have been obtained at each sample location. Provision A.2.a.(3)(b)(ii) states that "pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health." The potential risk assessments must consider any relevant information, such as guidelines set forth in the CA EPA's Office of Environmental Health Hazard Assessment (OEHHA) fish consumption policies, CA EPA's Department of Toxic Substances Control (DTSC) risk assessment, and the USEPA human health risk assessment policies.

Since the WQIPs are still in development and there will be not WQIP Annual Reports in 2015, the Copermittees will include the Sediment Monitoring Report with the Transitional Monitoring and Assessment Report due to the San Diego RWQCB on January 31, 2015. The Sediment Monitoring Report will include the results from the 2013 Bight Program and any follow-up monitoring collected in 2014 to satisfy Provisions D.1.e.(1)(b) and D.1.e.(2) of the Permit. Additional sediment quality monitoring or stressor identification studies conducted after 2014 will be included in the WQIP Annual Reports.

The schedule for completing the sediment quality monitoring requirements of the Permit and for submitting the Sediment Monitoring Report is shown in Table 14.

Table 14. Sediment Monitoring Report Schedule

Activity/Deliverable	Dates(s)*
San Diego RWQCB Order No. R9-2013-0001	Adopted May 8, 2013 and effective June 27, 2013
Southern California Bight Regional Monitoring Program	August-September 2013
Follow-up confirmation monitoring	August-September 2014
Final Sediment Monitoring Plan and Sediment Monitoring QAPP incorporated into WQIPs	December 2014
Draft Sediment Monitoring Report	December 2014
Final Sediment Monitoring Report incorporated into Transitional Monitoring and Assessment Report	January 31, 2015
Potential Stressor ID Studies	TBD

*Table does not include future permit cycles

GROUP D:
DATA VALIDATION AND USABILITY

ELEMENT 22 DATA REVIEW, VERIFICATION, AND VALIDATION

Data reduction, verification, validation, and reporting are ongoing processes, which involve the field technicians, laboratory technicians, Laboratory Managers, and QA personnel. Data generated by the sediment monitoring activities including field sampling and laboratory analyses will be reviewed against the DQOs presented in Element 7 and the QA/QC practices cited in this QAPP. This includes field logbooks, COC forms, and all data related to laboratory analytical procedures (e.g., sample preparation logs, instrument logs, etc.). Data entry of field sampling data will be reviewed to check for accuracy and completeness. Analytical laboratory electronic data deliverables and hard copy reports will be reviewed to ensure that the proper QC elements are included (e.g., blanks, lab duplicates, etc.), all sample analyses are correct, holding times were met, and data failing to meet QC criteria are properly qualified. Data that does not meet the DQOs will be evaluated to determine the impact of the failure on the data quality. If sufficient evidence is found to support the use of the data, the data will be qualified, and entered into the database.

ELEMENT 23 VERIFICATION AND VALIDATION METHODS

After each sampling event, the field data sheets will be removed from the field logbooks, and the sheets will be checked for completeness and accuracy by the QA Officer or Project Manager. The appropriate field sheets must be present. If there are any questions, clarification from the Field Task Manager will be obtained as soon as possible.

In the laboratory, sample preparation activities will be documented in bound laboratory notebooks or on bench sheets. Data validation includes dated and signed entries by technicians on the data sheets and logbooks used for the samples, the use of sample tracking and numbering systems to track the progress of samples through the laboratory, and the use of QC criteria to reject or accept specific data. The laboratory generating the data will have the prime responsibility for the accuracy and completeness of the data. Each laboratory will review the data to ensure that the following information is correct and complete: sample description information, analysis information, results, and documentation of the data. Further data validation is performed by the Laboratory Manager. Validation is accomplished through routine audits of the data collection and flow procedures and by monitoring of QC sample results. In the data review process, the data will be compared to information such as the sample's history, sample preparation, and QC sample data to evaluate the validity of the results. Corrective action will be minimized through the development and implementation of routine internal system controls. Analysts are provided with specific criteria that must be met for each procedure, operation, or measurement system.

ELEMENT 24 RECONCILIATION WITH USER REQUIREMENTS

The QA personnel will review data after each survey to determine if DQOs have been met. If data do not meet project specifications, the QA personnel will review errors and determine if the problem is due to calibration/maintenance, sampling techniques, or other factors, and they will suggest corrective action. It is expected that the problem would be correctible through personnel re-training, technique revision, or supplies/equipment replacement. If not, the DQOs will be reviewed for feasibility. If specific DQOs are not achievable, the QA personnel will recommend appropriate modifications. Any revisions would need approval by the Copermittee or Contractor Project Manager.

ELEMENT 25 REFERENCES

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Appendix 5G – Riverside County Flood Control & Water Conservation District Low Impact Development (LID) Demonstration Facility Monitoring Plan and Quality Assurance Project Plan (QAPP)

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Appendix 5G.1 – Riverside County Flood Control & Water Conservation District LID Demonstration Facility Monitoring Plan

LOW IMPACT DEVELOPMENT (LID) BEST MANAGEMENT PRACTICE (BMP) DEMONSTRATION & TESTING FACILITY

MONITORING PLAN

LID BMP WATER QUALITY MONITORING PROJECT

September 28, 2015

This LID BMP Monitoring Plan is a working document. District procedures may change or be revised to ensure the most accurate results for this project. All changes will be updated as necessary to reflect the current working practices.

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ATTACHMENTS

Attachment A: Riverside County Flood Control and Water Conservation District Field Data Sheet
Attachment B: Health and Safety Procedures, Appendix J to Volume II of the Riverside County Consolidated Monitoring Plan

P8/200051

Acronyms and Abbreviations

Babcock	Babcock Laboratories, Inc.
BMP	Best Management Practice
COC	Chain of Custody
CMP	Riverside County Consolidated Monitoring Plan
District	Riverside County Flood Control & Water Conservation District
DQOs	Data Quality Objectives
EDD	Electronic Data Deliverable
LCS	Laboratory Control Sample
LID	Low Impact Development
MP	Monitoring Plan
MS/MSDs	Matrix Spike/Matrix Spike Duplicates
NPDES	National Pollutant Discharge Elimination System
Project	LID BMP Testing Facility Monitoring Project
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RCFC&WCD	Riverside County Flood Control and Water Conservation District
TPH	Total Petroleum Hydrocarbons
SAWPA	Santa Ana Watershed Project Authority
SCCWRP	Southern California Coastal Water Research Project
SMC	Southern California Stormwater Monitoring Coalition
SOP	Standard Operating Procedure
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
USEPA	United States Environmental Protection Agency
µg/L	micrograms per liter
mg/L	milligrams per liter

1.0 INTRODUCTION

This section describes the background, project goals and project description for the District's LID BMP Test Facility Monitoring Project (Project).

1.1 BACKGROUND

The District's jurisdiction is comprised of 2,700 square miles and three distinct watersheds: Santa Ana, Santa Margarita, and Whitewater. The District extends from the northwest portion of Riverside County east to Desert Hot Springs and Palm Springs and south to the San Diego County line through the Temecula area.

The District has experienced a 14% increase in urban land use percentages since 1993, leading to an increase in the amount of impervious surfaces present within the District (RCFCWCD 2009). In order to comply with the United States Environmental Protection Agency (USEPA) National Pollutant Discharge Elimination System (NPDES) Permits, many municipalities nationwide now incorporate BMPs into development projects in order to mitigate the potential water quality impacts of those developments. LID has been recognized as a cost-effective means to reduce pollutant loads in stormwater runoff; however, there are little data available on appropriate and cost-effective BMPs for a semi-arid environment with highly pervious soils, such as those found in and around the District's jurisdiction.

1.2 PROJECT GOALS

This Project is designed to test the potential effectiveness of particular LID designs in the semi-arid environment of Southern California. Prior to employing specific types of LID for new developments and redevelopment areas, the District is constructing and monitoring test sites to determine the most effective BMPs for the District's area, based on the vegetative and atmospheric conditions present in Southern California. The goals of the monitoring project are:

- Identify effectiveness of multiple LID BMPs to reduce the volume of stormwater runoff;
- Characterize BMP effectiveness to remove pollutants from stormwater runoff; and
- Provide data to determine effective LID BMPs for areas with climate similar to that of the semi-arid environment of Southern California

1.3 PROJECT DESCRIPTION

The Project is installed on the District's property at 1995 Market Street, in Riverside, California. The Project is designed to determine effective and appropriate LID BMPs for the District's semi-arid Mediterranean climate in conjunction with local drought resistant vegetation and highly pervious sandy soil. The District has implemented various BMPs within the Project to test BMPs listed for potential use within the District's jurisdiction for their effectiveness at mitigating stormwater pollutant runoff and stormwater runoff volume. The Project data are expected to provide insight into which BMPs may be effective for mitigation of stormwater runoff and a baseline for the water quality treatment and runoff reduction that may be expected from the associated LID designs.

Monitoring stations for this Project include four porous pavement BMPs, a landscape filter basin (rain garden), a planter box capturing roof runoff, and parking lot and roof runoff control sites. BMPs were designed to meet the existing 0.2"/hr flow-based treatment requirements as well as the 85th percentile runoff-based treatment requirements. Design criteria of the LID technologies tested were determined by an evaluation of existing criteria standards for LID BMP design features, as published in recognized

design guidance manuals or criteria previously established by other municipalities and government agencies. The porous pavement BMPs are lined with an impervious material to provide data on the effectiveness of the BMP, without the influence of the specific soils and geological features present on the site.

1.4 GENERAL SCOPE OF MONITORING

Ten stations shall be monitored each fiscal year for a total of five (5) years. The monitoring stations are described in Section 2.2. Depth through prismatic control will be recorded to be used to assess the flow-weighted composite samples which will be collected and analyzed for conventional constituents, nutrients, metals, and petroleum products. The constituent list is detailed in Section 3.0. The list will be reviewed and adjusted to reflect the most productive use of resources. Flow at each station will be recorded in one-minute intervals for the duration of each storm.

1.5 PROJECT ORGANIZATION AND RESPONSIBILITIES

The District is the lead agency implementing the LID BMP Project. Mark Zavislak is the District's Systems Specialist and is responsible for oversight of field data collection at the Project and compliance with monitoring procedures in this Monitoring Plan, including flow and hydrograph data. David Garcia is the Project Manager and has the responsibility for overseeing all of the Project work items.

The primary contacts for this Project are listed in Table 1-1.

Table 1-1: Project Contacts

Affiliation	Name/Title	Contact Information
RCFC&WCD	David Garcia Project Manager	Ph: (951) 955-1330 E-mail: dhgarcia@rcflood.org
RCFC&WCD	Mark Zavislak Systems Specialist	Ph: (951) 955-1213 E-mail: mzavisla@rcflood.org

2.0 MONITORING

This section describes the monitoring approaches for determining effectiveness of LID BMPs for removal of pollutants and storm water runoff reduction. Porous pavement BMPs, roof runoff BMP (planter box) and a landscape filter basin will be monitored.

2.1 MONITORING APPROACH

This monitoring program is designed to characterize the flow and water quality of runoff from different BMP stations and control stations during storm events. Flow, pH, dissolved oxygen DO), electric conductivity (EC), and temperature will be measured and logged. Samples will be collected from a total of ten stations:

1. Pavement control;
2. Porous concrete pavement with filtration;
3. Porous concrete pavement without filtration;
4. Porous asphalt pavement with filtration;
5. Porous asphalt pavement without filtration;
6. Landscape filter basin subdrain (effluent);
7. Landscape filter basin overflow (effluent);
8. Landscape filter basin influent;
9. Planter box effluent (roof runoff);
10. Roof runoff control (planter box influent).

Sampling will consist of flow-weighted composite samples collected by automated sampling equipment and field measurements. Monitoring procedures are based on SWAMP SOP recommendations and USEPA guidelines.[1] (USEPA 1992) Mobilization criteria will be consistent with the District's Consolidated Monitoring Plan (CMP) (RCFC&WCD 2014), and sampling events will be coordinated with the District's other wet weather programs. Dry weather flows at the Project are not anticipated; thus, there is no dry weather monitoring component to the Project. Samples will be analyzed for the constituents listed in Section 3.0 of this Monitoring Plan.

2.2 MONITORING LOCATIONS

The BMPs implemented in the Project are designed to reduce impervious areas, reduce the velocity of runoff, reduce the amount of runoff, and/or improve water quality. Three types of BMPs will be monitored: porous pavement BMPs, roof runoff BMP (planter box) and a landscape filter basin. Table 2-1 provides a description of monitoring stations.

2.2.1 BMP Descriptions

Porous Pavement – Porous pavements are designed to reduce impervious areas, reduce the velocity of runoff and improve the water quality from the Project. Four different porous pavements including concrete and asphalt pavement with and without filtration were constructed. These BMPs will be compared to one control station that is a pre-existing area of asphalt parking lot without BMPs. The bottom and sides of the porous pavement BMPs are lined with an impermeable composite layer. BMP

[1] Procedures may be modified as necessary for automated equipment and the needs of the Project.

effluent will be collected through a 6" perforated sub-drain on top of the impermeable layer and flow to a central monitoring station on the Project site.

Planter Box – A planter box was constructed at the base of the downspout at Building 1, to reduce the amount of and improve the water quality of roof runoff. The roof control site will collect the runoff directly from another downspout that drains an adjacent roof area of Building 1.

Landscaped Filter Basin – The landscaped filter basin is designed to reduce the velocity and improve the water quality of runoff. An influent station will collect a sample of the runoff prior to entering the landscape filter basin. An effluent sample will be collected after the runoff infiltrates the landscape filter basin and will be compared to the influent station to determine its effectiveness. An overflow sample will be collected if the runoff reaches a level that bypasses the capacity of the landscape filter basin. This will be used to evaluate the capacity of the landscape filter basin and the quality of the overflow runoff.

Table 2-1: Description of Monitoring Stations

Station ID	Station Location (lat, long)	BMP	Description
1	Monitoring Center (34° 0' 12.4" N, 117° 22' 45.31" W)	Pavement Control	Pre-existing standard asphalt parking lot.
2	Monitoring Center (34° 0' 12.4" N, 117° 22' 45.31" W)	Porous Concrete with Filtration	8.5" pervious concrete, aggregate (avg. 12"), filter fabric, 9" Class 2 permeable material, filter fabric, aggregate (avg. 12").
3	Monitoring Center (34° 0' 12.4" N, 117° 22' 45.31" W)	Porous Concrete without Filtration	8.5" pervious concrete, 25" aggregate.
4	Monitoring Center (34° 0' 12.4" N, 117° 22' 45.31" W)	Porous Asphalt with Filtration	5" porous asphalt, aggregate (avg. 12"), filter fabric, 9" Class 2 permeable material, filter fabric, aggregate (avg. 12").
5	Monitoring Center (34° 0' 12.4" N, 117° 22' 45.31" W)	Porous Asphalt without Filtration	5" porous asphalt, 25" aggregate.
6	Monitoring Center (34° 0' 12.4" N, 117° 22' 45.31" W)	Landscape Filter Basin Sub-drain	Vegetation, 18" soil (deeper at sides), 9" aggregate, perforated sub-drain
7	Monitoring Center (34° 0' 12.4" N, 117° 22' 45.31" W)	Landscape Filter Basin Overflow	Catch basin level with top of basin, 1' below parking lot grade.
8	Northeast end of Landscape Filter Basin (34° 0' 13.10"N, 117° 22' 43.87"W)	Landscape Filter Basin Influent	New slot drain in pre-existing parking lot.
9	Planter Box 1 (34° 0' 9.51" N 117° 22' 40.69" W)	Planter Box, Building 1	Perforated spreader pipe at end of downspout, 18" soil, 6" aggregate, perforated sub-drain.
10	West side of Building 1 (34° 0' 10.21" N 117° 22' 41.26" W)	Roof Runoff Control	Catch basin at end of downspout.

2.2.2 Monitoring Design

The Project is designed to facilitate monitoring of the BMPs. Figure 2-1 is a diagram of the Facility depicting drainage areas, BMPs, and location of the Monitoring Center. Figure 2-2 shows a schematic view and plumbing leading for the Monitoring Center.

Seven of the sampling stations are located at a specially designed monitoring facility at the north end of the infiltration basin (Monitoring Center). Flow is piped from the pavement control area (Station 1), porous pavement BMPs (Stations 2-5), and the landscape filter basin (Stations 6 and 7) to the Monitoring Center. Flow from each pipe enters a basin, and then flows through a 12-inch pipe for 12 feet, providing laminar flow. At the end of each 12-foot pipe, a Thel-Mar weir is installed, discharging into a second

basin. The stage of the water in the pipe behind the weir will be measured by a bubbler to provide accurate flow readings. Sample intake tubing and a multi-parameter sonde will be placed in the second catch basin. The sonde cable, the bubbler tube, and sampler tube will run through pre-installed, 3-inch diameter electrical conduit to the Monitoring Center. (See Section 2.4). The Monitoring Center, approximately 14 feet wide by 24 feet long, has standard AC power and will house the flow meters and automated sampling equipment for the seven stations. An on-site rain gauge (Riverside North) will be utilized for precipitation measurement.

Monitoring equipment for the remaining three stations are installed in fiberglass enclosures on concrete pads immediately adjacent to the source of runoff. The enclosures will be chosen by the District in consideration of aesthetics. Standard AC power will be supplied to each location during construction of the Facility.

At the landscape filter basin influent (Station 8), a catch basin collects runoff from a standard asphalt parking lot. Similar to the arrangement described above, the catch basin discharges to an 8-inch pipe for eight feet, providing laminar flow, over a Thel-Mar weir, and into a second catch basin with the sample intake tubing.

Runoff from Building 1's roof will flow into a planter box (Station 9). Effluent from this box is discharged through a perforated sub-drain, over a Thel-Mar weir, and into a collection bay constructed as part of the concrete slab. The equipment will be installed on the slab, with the sample intake tubing in the collection bay and the pressure transducer tubing installed behind the weir.

The roof runoff control station (Station 10) is similar to the planter box station. Runoff from the downspout is directed into a catch basin. The basin discharges over a Thel-Mar weir into a collection bay.

Figure 2-1: LID BMP Facility Flow Areas and BMP Locations

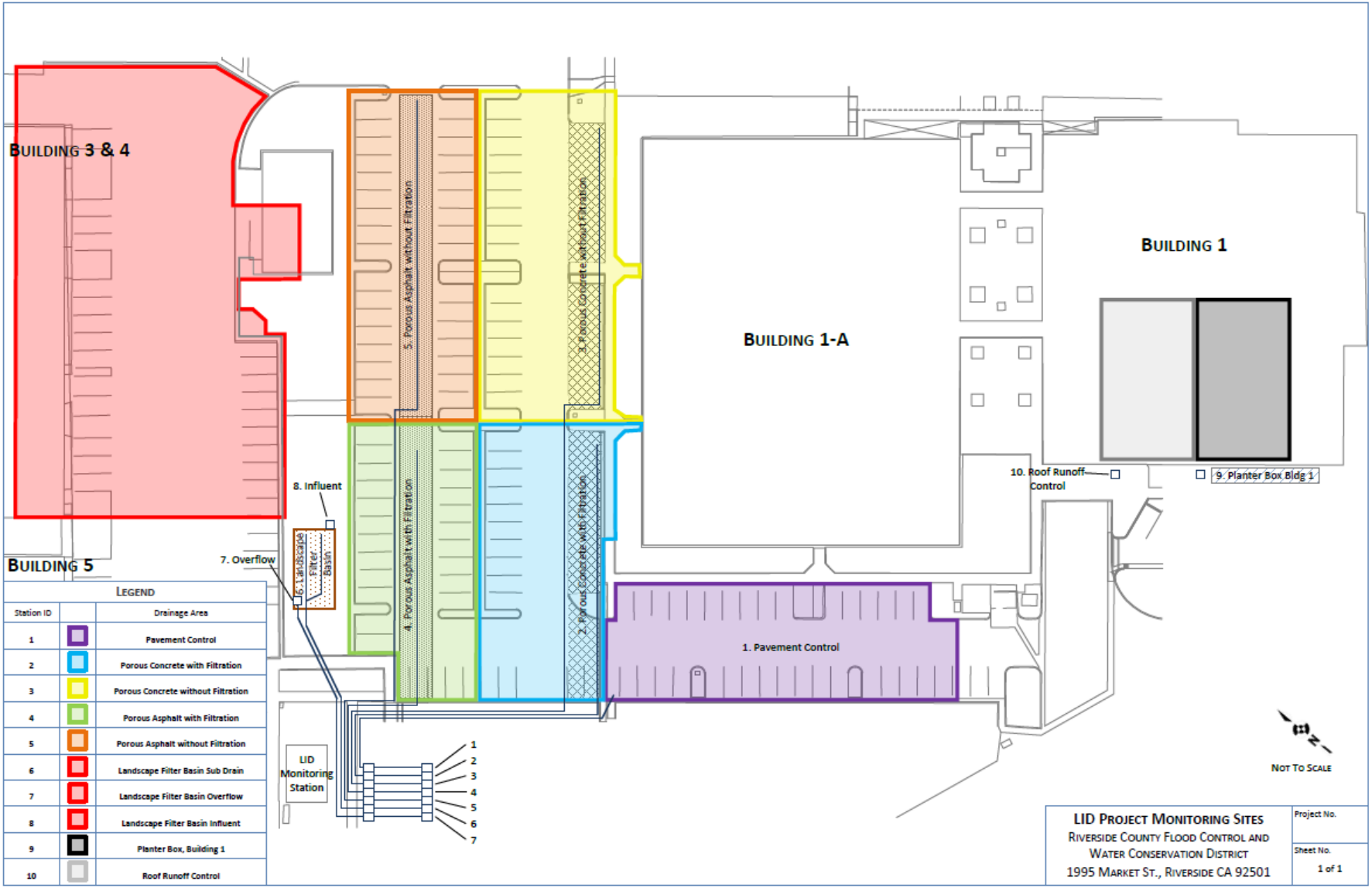
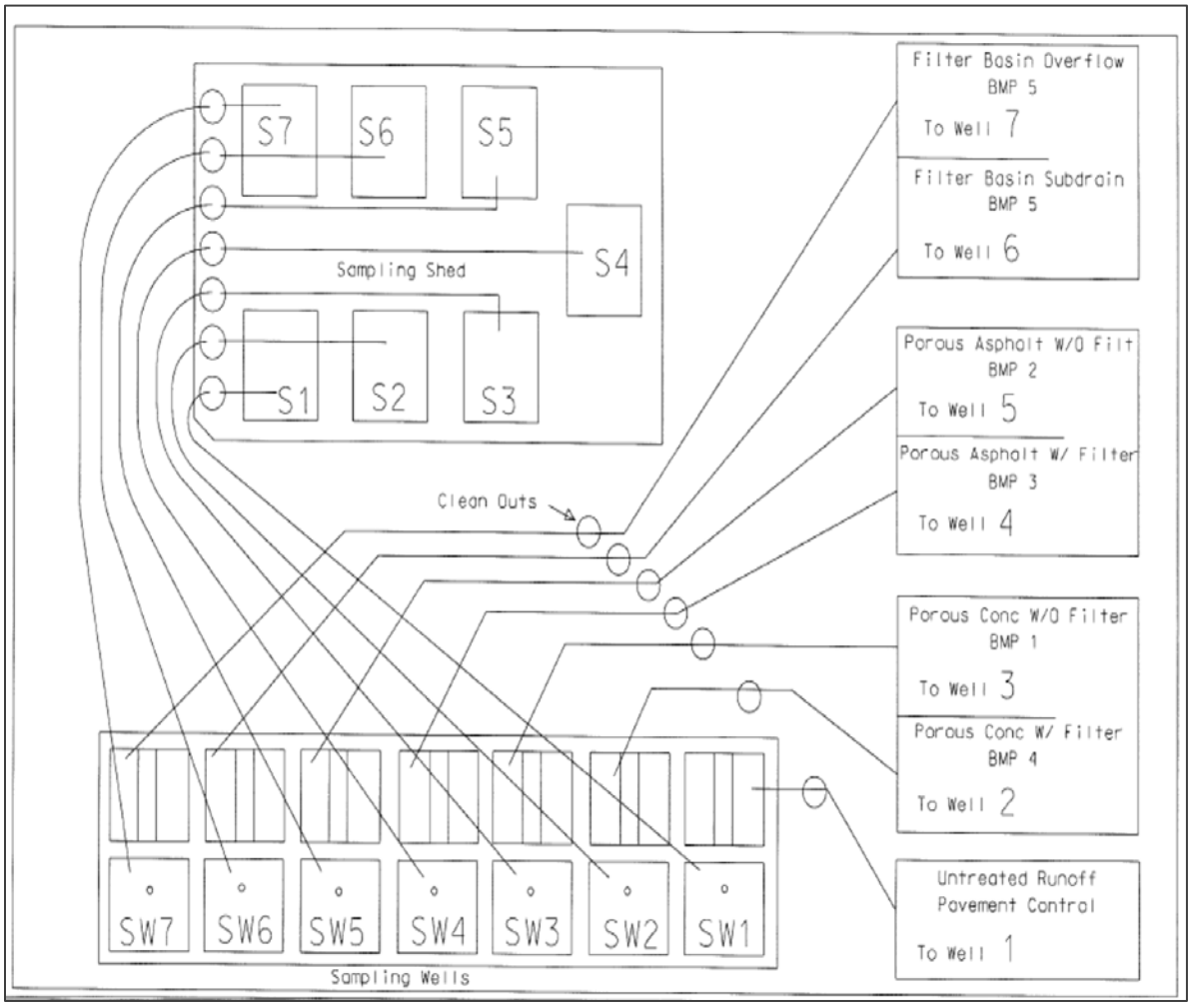


Figure 2-2: LID BMP Monitoring Center Layout and Schematic



2.3 SAMPLING METHODOLOGY

Sampling activities will consist of composite and grab sampling, flow and water quality parameter measurement, and field observation. These are as described in the following sections.

2.3.1 Composite Sampling

A composite sample is a series of aliquot samples collected over the course of a storm event. In order for the sample to represent the whole storm, the timing of the aliquots must be based on the flow rate. More aliquots are collected as the flow is rising and high relative to periods of low flow. This is achieved by programming the flow meter to trigger the automated sampler to collect an aliquot every time a given volume of water, referred to as the volume-to-sample or sample pacing, passes the sampling point. The sample pacing is set by estimating the volume of runoff from the predicted amount of rainfall. To determine the appropriate volume to sample number, the drainage area in acres and the runoff coefficient must be determined. To determine the volume of water expected at a particular station for anticipated rainfall amounts, the following equation is used:

P x A x C = Volume to Sample

P = inches of rainfall anticipated
A = drainage area
C = runoff coefficient for drainage area

The result of the volume to sample equation will be divided by the number of samples needed to satisfy the water volume requirement for analysis to determine how much water should pass the station between samples. The goal is to collect a minimum of ten aliquots, with an indefinite maximum, approximately 100 in practice. The samplers will collect the aliquots into appropriate bottles, filling one bottle at a time. The bottles may be combined in equal proportions to prepare a flow weighted composite sample. The aliquot volume is programmed so that all bottles fill completely. The sample pacing may only be changed during an event if aliquots are collected into separately marked bottles. Then, the total flow represented by each set of bottles will be used as the proportion of each set included in the flow-weighted composited sample. In practice, it is better to set the pacing low and the aliquot volume high, and then add bottles as necessary, rather than fail to collect enough sample volume. Experience at a given monitoring location can significantly improve estimation of these two variables. Table 2-2 below provides initial pacings for the ten stations based on the impervious area for several different storm volumes (CVALDO 2009). These pacings may be used for initial storms and revised as experience dictates.

When the rain has stopped and the flow at a station is very low or has ceased, the sample bottles (four or more at each station) will be placed in coolers on ice for delivery to the laboratory. The laboratory will combine the bottles in equal proportion (unless a pacing change was made and noted on the chain-of-custody (COC)) to prepare a flow-weighted composite sample for analysis.

2.3.2 Grab Sampling

One grab sample for each of the monitoring locations will be collected and analyzed for bacteria. Due to a holding time of 8 hours, between collection of the sample and analysis, a composite sample over the entire hydrograph is not feasible for this constituent. A grab sample for bacteria will be taken by field personnel during the rise of the hydrograph. This grab sample will be collected at the outfall of the monitoring stations using sampling protocol discussed in Section 4.

2.3.3 Flow Monitoring and Rainfall Data

Flow data will include stage and instantaneous flow. Flow and rainfall will be recorded as one-minute averages. Rainfall data will be recorded during each event at the District's campus gauge farm. During rain events, the flow meters convert instantaneous flow into total runoff volume. Data containing storm and hydrological information is electronically stored in the flow meter, with each monitoring event stored separately.

The information recorded includes:

- Flow rate, rainfall, and field data at the time of each sample
- Time of peak flow rate
- Cumulative rainfall
- Rainfall intensity
- Discharge volume totals

2.3.4 Water Quality Parameter Measurement and Field Observations

During each event, a multi-parameter probe will be used to measure and record water quality parameters (pH, temperature, EC, and dissolved oxygen) continuously at each station during the event. District personnel will also note and record any field observations; field measurements or observations will be recorded on Field Data Sheets (see Attachment A of this Monitoring Plan).

2.3.5 Clean Sampling Protocol

Monitoring for the Project will follow basic clean sampling techniques outlined in the USEPA NPDES Storm Water Sampling Guidance Document (USEPA 1992).

- Using certified clean bottles as discussed in Section 4.2.1;
- Replacing equipment tubing as discussed in Section 4.2.1;
- Wearing powder free gloves as discussed in Section 4.2.1;
- Not touching the inside of bottles, including the inside lid;
- Ensuring careful handling of bottles;
- Changing gloves frequently and in between contact with individual sample containers when placing the lid on those containers and switching out/removing bottles;
- Containment of sampling equipment and containers reducing potential exposure to environmental factors.

Table 2-2: Sample Pacings*

Predicted Rain			0.25 in.			0.5 in.			0.75 in.			1 in.			1.5 in.			2 in.		
Station		**Area** (acres)	**~~V~~**	**C**	**P**	**~~V~~**	**C**	**P**	**~~V~~**	**C**	**P**	**~~V~~**	**C**	**P**	**~~V~~**	**C**	**P**	**~~V~~**	**C**	**P**
1	Pavement Control	0.17		0.89			0.89			0.89			0.89			0.89			0.89	
2	Concrete w/ Filtration	0.22		0.89			0.89			0.89			0.89			0.89			0.89	
3	Concrete w/o Filtration	0.23		0.89			0.89			0.89			0.89			0.89			0.89	
4	Asphalt w/ Filtration	0.16		0.89			0.89			0.89			0.89			0.89			0.89	
5	Asphalt w/o Filtration	0.22		0.89			0.89			0.89			0.89			0.89			0.89	
6	Basin Sub-drain	0.89		0.41			0.41			0.41			0.41			0.41			0.41	
7	Basin Overflow	0.89		0.41			0.41			0.41			0.41			0.41			0.41	
8	Basin Influent	0.89		0.41			0.41			0.41			0.41			0.41			0.41	
9	Bldg. 1 Planter Box	0.13		1.00			1.00			1.00			1.00			1.00			1.00	
10	Roof Runoff Control	0.13		1.00			1.00			1.00			1.00			1.00			1.00	

~~V~~ = P x A x C
~~V~~ = volume to sample
P = inches of rainfall anticipated
A = drainage area
C = runoff coefficient for drainage area

* Sample pacing to be determined in the field.

2.4 MONITORING EQUIPMENT

The stormwater sampling equipment is designed to measure flow and collect composite samples of stormwater runoff in a flow-proportioned manner. The selected equipment has been found to be accurate, reliable, durable, versatile, non-contaminating, and is typically used in other water quality monitoring studies. While the equipment is automated, field crews will be on-site. Automated equipment will be powered from the District's nearest structure. These features allow reductions in operating effort and increase the reliability and quality of the stormwater monitoring data.

The following equipment components will be installed at monitoring sites prior to the wet season:

- Data-logging flow meter;
- Data-logging multi-parameter probe;
- Automated composite sampler;
- Tipping bucket rain gauge;
- Remote monitor and control connection (i.e. GSM cellular modem, network line, or phone line)

Equipment for Stations 1-7 will be kept in the Monitoring Center, a structure constructed to house seven sampling vaults, an equipment storage area, and a work area. Equipment for Station 8 will be installed in an enclosure at Sampling Vault 8. Enclosures will be constructed and equipment installed on a concrete pad near Stations 9 and 10. An overview of the main flow monitoring components and all other monitoring equipment is given below.

2.4.1 Data-Logging Flow Meter

An ISCO 6712 automatic sampler with flow meter module will be used to measure the water depth at each station. The ISCO 730 bubbler flow module measures water depth using a dry pressure transducer. An orifice tube is mounted at the invert of each 12" outlet. Depth data is logged and used by the flow meter to calculate and log flow data.

2.4.2 Flow Meter Logging and Sampler Control

The data logging feature of the ISCO 6712 automated sampler is a required component of any flow monitoring sampling station. The ISCO 6712 is connected to the 730 bubbler flow meter. In this configuration, the flow meter provides a method to control or pace the sampler, store sampling data and other auxiliary data, which will then be uploaded to a central computer. The flow meters will measure and log flow levels and sample history.

2.4.3 Data-Logging Multi-Parameter Probe

A YSI 6600 v2-4 multi-parameter sonde will be used to measure the water quality at each station. The YSI 6600 v2-4 measures water depth, conductivity, temperature, pH, and DO simultaneously using four optical sensor ports.

2.4.4 Automated Sampler and Other Sampling Equipment

This project will employ ISCO 6712 automated samplers. At each station, the sampler will be programmed to collect flow-weighted composite samples throughout the monitoring event.

The Monitoring Center will contain sampling equipment connected to sampling vaults for Stations 1-7 via a 3-inch electrical conduit. Runoff will flow through a 6-inch PVC pipe to the primary sampling area, into a collection box, through a 12-inch PVC pipe for 12 feet (1 foot per inch) to produce laminar flow. The runoff will then pass through a Thel-Mar weir and bubbler to measure the stage within the 12-inch conduit. Once the pressure in the bubbler has reached its trigger threshold, the automated sampling equipment begins sample collection as the flow is released into a catch basin. Installed within each catch basin is an intake strainer attached to the poly intake tubing. This tubing is connected via the 3-inch conduit to each sampler's peristaltic pump, located in the Monitoring Center, which then discharges programmed aliquots into the sample bottles.

Enclosures for sampling equipment are installed on concrete pads at sampling sites 8, 9, and 10. Within each enclosure is a sampler flow meter typical. At Station 8, poly tubing will run from the enclosure through a 3 inch conduit to the sampling well of the input side of the filter basin. At Station 9, poly tubing will run from the shelter immediately to a small sampling well at the outlet of the rain garden. At Station 10, poly tubing will run from the enclosure immediately into a concrete collection bay from which samples will be drawn.

2.4.5 Telecommunications

Each sampler will have an internal phone modem connected to a phone line for the purpose of remote programming, control, and monitoring of sampler and flow meter. Flowlink software, located on a base computer, will be used to call the samplers to download and store flow and sonde data. Data will be transferred periodically from the intermediate Flowlink database to the working Hydstra database.

Current flow conditions, total rainfall, and sample history can be remotely viewed using the Flowlink Software. In addition, a sampler pacing can be set remotely if last-minute pacing modifications are necessary due to changing storm conditions.

2.4.6 Rain Gauges

A tipping bucket rain gauge is employed on the District's campus gauge farm. The rain gauges used for this program will log and transmit every 0.2 millimeters of rain. This data will be stored in the Hydstra program database. The processing of the rainfall data into intensity and cumulative totals for each aliquot will be triggered when the flow and sonde data is imported from the intermediate Flowlink database into Hydstra.

2.4.7 Power

The automated sampling equipment and flow meters will be powered by electrical connection to the District's facility buildings. Stations 1-7 will be wired to the primary sampling area structure. Station 8 has power running from the primary sampling structure to the concrete pad. Stations 9 and 10 will be wired to Building 1.

2.4.8 Equipment Security Housing

Equipment at Stations 1-7 will be housed in the Monitoring Center, which is secured by the campus security alarm system. For Stations 8-10, fiberglass enclosures will be installed. The enclosures will house all monitoring equipment and will be locked and bolted to the concrete pads to secure the monitoring equipment.

3.0 CONSTITUENTS

Constituents to be analyzed in this project, along with their analytical methods and target reporting limits are presented in Table 3-1.

3.1 ANALYTICAL CONSTITUENTS

Table 3-1 provides constituents to be monitored under this program, along with analytical methods (CFR 2011) and reporting limits. Constituent lists will be reviewed annually along with the accumulated data. Constituents will be removed from the list for a given BMP type (porous pavement, planter box, or filter basin) when three consecutive non-detects are observed at both the control (or influent) station and all of the corresponding BMP monitoring sites.

Table 3-1: Selected Analytical Constituents

Constituent	Unit	Method	Target Reporting Limit*	Sample Container
Conventional				
Conductivity	µmhos/cm	Field Meter	±1.0	N/A
pH	pH Units	Field Meter	±0.1	N/A
Temperature	°C	Field Meter	±0.1	N/A
Turbidity	NTU	Field Meter	±0.5	N/A
Dissolved Oxygen	mg/L	Field Meter	±0.1	N/A
Hardness as $CaCO_3$	mg/L	SM 3120B	1.0	1 Liter Polypropylene Bottles
Total Dissolved Solids (TDS)	mg/L	SM 2540C	10	
Total Suspended Solids (TSS)	mg/L	SM 2540D	0.5	
Dissolved Organic Carbon (DOC)	mg/L	SM 5310B	0.6	
Total Organic Carbon (TOC)	mg/L	SM 5310B	0.6	
Oil & Grease (O&G)	mg/L	EPA 1664A	1.4	1 Liter H_2SO_4 Amber Glass Bottle
E. coli	MPN/ 100mL	SM 9221E	2	120 mL $Na_2S_2O_3$ preserved poly Bottle
Nutrients				
Ammonia as Nitrogen (NH_3-N)	mg/L	SM 4500 NH3H	0.01	1 Liter Polypropylene Bottles
Nitrate as Nitrogen (NO_3-N)	mg/L	EPA 300.0	0.01	
Total Kjeldahl Nitrogen (TKN)	mg/L	EPA 351.2	0.1	
Total Phosphorous	mg/L	SM4500P B E	0.05	
Dissolved Ortho-Phosphate	mg/L	SM4500P E	0.01	

*Reporting limits in this table represent the SWAMP required reporting limits unless laboratory reporting limits are more stringent. Laboratory analysis of constituents will attempt to meet these reporting limits. Please note that pH, temperature, metals (dissolved and total) and petroleum products do not have SWAMP required reporting limits.

Table 3-1: Selected Analytical Constituents (continued)

Constituent	Unit	Method	Reporting Limit*	Sample Container
Metals (total recoverable & dissolved)				
Arsenic (As)	µg/L	EPA 200.8	1	1 Liter Polypropylene Bottles
Cadmium (Cd)	µg/L	EPA 200.8	0.25	
Chromium (Cr)	µg/L	EPA 200.8	0.5	
Copper (Cu)	µg/L	EPA 200.8	0.5	
Iron (Fe)	µg/L	EPA 200.8	50	
Lead (Pb)	µg/L	EPA 200.8	0.5	
Manganese (Mn)	µg/L	EPA 200.8	10	
Nickel (Ni)	µg/L	EPA 200.8	1	
Zinc (Zn)	µg/L	EPA 200.8	1	
Zinc (Zn)	µg/L	EPA 200.8	1	
Petroleum products				
TPH (diesel)	mg/L	EPA 8015	5	1 Liter H_2SO_4 Amber Glass Bottle
TPH (motor oil)	mg/L	Calculated	5	

*Reporting limits in this table represent the SWAMP required reporting limits unless laboratory reporting limits are more stringent. Laboratory analysis of constituents will attempt to meet these reporting limits. Please note that pH, temperature, metals (dissolved and total) and petroleum products do not have SWAMP required reporting limits.

3.2 ANALYTICAL METHODS

Analytical methods presented in Table 3-1 are suggested USEPA analytical methods for constituents analyzed (CFR 2011). SWAMP recommended target reporting limits are also included, unless laboratory limits are lower. Sample analysis will be conducted by Edward S. Babcock and Sons Laboratories, Inc. (Babcock)[2]. Babcock will attempt to meet the SWAMP target reporting limits for each analyte. Laboratory reports and a SWAMP compatible electronic data deliverable (EDD) shall be delivered by the laboratory within four weeks of sampling events.

3.3 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are quantitative and qualitative statements that define project objectives and specify the acceptable ranges of field sampling and laboratory performance. Numeric DQOs for the constituents being analyzed are listed in Table 3-2.

3.3.1 Composite Sample Representativeness

A flow-weighted composite sample consists of a mixture of constant volume aliquots collected at variable time intervals. For example, at higher flow rates (i.e., larger cumulative volume), the aliquot times are more closely spaced. The resulting composite is representative of the average concentration throughout the storm hydrograph.

[2] An analytical laboratory certified by the National Environmental Laboratory Accreditation Conference, NELAP No. 0201CA, California ELAP No. 2698, and EPA No. CA00102.

The representativeness of any composite sample is dependent upon many factors, but is most heavily dependent upon:

- The spacing of samples collected relative to the hydrograph, and
- The number of samples collected during the event.

Generally, relatively fewer samples can be collected provided they represent the significant periods of the event; the rising stage and the peak(s). Immediately following sample collection, composite sample representativeness will be evaluated by comparing the first sample aliquot times to the flow start times and confirming that sample aliquots are collected throughout the flow event. If significant portions of a storm are not represented in the sample, because of equipment malfunction or operator error, the sample may not be considered representative and may not be analyzed. The decision to analyze samples with questionable representativeness will be made by technical staff responsible for the operation of the sample process and NPDES management staff.

3.3.2 Reporting Limits, Accuracy, Precision, and Completeness

Numerical DQOs for constituent reporting limits, precision, accuracy, and completeness are summarized in Table 3-2.

Table 3-2: Data Quality Objectives

Constituent	Reporting Limit*	Units	Accuracy (Recovery)	Precision (% RPD)	Completeness	Holding Time
CONVENTIONALS (WATER ANALYSIS)						
Conductivity	±1	µmhos/cm	N/A	N/A	90%	N/A Field Meter
pH	±0.1	pH Units	N/A	N/A	90%	N/A Field Meter
Temperature	±0.1	° Celsius	N/A	N/A	90%	N/A Field Meter
Turbidity	±0.1	NTU	N/A	N/A	90%	N/A Field Meter
Dissolved Oxygen (DO)	±0.1	mg/L	N/A	N/A	90%	N/A Field Meter
Total Hardness as $CaCO_3$	1.0	mg/L	80-120%	0-25	90%	6 Months
Total Dissolved Solids (TDS)	1.0	mg/L	80-120%	0-25	90%	7 Days
Total Suspended Solids (TSS)	0.5	mg/L	80-120%	0-25	90%	7 Days
Dissolved Organic Carbon (DOC)	0.6	mg/L	80-120%	0-25	90%	28 Days
Total Organic Carbon (TOC)	0.6	mg/L	80-120%	0-25	90%	28 Days
Oil & Grease	1.0	mg/L	50-150%	0-25	90%	28 days
E. coli	2	MPN/100mL	N/A	N/A	90%	6 Hours
NUTRIENTS (WATER ANALYSIS)						
Ammonia as Nitrogen (NH_3-N)	0.01	mg/L	80-120%	0-25	90%	48 Hours/28 Days[(a)]
Nitrate as Nitrogen (NO_3-N)	0.01	mg/L	80-120%	0-25	90%	48 Hours
Total Kjeldahl Nitrogen (TKN)	0.10	mg/L	80-120%	0-25	90%	7 Days/28 Days[(a)]
Total Phosphorous	0.03	mg/L	80-120%	0-25	90%	28 Days
Dissolved Ortho-Phosphate	0.01	mg/L	80-120%	0-25	90%	48 Hours
METALS (WATER ANALYSIS)						
Total and Dissolved Trace Metals	0.02 - 5.0	µg/L	75-125%	0-25	90%	48 Hours/6 Months[(a)]
PETROLEUM PRODUCTS (WATER ANALYSIS)						
TPH (diesel)	0.05	mg/L	50-150%	0-25	90%	7 Days/40 Days[(a)]
TPH (motor oil)	0.05	mg/L	50-150%	0-25	90%	7 Days/40 Days[(a)]

* Reporting limits in this table represent the SWAMP required reporting limits unless laboratory reporting limits are lower. Laboratory analysis of constituents will attempt to meet these reporting limits. Please note that pH, temperature, metals (dissolved and total) and petroleum products do not have SWAMP required reporting limits.

(a) The first time period represents the holding time for the preparation, preservation, or extraction required by the method; and the second time period represents the holding time for the analysis given that the appropriate preparation was conducted.

4.0 PREPARATION AND LOGISTICS

This section is based on the following SWAMP procedures: Mobilization Criteria; Laboratory Coordination; Equipment Cleaning, Calibration, and Maintenance; Health and Safety protocols; and Field QA/QC procedures.

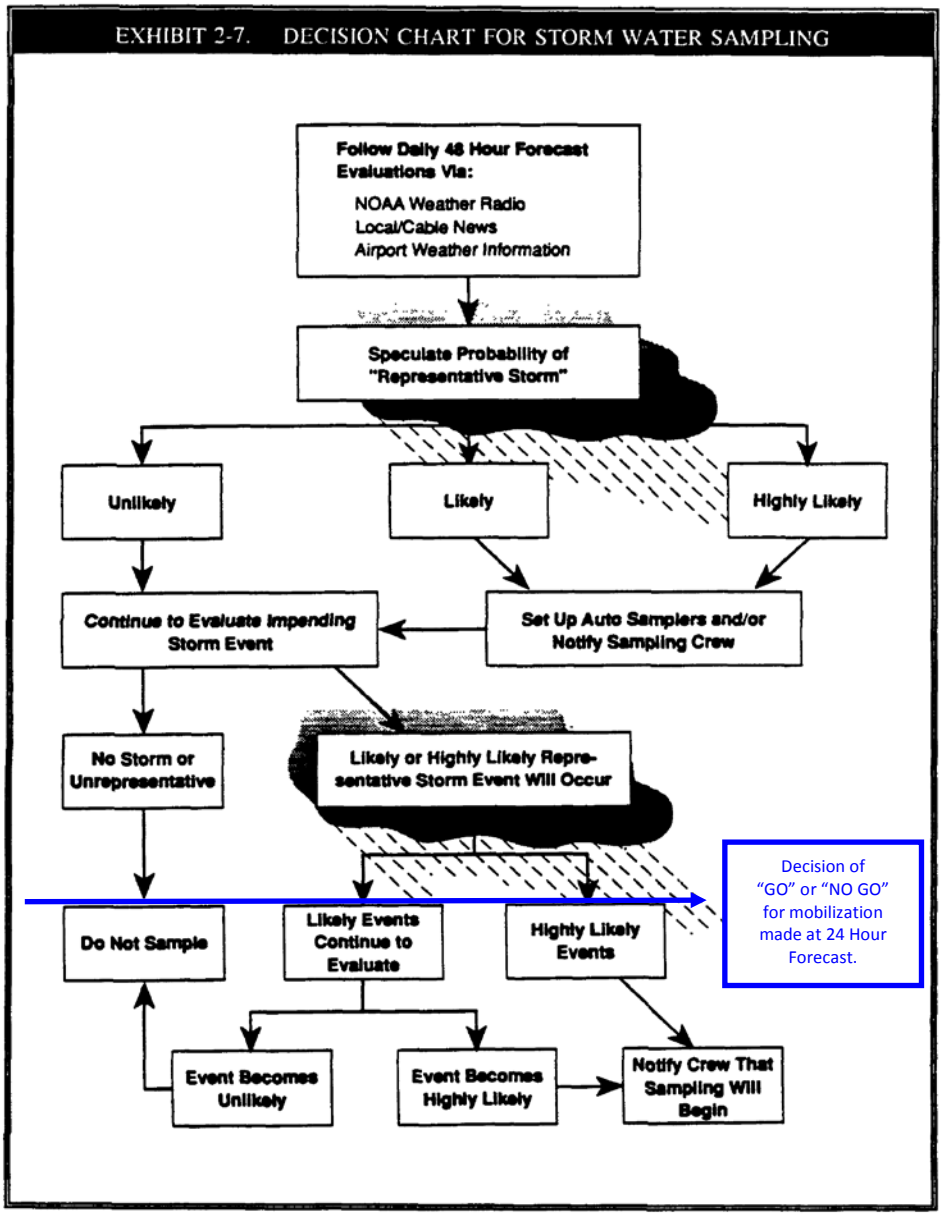
As the ten monitoring stations for this LID project are located at the District offices all equipment, manuals and protocols are onsite and available for field personnel use during all sampling activities. Each monitoring station also has a field notebook where observations and O&M logs are kept. A Master Project notebook is also kept with overall project information, a copy of this MP, the QAPP, and Appendix J to Volume II of the Riverside County CMP (District Health and Safety Procedures).

4.1 MOBILIZATION CRITERIA

If a storm event is forecasted by the NWS QPS to be greater than 0.1" within the next 48 hours and there is at least 72 hours between the forecasted event and a previous measurable (>0.1") rainfall event:

- The District will follow the procedure outlined in Exhibit 2.7 of USEPA NPDES Storm Water Guidance Document (EPA 833-B-92-001) included below as Figure 4-1;
- Pursuant to EPA 833-B-92-001, a representative event is between:
    - 0.27" in 6 hours; and
    - 0.81" in 18 hours, when possible.
- Pursuant to NWS standard practice, "Likely" represents a Probability of Precipitation (PoP) of at least 60%.

Figure 4-1: USEPA Decision Chart for Storm Event Sampling



Field Teams will not be mobilized during or near certain holidays.[3] This includes the following days of each year:

- Thanksgiving (fourth Thursday and Friday of November)
- Christmas Eve (December 24th) and Christmas Day (December 25th)
- New Year's Eve (December 31st) and New Year's Day (January 1st)
- President's Day (third Monday of February)

[3] These holidays may also coincide with Laboratory holidays.

4.2 STATION PREPARATION

Prior to storm events, sampling equipment and stations will be ready to monitor. District personnel will visually check the monitoring locations, catch basins, and sampling points to ensure they are clear of obvious debris and in working order.

4.2.1 Equipment Cleaning, Calibration, and Maintenance

Preparations will include equipment inspection, maintenance, and/or calibration, entering the correct "Volume to Sample" values.

New, certified-clean, bottles will be used for all samples. Sample tubing will be replaced each year or as needed. Equipment that does not contact samples, such as the sampler bodies and the Monitoring Center will be kept clean and orderly. All equipment will be maintained according to manufacturer specifications. Temperature, pH, DO, and EC meters will be calibrated according to the manufacturer's recommended protocols. Equipment maintenance and calibration shall be performed by District staff during dry weather and no more than seven days before a monitoring event. The District will install any replacement parts as necessary. Calibration logs will be kept with the project file.

4.2.2 Sample Labels

All samples bottles will be labeled with the following information:

- Project name
- Station ID
- Event number
- Sample date
- Sample time
- Bottle __ of __
- Sampler's initials
- Analyses

Sample Identification numbers (Sample IDs) will follow the process describe in the CMP (RCFC&WCD 2014).

4.2.3 Monitoring Equipment Checklist

Field crews shall ensure equipment is either on site prior to mobilization or is brought to the site when mobilization occurs. The following list of equipment shall be present during all Wet Weather sampling events at the Project:

- All required bottles for sampling, properly labeled (and additional spare bottles/labels);
- Cable ties;
- Powder free protective gloves;
- Ice and coolers;
- Reagent-grade, analyte-free, de-ionized water;
- First aid kit;
- Personal rain gear;
- Flashlights (2);
- A mobile communication device;
- Any additional safety gear reasonably necessary for safe sampling at the facility;

- Indelible markers;
- Field data Sheets;
- COCs; and
- Digital camera.

4.3 LABORATORY COORDINATION

The District will notify the laboratory before any mobilization occurs. The laboratory will provide bottles for sample collection, including one field blank per event. District field crews will notify the laboratory after samples are collected and before they are to be delivered to the laboratory. The laboratory will ensure that appropriate staff is present to meet District field crews for relinquishment of samples. District field crews will deliver samples to the laboratory in coolers on ice. The laboratory will provide the District with a copy of the COC upon acceptance of samples. The laboratory will provide the District analytical results within four (4) weeks of samples being delivered.

4.4 HEALTH AND SAFETY PROTOCOLS

Health and safety protocols are based on SWAMP procedures and the Riverside County CMP (RCFC&WCD 2014). For the complete discussion of health and safety protocols, see Appendix J to Volume II of the Riverside County CMP. The CMP is available to all field personnel during sampling events at the District offices where the LID project is located; Appendix J to Volume II of the CMP is included in this MP as Attachment B. Important health and safety procedures include:

- Driving carefully to and from sampling site and always being wary of traffic when on foot;
- Wearing gloves, proper raingear, appropriate footwear, and proper head and eye protection when necessary;
- Always watching your step, avoid walking through moving water if possible;
- Employing proper bending and lifting techniques, including bending at the knees.

IF AN INJURY OCCURS, A SUPERVISOR MUST BE NOTIFIED IMMEDIATELY

5.0 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

This section addresses Quality Assurance/Quality Control (QA/QC) activities associated with both field sampling and laboratory analyses. The field QA/QC samples are used to evaluate potential contamination and sampling errors introduced prior to submittal of the samples to the analytical laboratory. Laboratory QA/QC samples provide information to assess potential laboratory contamination, analytical precision, and accuracy.

5.1 FIELD SAMPLING QA/QC

Sampling crews are required to wear powder free gloves, change them between each sample or potential contact with a contaminant, and to follow the protocols for water quality sampling, as discussed in Section 2.3 of this Monitoring Plan.

Two types of QA/QC samples will be collected:

- **Field Blanks** – Field blanks verify that field conditions, field sampling activities, and air deposition are non-contaminating. A sample bottle is filled with reagent-grade, analyte-free de-ionized water in the field during a sampling event. One field blank will be collected during each event.
- **Equipment Blanks** – Equipment blanks verify that the sampling containers and tubing are contaminant free prior to sampling. After installation of new sample tubing each year, one equipment blank will be collected by sampling de-ionized water at one station.

5.2 LABORATORY QA/QC

All samples will be recorded on a COC, and placed in a cooler filled with ice for transportation to Babcock Laboratory, a California-certified laboratory located in Riverside, California, in accordance with ASTM D 4840 for COC protocols (ASTM International 1999). Laboratory analytical QA/QC procedures are available upon request to Babcock Laboratories.

5.3 CORRECTIVE ACTIONS

Corrective action is taken when an analysis is deemed suspect for some reason. The reasons include exceedances of the RPD ranges, spike recoveries, and blanks. The corrective action varies somewhat from analysis to analysis, but typically involves the following:

- Check of procedure
- Review of documents and calculations to identify any possible error
- Error correction
- Re-analysis of the sample extract, if available, to see if results can be improved
- Complete reprocessing and re-analysis of additional sample material, if it is available

Any failures (e.g., instrument failures) that occur during data collection and laboratory analyses will be assessed in order to make improvements. In the case of field instruments, problems may be addressed through instrument cleaning, repair, or replacement of parts or the entire instrument, as warranted. Field crews will carry basic spare parts and consumables with them, and will have access to spare parts to be stored at the office. Records of all repairs or replacements of field instruments will be maintained at the District. The laboratory has procedures in place to follow when failures occur, and will develop appropriate documentation for action.

6.0 DATA MANAGEMENT

6.1 DATA MANAGEMENT

Water quality data management will be initiated through the use of COCs and field data sheets during monitoring and sample relinquishment to the laboratory. The COC form for this Project is attached in Appendix A of the QAPP. The Field Data Sheet is located in Attachment A of this Monitoring Plan. Overall sample handling and management of data will be consistent with SWAMP procedures for water monitoring projects.

Analytical data quality control checks will be conducted by the laboratory and the District. The laboratory will provide data to the District in both an SWAMP-compatible electronic data deliverable (EDD) and electronic laboratory reports within four weeks of a monitored event.

The District will develop notes and a discussion of the storm and monitoring activities, field data sheets, equipment calibration logs, difficulties encountered, hydrographs, and flow data. The District will conduct QA/QC of flow data and hydrographs. Flow data will include the following:

- Flow measurement based on 20-minute intervals (or less)
- Minimum and maximum flow rates
- Cumulative rainfall
- Rainfall intensity

7.0 REFERENCES

ASTM International. ASTM D 4840, "Standard Guide for Sampling Chain-of-Custody Procedures." December 10, 1999.

Code of Federal Regulations (CFR). 40CFR122.21 (g)(7)(ii) – Subpart B-permit application and special NPDES program requirements. July 1998.

Code of Federal Regulations (CFR). 40CFR136 – Guidelines establishing test procedures for the analysis of pollutants. November 2011.

CValdo Corporation. Project Specific Water Quality Management Plan for RCFC&WCD LID Testing and Demonstration Facility/Parking Renovation Plan. November 2009.

Riverside County Flood Control and Water Conservation District (RCFC&WCD). "Riverside County Consolidated Monitoring Plan (Revised)". June 2012.

RCFC&WCD. "Riverside County Flood Control and Water Conservation District Project Assessment and Evaluation Plan (PAEP) for Low Impact Development Integrated Management Practices Testing and Demonstration Facility." January 2010.

Santa Ana Watershed Project Authority. State Water Board Grant Agreement No. 09-346-550. Executed July 21, 2010.

San Bernardino County Flood Control District (SBCFCD). Monitoring Plan – San Bernardino Low Impact Development Training and Guidance Program. September, 2008.

United States. Environmental Protection Agency (USEPA). NPDES Storm Water Sampling Guidance Document (EPA 833-B-92-001). July 1992.

Attachment A

Riverside County Flood Control and Water Conservation District

Field Data Logs

Riverside County Flood Control & Water Conservation District

SAMPLING DATA LOG– LID BMP FACILITY

I. Storm Event Empirical Observations for Study Area

GENERAL INFORMATION:

Project Name: LID BMP Testing Facility	**Site Nos.:** **601, 602, 603, 604, 605, 606, 607, 608, 609, 610**	
Date (mm/dd/yyyy):	**Time in:**	**Time out:**
Team Member Initials:	**Agency/Consultant:**	
Other Personnel:	**Temperature:**	

Event Type (check all that apply):

- ☐ Storm Event (flow & sonde data only)
- ☐ Storm Event (flow, sonde & samples taken)
- ☐ Pre-season sampling event (explain in Notes)
- ☐ Calibration Event (flow &/or sondes only)
- ☐ Special inspection (explain in Notes)
- ☐ Maintenance

HYDROLOGIC AND HYDRAULIC CHARACTERISTICS:

Flow conditions (*check all that apply)*:

- ☐ Runoff entering facility
- ☐ Flow distributed uniformly throughout study area
- ☐ Flow not uniformly distributed throughout study area

If flow is not uniformly distributed throughout the study area, describe distribution (e.g., where concentrated, where channelized, approximate dimensions and depths of concentrations and/or channel):

Flow conditions (continued, *check all that apply)*:

- ☐ Water flowing through study area at a perceptible velocity
- ☐ Facility discharging
- ☐ Flow bypassing facility
- ☐ Flow overtopping facility

Comments:

Present rainfall: ☐ None ☐ Intermittent ☐ Light (averaging <0.05 cm/hour) ☐ Moderate (averaging ~ 0.05-0.18 cm/hour) ☐ Heavy (averaging > 0.18 cm/hour)

Meteorological characteristics comments:

Photos taken:

Notes:

_____

(Team Leader's Signature)

SAMPLING DATA LOG– LID BMP FACILITY

II. During Storm

GENERAL INFORMATION:

Date (mm/dd/yyyy):	**Time** (24-hr):
Team Member Initials:	**Agency/Consultant**:
Project Name: Low Impact Development	**Site No.:**

METEOROLOGICAL CHARACTERISTICS:

Time since end of previous storm event: ☐ > 72 hours ☐ 48-72 hours ☐ 24-48 hours ☐ < 24 hours

QPS set at _____ inches

Pacing = _____ liters per _____ minutes OR _____ acre feet

FLOW AND FIELD MEASUREMENTS (take at least once per monitoring event) :

Presence of oil (extent):

Floating Material:

Other observations (water color, turbidity, erosion, odor, etc):

Flow Level Calibration Measurements *(at least one hand reading per storm – QA/QC on Level Calibration)*		**Turbidity Reading**		**Sample Times (24 hrs)**	
Flow Level (flow meter, ft)	**Hand Level** (ruler, ft)	**Time**	**NTU**	**Grab:** (O&G, *E. coli*)"	
				Peak:	
				Last Aliquot:	

Notes/Comments/System Modifications:

_____

(Team Leader's Signature)

SAMPLING DATA LOG– LID BMP FACILITY

III. Post-Storm

GENERAL INFORMATION:

Date (mm/dd/yyyy):	**Time** (24-hr.):
Team Member Initials:	**Agency/Consultant:**
Site Name:	**Site No.:**

End of Storm Information:

Total flow volume:		Total Rainfall (inches):	
Total aliquots attempted:		Flow duration Start (date/time):	
Total aliquots missed:		Flow duration Stop (date/time):	
Total aliquots collected:		Total flow duration (hh:mm):	
Time first aliquot collected:		Approx collected sample volume (L):	
Time last aliquot collected:		Approx volume overflowed (L):	
Rain Duration Start (date/time):		# bottles & size sent to Lab: (#, size)	
Rain Duration Stop (date/time):			
Total rain duration (hh:mm):			

Aliquot Sample ID	Time Collected	% Composite Sample	Comments

Notes/Comments:

_____
(Team Leader's Signature)

Attachment B

Riverside County Flood Control and Water Conservation District

Health and Safety Procedures

APPENDIX J:

HEALTH AND SAFETY PROCEDURES



4. CONSOLIDATED MONITORING PROGRAM

A. Health and Safety

The information provided in this section are general safety guidelines. Additional, site-specific safety instructions are provided for most CMP stations. This guidance is available in David Ortega's (951-955-4390) office.

Safety of the sampling team is paramount. The field vehicle should start out with a full tank of gas and be in good repair. Extra care must be taken when driving at night or in the rain. If the sampling location is unsafe, make note of the unsafe situation and either do not collect a sample or come back after the hazardous situation has ceased.

1. Before You Leave

1.1 Always let someone else at the office know where you are, what your intended route or set of activities is, when you intend to return, and what to do if you don't come back at the appointed time. If in rough terrain, communicate with base when leaving and arriving at sampling sites.

1.2 Inspect the vehicle prior to leaving base. Make sure communication equipment and vehicle are in proper working condition. All safety equipment should be in the vehicle. Gas up the vehicle before you leave.

1.3 Know your equipment, sampling instructions, and procedures before going out into the field. Prepare labels, calibrate field meters, and clean equipment before you get started.

1.4 Know how to use and store chemicals. Do not expose chemicals or equipment to temperature extremes or long term direct sunshine.

2. Arriving at the Sampling Location

2.1 Prior to sampling, always assess the situation at the site. If it is unsafe, move on and return later or find a safer alternate location that will give comparable water quality results. If the situation remains unsafe, record the hazardous conditions in the *Field Data Sheet*, including photos, and do not collect a sample. **Your safety is more important than the data.**

2.2 If visibility is poor, use the vehicle lights to sweep the sampling site for safe entry and to illuminate the path. Use flashlights for additional lighting.

2.3 Do not cross low water crossings as the depth of the water and the integrity of the underlying roadway is uncertain. Floating debris may damage the vehicle or even push it from the roadway. Water as shallow as two feet deep can float a car.

2.4 Never cross private property without the permission of the landowner. Carry your employee identification card with you.

2.5 Watch for irate dogs, farm animals, wildlife, and insects such as ticks, hornets, wasps, and bees. Know what to do if you get bitten or stung.

3. Sampling Safety

3.1 When working with potentially hazardous materials, follow EPA, OSHA, and specific health and safety procedures. HAZWOPER certification is required if you will be sampling potentially hazardous materials.

3.2 Confined space entry is not allowed.

3.3 Avoid contact between chemical reagents and skin, eyes, nose, and mouth.

3.4 Know chemical cleanup and disposal procedures. Wipe up all spills when they occur.

3.5 Monitoring should be a team activity. Two person teams are required for night and wet weather sampling.

3.6 If you have health considerations such as epilepsy, severe allergies, or diabetes, let your partner know, as well as instructions on what to do if you need emergency assistance.

3.7 If in an active traffic area, cones should be placed around the parked vehicle, and personnel should be wearing reflective clothing. Make sure you are visible to passing traffic. Do not stand in front of the vehicle while sampling; better yet, park the vehicle a safe distance away. If visibility is poor, use flashlights when walking to and from the sampling site.

3.8 If sampling from a bridge, be wary of passing traffic, and personnel should be wearing reflective clothing. Never lean over the bridge rails unless you are firmly anchored to the ground or the bridge with good hand/foot holds. Never stand in front of the vehicle while sampling if it is parked on the bridge. Place flashing lights upload when sampling off a roadway bridge. If visibility is poor, use flashlights when walking to and from the sampling site.

3.9 The person performing the sampling should be properly secured, such as on a lifeline, and be wearing adequate protective equipment.

3.10 Stay out of the channel if at all possible. Dip sample rather than enter the channel.

3.1 If you must enter the channel, use two hands to descend and ascend the iron ladder attached to the channel wall. Have your partner lower the sample bottles in an ice chest attached to a rope.

3.12 Test the traction before walking down a slope.

3.13 Do not walk on unstable stream banks. Disturbing these banks can accelerate erosion, contaminate your sample, and might prove dangerous if a bank collapses.

3.14 Be very careful when walking in the stream itself. Rocky-bottom streams can be very slippery and can contain deep pools; muddy-bottom streams might also prove treacherous in areas where mud, silt, or sand have accumulated in sink holes. If you must cross the stream, use a walking stick to steady yourself and to probe for deep water or muck. Your partner(s) should wait on dry land ready to assist you if you fall. Never wade in swift or high water. A rule of thumb used by USGS is to not attempt wading in a stream where the depth multiplied by the velocity is equal to or greater

than 10 sq ft/s. Watch the stream stage, especially if there is a chance it could rise rapidly.

3.15 Wear hip boots or chest waders. Boots and waders protect against contaminants, cold, and underwater objects. Be aware that traction may be impaired while wearing them. Do not allow water to get into the boots or waders.

3.16 If sampling at night, carry a bright flashlight or use a head-mounted lantern. Avoid shining the light in others' eyes.

3.17 Do not go sampling if severe weather is predicted. If there is active lightning, find cover to avoid being struck.

3.18 Watch for poison ivy, oak or sumac, and other types of vegetation in your area, such as nettles, that can cause rashes and irritation.

3.19 Never drink the water in a stream, no matter how pristine the environment appears. Assume it is unsafe to drink, and bring your own water or sports drink from home. After monitoring, wash your hands with antibacterial soap.

3.20 The ideal comfort range for humans is between 60 and 90 degrees Fahrenheit. Hypothermia (cold) and hyperthermia (heat) may occur outside this range. Be aware of the symptoms of either and leave the sampling area if symptoms begin to appear.

3.21 If you become injured in the field, contact your supervisor or another supervisor for instructions. Contact the nearest worker's compensation medical clinic (Appendix D.4) for an appointment. If the injury creates an emergency situation, call 911 and contact the District after the situation is stabilized.

Medical Referral for Treatment of Work-related Injuries or Illnesses

The treatment of work-related injuries or illnesses is handled through the County of Riverside Human Resources Department, Workers' Compensation Division.

The following website will locate the closest medical provider. The Medical Provider Network (MPN) includes the Kaiser Occupational Clinics in Riverside and Fontana. Upon clicking the link below, the MPN search page will load. Simply type in the name of the provider or choose a specialty option and click "Find Providers". An option to adjust the range of the search is also provided by utilizing the "within miles" tool.

http://www.compcaremed.com/riverside/

More information on the MPN is accessible on the County's workforceExchange Website:

http://www.workforceexchange.net/HRToolbox/WorkersCompensation/MedicalProviderNetwork/tabid/1632/Default.aspx

Questions regarding the MPN program may be answered by contacting the following:

CorVel Corporation, MPN Department	800-966-5307
Riverside County Workers' Compensation Division (HR Dept)	951-955-3530

Appendix 5G.2 – Riverside County Flood Control & Water Conservation District LID Demonstration Facility QAPP

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LOW IMPACT DEVELOPMENT (LID) BEST MANAGEMENT PRACTICE (BMP)

DEMONSTRATION & TESTING FACILITY

QUALITY ASSURANCE PROJECT PLAN (QAPP)

LID BMP WATER QUALITY MONITORING PROJECT

January 2013

Facility Construction Only
Grant Agreement No. 09-346-550
Water Quality Monitoring Only
Grant Agreement No. 06-229-554-2

Riverside County Flood Control
& Water Conservation District
1995 Market St.
Riverside, CA 92501

GROUP A ELEMENTS: PROJECT MANAGEMENT

1. TITLE AND APPROVAL SHEETS

Quality Assurance Project Plan

Project Name:	Riverside County Flood Control and Water Conservation District LID BMP Water Quality Monitoring Project
Proposal Identification Number:	
Date:	
Name of Responsible Organization:	Riverside County Flood Control and Water Conservation District (RCFC&WCD)

APPROVAL SIGNATURES

CONSTRUCTION/MONITORING GRANT ORGANIZATION:

Title:	Name:	Signature:	Date*:
SAWPA Grant Manager	Peter Vitt	Peter Vitt	2/21/13
RCFC & WCD Project Director/QA Officer	Jason Uhley	J Uhley	2/21/13
RCFC & WCD Project Manager	Arlene Chun	Arlene Ch	2/21/13

STATE WATER RESOURCES CONTROL BOARD (SWRCB):

Title:	Name:	Signature:	Date*:
Contract Manager	Danielle Siebel	Danielle Siebel	2/28/13
QA Officer	Renee Spears	Renee Spears	02.28.2013

*This is a contractual document. The signature dates indicate the earliest date when the project can start.

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Appendix A: Riverside County Flood Control and Water Conservation District LID BMP Testing Facility Monitoring Project Monitoring Plan (Jan 2013)
Appendix B: Babcock Laboratory Quality Assurance Manual

Acronyms and Abbreviations

Babcock	Babcock Laboratories, Inc.
BMP	Best Management Practice
CEDEN	California's Environmental Data Exchange Network
CEQA	California Environmental Quality Act
COC	chain of custody
CMP	Riverside County Consolidated Monitoring Plan
District	Riverside County Flood Control & Water Conservation District
DQOs	data quality objectives
EDD	electronic data deliverable
LCS	laboratory control sample
LID	low impact development
MP	Monitoring Plan
MS/MSDs	Matrix Spike/ Matrix Spike Duplicates
NPDES	National Pollutant Discharge Elimination System
Project	LID BMP Testing Facility Monitoring Project
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RCFC&WCD	Riverside County Flood Control and Water Conservation District
TPH	total petroleum hydrocarbons
SAWPA	Santa Ana Watershed Project Authority
SCCWRP	Southern California Coastal Water Research Project
SMC	Southern California Stormwater Monitoring Coalition
SOP	Standard Operating Procedure
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
USEPA	United States Environmental Protection Agency
µg/L	micrograms per liter
mg/L	milligrams per liter

3. DISTRIBUTION LIST OF APPROVED QAPP

Table 3-1: Approved QAPP Distribution List

Title:	Name (Affiliation)	Telephone Number	No. of Copies
SWRCB Grant Manager	Danielle Siebal	(916) 341-5658	1
SWRCB Program Analyst	Melissa Miller	(916) 993-3872	1
SAWPA Program Manager	Celeste Cantu	(951) 354-4229	1
SAWPA Grant Manager	Peter Vitt	(951) 354-4227	1
RCFC&WCD Project Director	Jason Uhley	(951) 955-1273	1
RCFC&WCD Project Manager	Arlene Chun	(951) 955-5418	1
Laboratory QA Officer	Stacey Fry	(951) 653-3351 ext. 238	1
Laboratory Project Manager	Joseph Morrison	(951) 653-3351 ext. 251	1

4. PROJECT/TASK ORGANIZATION

4.1 Involved Parties and Roles

The Project falls under two distinct and separate grants – one for its construction and one for water quality monitoring.

The Santa Ana Watershed Project Authority (SAWPA) is overseeing the construction of the Low Impact Development (LID) Best Management Practice (BMP) Project (Project). Celeste Cantu is the Project Director and has the responsibility of program oversight. Peter Vitt is the Grant Manager and is responsible for ensuring compliance with grant requirements including quarterly progress reporting.

Riverside County Flood Control and Water Conservation District (District) is the lead agency implementing the LID BMP Project and is responsible for CEQA compliance. Mark Zavislak is the District's Technical Project Manager and is responsible for oversight of field data collection at the Project and compliance with monitoring procedures in this Monitoring Plan, including flow and hydrograph data. Arlene Chun is the Project Manager and has the responsibility for overseeing all of the Project work items, providing coordination of participating entities, providing laboratory data to SCCWRP for reporting and analysis purposes, and providing quarterly construction progress reports to SAWPA. Jason Uhley is the District's Program Director and QA/QC Manager and is responsible for CEQA compliance and QA/QC of lab analysis data. Bob Cullen is the District's Design and Construction Director, responsible for overseeing the design and construction of the Project.

There are multiple consultants that are assisting with the Project. The CValdo Corporation is responsible for site design. Babcock Laboratories, Inc. (Babcock) will be conducting chemical analyses on BMP stormwater samples. Joseph Morrison is Babcock's Project Manager and is responsible for providing laboratory reports to the District.

Table 4-1: Personnel Responsibilities

Name	Organizational Affiliation	Title	Contact Information
Danielle Siebal	SWRCB	Grant Manager	Ph: (916) 341-5658 E-mail: dsiebal@waterboards.ca.gov
Melissa Miller	SWRCB	Program Analyst	Ph: (916) 993-3872 E-mail: mmiller@waterboards.ca.gov
Celeste Cantu	SAWPA	Project Director (Construction)	Ph: (951) 354-4229 E-mail: ccantu@sawpa.org
Peter Vitt	SAWPA	Grant Manager (Construction)	Ph: (951) 354-4227 E-mail: pvitt@sawpa.org
Ken Schiff	SCCWRP	SMC Project Director (Monitoring)	Ph: (714) 755-3202 E-mail: kens@sccwrp.org
Marc Rodabaugh	SBCFCD	SMC Project Manager (Monitoring)	Ph: (909) 387-8112 E-mail: marc.rodabaugh@dpw.sbcounty.gov
Jason Uhley	RCFC & WCD	Program Director and QA Officer	Ph: (951) 955-1273 E-mail: juhley@rcflood.org
Bob Cullen	RCFC & WCD	Project Director (Construction)	Ph: (951) 955-8170 E-mail: bcullen@rcflood.org
Arlene Chun	RCFC & WCD	Project Manager	Ph: (951) 955-5418 E-mail: abchun@rcflood.org
Mark Zavislak	RCFC & WCD	Technical Manager (Monitoring)	Ph: (951) 750-4350 E-mail:mzavisla@rcflood.org
Abigail Suter	RCFC & WCD	Lead Technician (Monitoring)	Ph: (951) 955-1734 E-mail: adsuter@rcflood.org
Joseph Morrison	Babcock	Laboratory Project Manager	Ph: (951) 653-3351 ext. 251 E-mail: hlee@babcocklabs.com
Stacey Fry	Babcock	Laboratory QA Officer	Ph: (951) 653-3351 ext. 238 E-mail: sfry@babcocklabs.com

4.2 Quality Assurance Officer Role

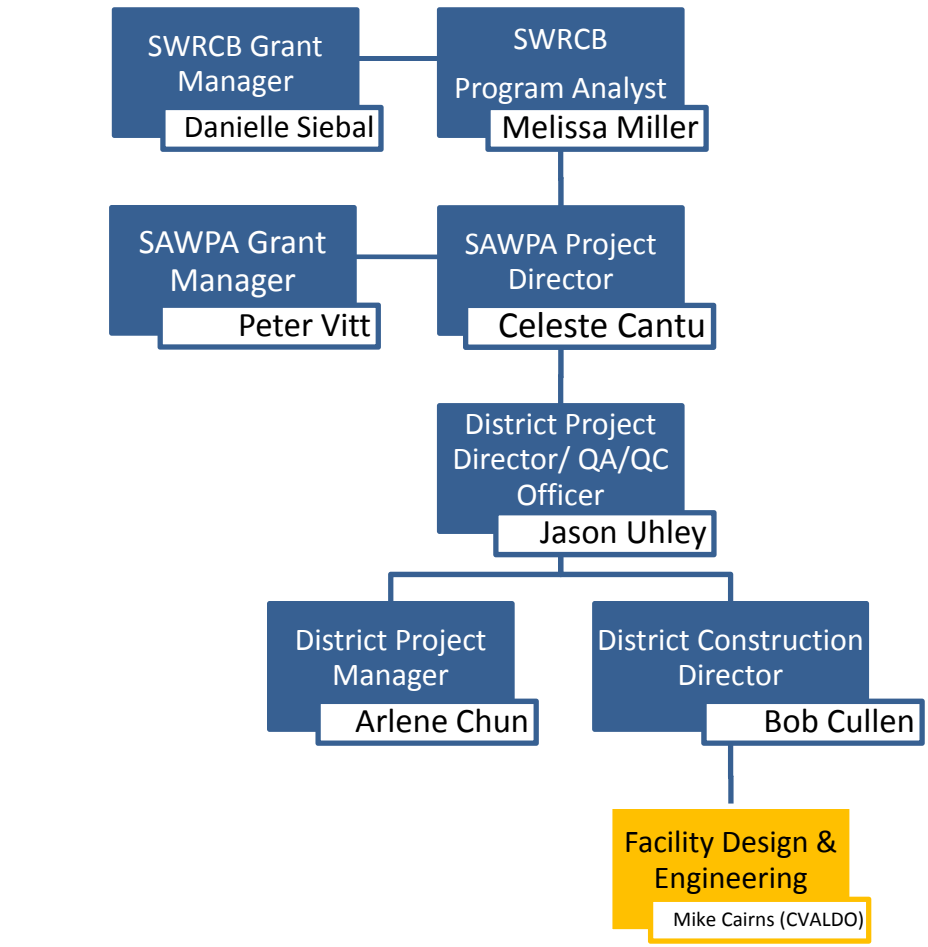
Jason Uhley is the District's Quality Assurance (QA) Officer for this project. The QA Officer's role is to establish the quality assurance and quality control procedures in this QAPP as part of the overall project. The QA officer will also review and assess all procedures during the project against QAPP requirements. The District's QA Officer will work closely with the consultants and laboratory to implement this project in compliance with the requirements of the QAPP. The District QA officer may stop all actions, including those conducted by any laboratory or consultant, if there are significant deviations from required practices or if there is evidence of a systematic failure.

Stacey Fry is Babcock's QA Officer for the laboratory analysis and electronic data management portion of the project. The QA officer will review and assess all procedures against QAPP requirements and will report all findings to the District's Project Manager, including all requests for corrective action.

4.3 Persons Responsible for QAPP Update and Maintenance

The District's Project Manager and QA Officer are responsible for creating and maintaining this QAPP. Changes and updates to this QAPP may be made by the District's Project Manager and QA Officer. The Project Manager will be responsible for making the changes and making sure these updates are provided to each of the participating agencies. Previous versions of the QAPP should be deleted from project files to avoid any confusion as to current versions of the QAPP.

Figure 4-1: Project Construction Organizational Chart

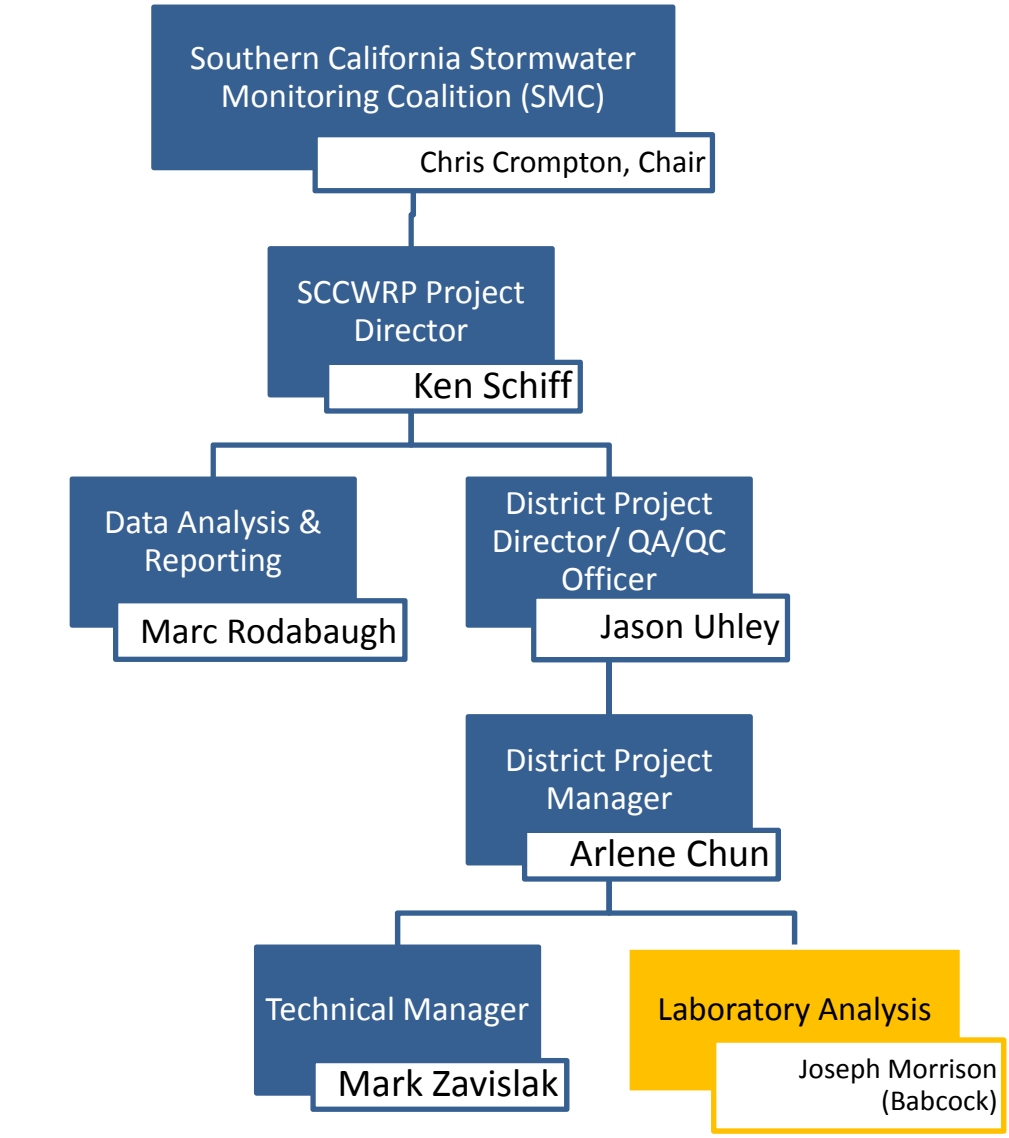


Notes:

= Government Agency

= Consultant

Figure 4-2: Project Water Quality Monitoring Organizational Chart



Notes:

= Government Agency

= Consultant

5. PROBLEM DEFINITION/BACKGROUND

5.1 Problem Statement

The District is comprised of 2,700 square miles and three distinct watersheds: Santa Margarita, Santa Ana, and Whitewater. The District extends from the northwest portion of Riverside County east to Desert Hot Springs and Palm Springs and south to San Diego County through the Temecula area.

The District has experienced a 14 percent increase in urban land use area since 1993, leading to an increase in the amount of impervious surfaces present within the District (RCFCWCD, 2009). In order to comply with the United States Environmental Protection Agency (USEPA) National Pollutant Discharge Elimination System (NPDES) Permits, many municipalities nationwide now incorporate BMPs into development projects in order to mitigate the water quality impacts of those developments. LID has been noted as a cost-effective means to reduce pollutant loads in storm water runoff; however, there is little data available on appropriate and cost-effective BMPs for a semi-arid environment with highly pervious soils, such as those found in and around the District.

5.2 Decisions or Outcomes

The goal of this study is to construct a facility with LID BMPs for demonstration purposes and to monitor the effectiveness of the BMPs during multiple wet seasons. The Project will help to achieve the Southern California Integrated Watershed Program (SCIWP) goals of basin water banking, programs for water conservation and efficiency and storm water capture and management, and planning and implementation of a flood control program to assist in abating the effects of waste dischargers into waters of the state. The centralized location is convenient for training residents, regulators, developers, municipal employees, and other interested stakeholders in greater Santa Ana Watershed, including Riverside, San Bernardino, and Orange Counties.

The monitoring program is designed to test the effectiveness of particular LID designs in the semi-arid environment of Southern California. Prior to employing specific types of LID for new developments and redevelopment areas, the District is constructing and monitoring test sites to determine the most effective BMPs for the District's area based on the vegetative and atmospheric conditions present in Southern California. The expected outcomes of the monitoring project are:

- Identify effectiveness of multiple LID BMPs to reduce the volume of storm water runoff
- Characterize BMP effectiveness to remove pollutants from storm water runoff
- Provide data to determine the most effective LID BMPs for areas with a climate similar to that of the semi-arid environment of Southern California

This project will provide information about BMP effectiveness. This information will be incorporated into the Southern California Stormwater Monitoring Coalition (SMC) Low Impact Development (LID) Project, in which the San Bernardino County Flood Control District is the administrative lead. (SBCFD, 2008)

5.3 Water Quality or Regulatory Criteria

The project is not a result of regulatory action. Water quality data collected in this project will not be compared to action limits or regulatory criteria. BMP water quality data will be compared to control site data in order to evaluate removal rates and overall BMP effectiveness. This project utilizes the target reporting limits provided by the California Surface Water Ambient Monitoring Program (SWAMP). Data gathered will be peer reviewed per SWAMP standards when applicable.

6. PROJECT/TASK DESCRIPTION

6.1 Work Statement and Produced Products

The District Project will be installed on the District's property at 1995 Market Street in Riverside, California. The general approach of this project is to monitor BMP sites and corresponding control sites in order to generate data to quantify the pollutant removal effectiveness, incidental volume reduction, and peak attenuation of various flow-through LID BMP technologies.

This project includes: (1) four pervious pavement BMPs; (2) a landscape filter basin (rain garden) with monitoring of the influent, effluent, and overflow; (3) a planter box capturing roof runoff; and (4) parking lot and roof runoff control sites. The BMPs were designed to meet the 0.2 inch-per-hour flow-based treatment requirements and the 85 percent volume based treatment requirements specified in the CASQA BMP Handbook for New Development and Redevelopment, Section 5.5.1. Design criteria of the LID technologies tested were determined by evaluating criteria and standards for LID BMP design features, as published in recognized design guidance manuals, or as previously established by other municipalities and government agencies. The pervious pavement BMPs will be lined with an impervious material to provide data reflecting the baseline effectiveness of the relative BMPs without the influence of the specific soils and geological features present on the site.

The BMPs will be monitored during a minimum of three storms during each fiscal year for five years, beginning in Fiscal Year 2012-2013. Wet weather events will be tracked to determine appropriate mobilization criteria for wet weather events during which sampling will occur.

6.2 Constituents to Be Monitored and Measurement Techniques

Samples will be analyzed for conventional constituents, nutrients, metals, and petroleum products. The constituent list is provided in Table 6-1. The analytical methods and/or measurement techniques are also contained in Table 6-1. The list of constituents will be reviewed annually with the cumulative results and may be reduced to reflect the most productive use of resources.

6.3 Project Schedule

Table 6-2 presents the anticipated project schedule.

Table 6-1: Selected Analytical Constituents

Constituent	Unit	Method	Reporting Limit*
Conventional			
Conductivity	µmhos/cm	Field Meter	±1.0
pH	pH Units	Field Meter	±0.1
Temperature	°C	Field Meter	±0.1
Turbidity	NTU	Field Meter	±0.5
Dissolved Oxygen	mg/L	Field Meter	±0.1
Hardness as $CaCO_3$	mg/L	SM 2340B	1.0
Total Dissolved Solids (TDS)	mg/L	EPA 160.1	1.0
Total Suspended Solids (TSS)	mg/L	EPA 160.2	0.5
Dissolved Organic Carbon (DOC)	mg/L	EPA 415.1	0.6
Total Organic Carbon (TOC)	mg/L	EPA 415.1	0.6
E. coli	MPN/ 100mL	SM 9221E	2
Oil & Grease	mg/L	EPA 1664A	1.0
Nutrients			
Ammonia as Nitrogen (NH3-N)	mg/L	EPA 350.3	0.01
Nitrate as Nitrogen (NO3-N)	mg/L	EPA 300.0	0.01
Total Kjeldahl Nitrogen (TKN)	mg/L	EPA 351.2	0.1
Total Phosphorous	mg/L	EPA 365.2	0.03
Dissolved Ortho-Phosphate	mg/L	EPA 365.2	0.01
Metals (Total Recoverable)			
Arsenic (As)	µg/L	EPA 200.8	0.5
Cadmium (Cd)	µg/L	EPA 200.8	0.03
Chromium (Cr)	µg/L	EPA 200.8	1.0
Copper (Cu)	µg/L	EPA 200.8	1.0
Iron (Fe)	µg/L	EPA 200.8	50
Lead (Pb)	µg/L	EPA 200.8	0.5
Manganese (Mn)	µg/L	EPA 200.8	10
Nickel (Ni)	µg/L	EPA 200.8	1.0
Zinc (Zn)	µg/L	EPA 200.8	5.0
Metals (Dissolved)			
Arsenic (As)	µg/L	EPA 200.8	0.5
Cadmium (Cd)	µg/L	EPA 200.8	0.03
Chromium (Cr)	µg/L	EPA 200.8	1.0
Copper (Cu)	µg/L	EPA 200.8	1.0
Iron (Fe)	µg/L	EPA 200.8	50
Lead (Pb)	µg/L	EPA 200.8	0.5
Manganese (Mn)	µg/L	EPA 200.8	10
Nickel (Ni)	µg/L	EPA 200.8	1.0
Zinc (Zn)	µg/L	EPA 200.8	5.0
Petroleum Products			
Total Petroleum Hydrocarbons (TPH) (diesel)	mg/L	EPA 8015	0.05
TPH (motor oil)	mg/L	EPA 8015	0.05

* The Reporting limits in this table represent the SWAMP-required reporting limits unless laboratory reporting limits are more stringent. Laboratory analysis of constituents will attempt to meet these reporting limits. Please note that pH, temperature, metals (dissolved and total), and petroleum products do not have SWAMP-required reporting limits.

Table 6-2: Project Schedule Timeline

Activity	Grant/Project Name	Responsible Entity	Entity Receiving Deliverable	Anticipated Date of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Start Project	Construction	District	N/A	7/21/2010	4/10/2012	N/A	N/A
GPS Information Provided for Site/ Monitoring Locations	Construction	District	SWRCB	4/30/2010	7/30/2010	GIS Data	Day 90, prior to first disbursement
CEQA/NEPA Documentation	Construction	District	SWRCB	3/01/2010	04/01/2010	CEQA/NEPA Exemption	30 days after initiation of project
Project Assessment and Evaluation Plan	Construction	District	SWRCB	7/21/2010	8/01/200	Project Assessment and Evaluation Plan	8/05/2010
Quarterly Reporting	Construction	District SAWPA	SAWPA SWRCB	7/21/2010	4/20/2013	Quarterly Report	20 days after the end of each Fiscal Year quarter
Monitoring Plan	Construction, SMC LID	District	SWRCB	7/21/2010	6/30/2012	Monitoring Plan	Prior to sampling efforts
Quality Assurance Project Plan	Construction, SMC LID	District	SWRCB	7/21/2010	6/30/2012	Quality Assurance Project Plan	Prior to sampling efforts
Constituent Analysis (Laboratory)	SMC LID	Babcock	District	10/01/2012	6/30/2018	Lab Report (1 electronic copy, 1 electronic data deliverable per site)	Within 4 weeks of receipt of samples
BMP Monitoring	SMC LID	District	SCCWRP	10/01/2012	6/30/2018	Post Storm Tech Memos (electronic)	Within 10 days of each event (file) July 31 annually (SCCWRP)
Annual Data Deliverable	SMC LID	District	SCCWRP	7/31/2013	7/31/2018	Complete data set per year of data collection	July 31 of each year
Draft Project Report	Construction	District	SAWPA	8/01/2012	1/31/2013	Draft Project Report	2/01/2013
Final Project Report	Construction	District	SAWPA	2/01/2013	2/28/2013	Final Project Report	3/01/2013

6.4 Geographical Setting

The Project location is at 1995 Market Street in Riverside, California. Riverside has a semi-arid Mediterranean climate with highly pervious soils. A map of the facility is located in Figure 10-1 of this QAPP.

6.5 Constraints

Construction of the Project must be completed by April 30, 2015, as required by the Construction Grant, in partnership with SAWPA. The monitoring portion of this Project is not a component of the Construction Grant, although submittal of this QAPP and corresponding Monitoring Plan is a deliverable for the Construction Grant. Monitoring and resulting data of the Project will be conducted under the umbrella of the SMC LID Project. Monitoring is expected to begin in fiscal year 2012-2013 and continue for five years.

Mobilization for this project will coincide with the District-led NPDES Permit monitoring programs. Attempted compliance with the USEPA-recommended storm criteria may result in some wet weather events not warranting mobilization. In addition, while forecasted precipitation amounts may fall within the USEPA-recommended storm criteria, actual rainfall amounts may measure outside the ranges for a USEPA-recommended storm. Typically, this cannot be determined until the wet weather event has subsided. As a result, certain wet weather events may not be consistent with the USEPA-recommended storm criteria.

Data from this study will be evaluated as part of the SMC LID Project. The SMC LID Project will provide a brief technical memorandum as the Final Long-Term Technical Memorandum and the full reporting of the data will be conducted under the San Bernardino Project. Thus, the District has limited control over data reporting.

7. QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

Data quality objectives (DQOs) for this project will consist of the following:

Table 7-1: Applicable Data Quality Objectives

Measurement or Analyses Type	Applicable Data Quality Objective
Field Testing, pH, Conductivity, Temperature, Turbidity, Dissolved Oxygen, Flow	Accuracy, Precision, Completeness
Laboratory Testing, Metals	Accuracy, Precision, Recovery, Completeness
Laboratory Testing, Conventionals	Accuracy, Precision, Recovery, Completeness
Laboratory Testing, Nutrients	Accuracy, Precision, Recovery, Completeness
Laboratory Testing, Petroleum Products	Accuracy, Precision, Recovery, Completeness

Accuracy is the measurement of a sample of known concentration and comparison of the known value against a measured value. Accuracy will be determined by measuring one or more analytes selected from performance testing samples or standard solutions from sources other than those used for calibration. The accuracy of chemical measurements will be checked by performing tests on standards prior to and/or during sample analysis at the laboratory. The concentration of the standards will be unknown to the analyst until after measurements are determined.

Precision describes how well repeated measurements agree. Precision measurements will be determined on laboratory replicates. Precision objectives apply to replicate/split samples collected during field sampling and laboratory analysis as part of periodic QC checks.

Recovery is the accuracy of an analytical test measured against a known analyte addition to a sample, such as with a matrix spike. Recovery measurements will be determined by laboratory spiking of a replicate sample with a known analyte concentration at two times the original sample concentration when possible.

Completeness is the number of analyses generating useable data for each analysis divided by the number of samples collected for that analysis. The method used under this QAPP to determine completeness is a comparison of the number of measurements anticipated to be collected against the number of measurements actually collected that meet their respective DQOs. It is expected that 90 percent of all measurements will be taken as anticipated, including accounting for adverse weather conditions, safety concerns, and equipment problems.

SWAMP Target Reporting Limits, when available, are included to account for method sensitivity in addition to Minimum Levels as defined by the Inland Surface Water and Enclosed Bays and Estuaries Policy and levels able to be obtained by the laboratory. Babcock reporting limits shall also be utilized when more stringent than those recommended by SWAMP. Specific DQOs are presented in Tables 7-2 and 7-3.

Table 7-2: Data Quality Objectives for Field Measurements

Group	Parameter	Accuracy	Precision (% RPD)	Recovery	Target Reporting Limits*	Completeness
Field Analyses	pH	±0.5 units	0-25*	NA	± 0.1	90%*
	Temperature	± 0.5 °C	0-25*	NA	± 0.1	90%*
	Conductivity	± 5 %	0-25*	NA	± 1	90%*
	Turbidity	± 0.5 NTU	0-25*	NA	± 1	90%*
	Dissolved Oxygen	0.1 mg/L	0-25*	NA	± 1	90%*

* No SWAMP requirement present, recommendations only. Please note that pH and temperature do not have SWAMP required reporting limits.

Table 7-3: Data Quality Objectives for Laboratory Measurements

Group	Parameter	Accuracy	Precision (% RPD)	Recovery	Target Reporting Limits*	Completeness
Conventional	Total Hardness as $CaCO_3$	80-120%	0-25	80-120%	1.0	90%*
Conventional	Total Dissolved Solids	80-120%	0-25	80-120%	1.0	90%*
Conventional	Total Suspended Solids	80-120%	0-25	80-120%	0.5	90%*
Conventional	Dissolved Organic Carbon	80-120%	0-25	80-120%	0.6	90%*
Conventional	Total Organic Carbon	80-120%	0-25	80-120%	0.6	90%*
Conventional	Oil & Grease	50-150%	0-25	50-150%	1.0	90%*
Conventional	*E. coli*	N/A	N/A	N/A	2	90%*
Nutrient	Ammonia as Nitrogen	80-120%	0-25	80-120%	0.01	90%*
Nutrient	Nitrate as Nitrogen	80-120%	0-25	80-120%	0.01	90%*
Nutrient	Total Kjeldahl Nitrogen	80-120%	0-25	80-120%	0.1	90%*
Nutrient	Total Phosphorus	80-120%	0-25	80-120%	0.03	90%*
Nutrient	Dissolved Ortho-phosphate	80-120%	0-25	80-120%	0.01	90%*
Metal, Total	Arsenic	75-125%	0-25	75-125%	0.5*	90%*
Metal, Total	Cadmium	75-125%	0-25	75-125%	0.03*	90%*
Metal, Total	Chromium	75-125%	0-25	75-125%	1.0*	90%*
Metal, Total	Copper	75-125%	0-25	75-125%	1.0*	90%*
Metal, Total	Lead	75-125%	0-25	75-125%	0.5*	90%*
Metal, Total	Iron	75-125%	0-25	75-125%	50*	90%*
Metal, Total	Nickel	75-125%	0-25	75-125%	1.0*	90%*
Metal, Total	Manganese	75-125%	0-25	75-125%	10*	90%*
Metal, Total	Zinc	75-125%	0-25	75-125%	5.0*	90%*
Metal, Dissolved	Arsenic	75-125%	0-25	75-125%	0.5*	90%*
Metal, Dissolved	Cadmium	75-125%	0-25	75-125%	0.03*	90%*
Metal, Dissolved	Chromium	75-125%	0-25	75-125%	1.0*	90%*
Metal, Dissolved	Copper	75-125%	0-25	75-125%	1.0*	90%*
Metal, Dissolved	Lead	75-125%	0-25	75-125%	0.5*	90%*
Metal, Dissolved	Iron	75-125%	0-25	75-125%	50*	90%
Metal, Dissolved	Nickel	75-125%	0-25	75-125%	1.0*	90%
Metal, Dissolved	Manganese	75-125%	0-25	75-125%	10*	90%
Metal, Dissolved	Zinc	75-125%	0-25	75-125%	5.0*	90%*
Petroleum Product	TPH (diesel)	50-150%	0-25	50-150%	0.05	90%*
Petroleum Product	TPH (motor oil)	50-150%	0-25	50-150%	0.05	90%*

* No SWAMP requirement present. If laboratory recommended reporting limit is more stringent than SWAMP recommended reporting limit, laboratory reporting limit is used. Please note that metals (dissolved and total) and petroleum products do not have SWAMP required reporting limits.

8. SPECIAL TRAINING NEEDS/CERTIFICATION

8.1 Specialized Training or Certifications

No special training is needed and no certifications are required for this project. All field crews receive training before site mobilizations. In addition, Babcock is certified by the National Environmental Laboratory Accreditation Conference, Certificate No. 0201CA, California Environmental Laboratory Certification No. 2698, USEPA No. CA00102.

8.2 Training and Certification Documentation

The District retains training records for field crews. If needed, the District's health and safety protocols are based on SWAMP procedures and the Riverside County CMP (RCFC&WCD 2012). For the complete discussion of health and safety protocols, see Appendix J, Volume II of the Riverside County CMP.

Babcock maintains laboratory certification records, which are accessible, if needed, from Babcock's QA Officer.

8.3 Training Personnel

Field crews will be properly trained in the use of automated monitoring equipment and proper clean sampling techniques. District field crews will receive training from the Monitoring Project Manager.

Laboratory analysts shall be properly trained in analytical methods and clean analysis techniques. Babcock's records shall be maintained at Babcock's Riverside office.

Table 8-1: Specialized Personnel Training or Certification

Specialized Training Course Title or Description	Training Provider	Personnel Receiving Training/Organization	Location of Records and Certificates*
Laboratory Certifications	Babcock QA Officer	Babcock Laboratory Staff	6100 Quail Valley Court Riverside, CA 92507

*Training records are kept off site at their respective consultant offices.

9. DOCUMENTS AND RECORDS

All field observations and measurements will be recorded in the Field Data Log Sheets provided in Attachment 1 of the Monitoring Plan. Field Data Sheets include sample collection records, field measurements, and field observation records. Chain-of-custody (COC) forms will be completed for samples when the samples are delivered to the laboratory (Appendix A of this QAPP). Field sheets, COCs, and calibration logs will be scanned and stored in electronic PDF format by the District for a minimum of five years from the time the study is completed. The District's Project Manager will store flow and hydrograph data for a minimum of five years after completion of the Project. Babcock and the District will store lab results and COC forms for five years from the time the study is completed. All electronic data generated by this monitoring project will be managed and stored by SCCWRP under the SMC LID Grant. Upon completion of this project, all data and records will be managed and kept by SAWPA and/or SCCWRP.

Copies of records will be maintained for a minimum of five years after project completion. Additional information on document and record retention is contained in Table 9-1 below.

Table 9-1: Document and Record Retention, Archival, and Disposition Information

	Identify Type Needed	Retention	Archival	Disposition
Project Plan	QAPP	District	The District will retain a copy and review after each event.	SAWPA and SCCWRP will retain a copy for final disposition.
	Monitoring Plan	District	The District will retain a copy and review after each event.	SAWPA and SCCWRP will retain a copy for final disposition.
Analytical Records	Lab Reports	Babcock, District	The District will retain a copy and review after each event.	SCCWRP will retain a copy for final disposition.
	EDD	Babcock, District	The District will retain a copy and review after each event.	SCCWRP will retain a copy for final disposition.
Data Records	Flow Data and Hydrographs	District, SCCWRP	The District will retain a copy and review after each event.	SCCWRP will retain a copy for final disposition.
Assessment Records	QA/QC Assessment	District	The District will retain a copy and review after each event.	SCCWRP will retain a copy for final disposition.
Reports	Post-Storm Technical Memos	District	The District will retain a copy and review after each event.	SCCWRP will retain a copy for final disposition.

GROUP B ELEMENTS: DATA GENERATION AND ACQUISITION

10. SAMPLING PROCESS DESIGN

Sampling process and design is discussed in the District's Monitoring Plan, attached to this QAPP as Appendix A. In brief, the District's facility, comprised of over 600,000 square feet of drainage area, has been modified to incorporate various LID BMPs and control sites to test the effectiveness of different BMPs as to runoff volume reduction and constituent removal rates. Monitoring sites were predetermined and incorporated into the construction phase of this project, including sampling vaults.

10.1 BMP Descriptions

Each monitoring station is associated with a BMP or a control station. Runoff flows from the BMP or control station to their respective sampling vaults. Automated sampling equipment collects samples from the sampling vaults and pumps the samples into bottles at the adjacent monitoring stations. The numbering for sampling vaults and their associated monitoring stations are consistent with one another. The following is a list of the Facility sampling stations/vaults and BMPs (or control stations) that will be monitored:

- Station 1/Vault 1: Pavement Control Area
- Station 2/Vault 2: Pervious Concrete with Filtration
- Station 3/Vault 3: Pervious Concrete without Filtration
- Station 4/Vault 4: Pervious Asphalt with Filtration
- Station 5/Vault 5: Pervious Asphalt without Filtration
- Station 6/Vault 6: Landscape Filter Basin Sub-drain
- Station 7/Vault 7: Landscape Filter Basin Overflow
- Station 8/Vault 8: Landscape Filter Basin Influent
- Station 9/Vault 9: Planter Box 1
- Station 10/Vault 10: Building 1Roof Runoff Control Area

10.2 Sampling Locations

Runoff from BMPs is piped directly to the Monitoring Center (Stations 1-7) or monitoring enclosure (Stations 8-10) housing sampling equipment. Seven of the monitoring stations are located at a specially-designed Monitoring Center at the north end of the infiltration basin. Flow is piped from the four pavement BMPs, the pavement control area, and the landscape filter basin sub-drain (effluent) and overflow to the facility. The landscape filter basin influent monitoring enclosure is located northwest of the landscape filter basin. The roof runoff control area station and the planter box station collect runoff at monitoring enclosures east of the infiltration basin. Figure 10-1 shows the Facility, BMP locations, drainage areas and the sampling vaults. Figure 10-2 shows a detail of the sampling vaults and plumbing lines.

Figure 10-1: LID BMP Facility Flow Areas and BMP Locations

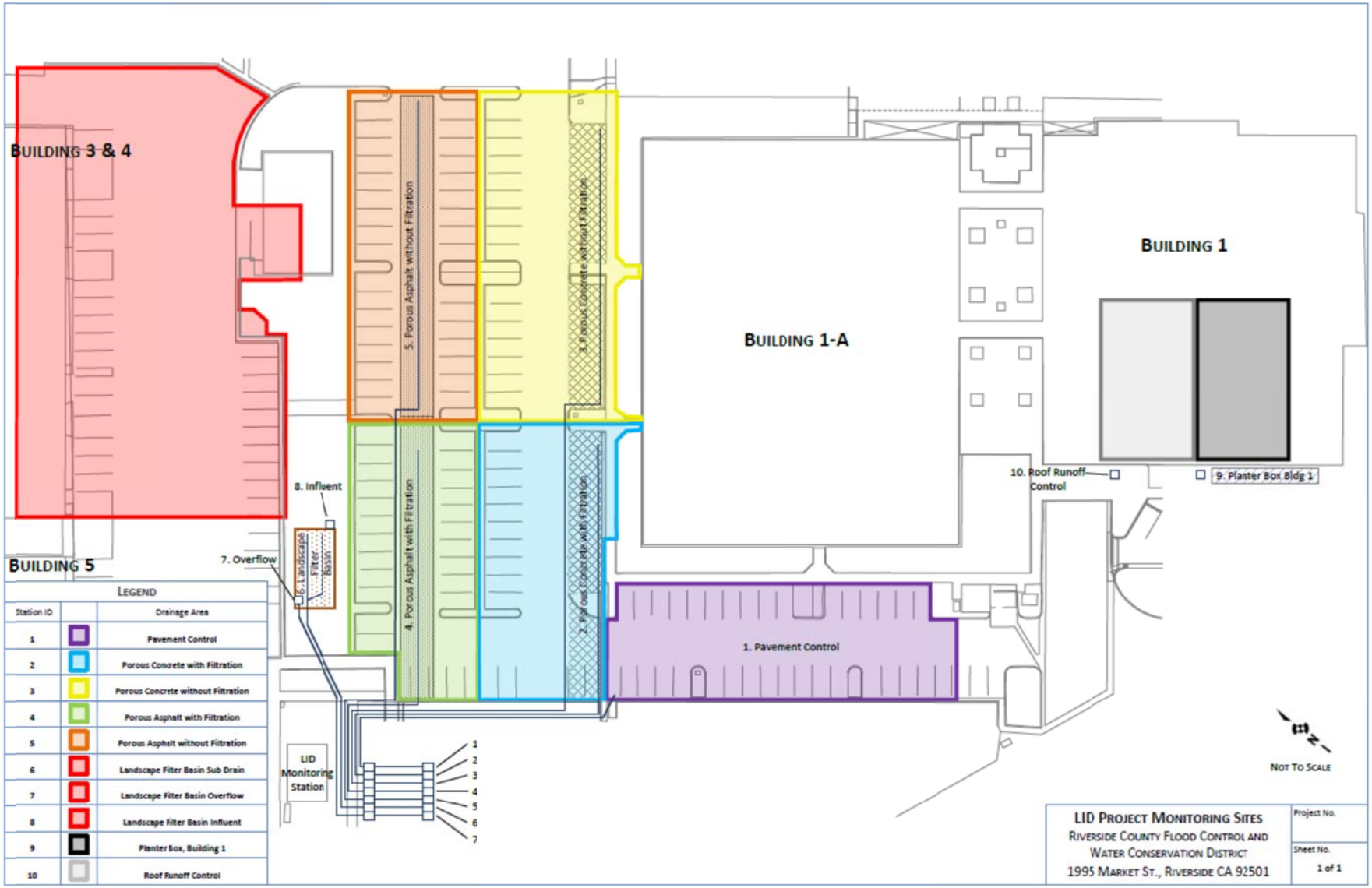
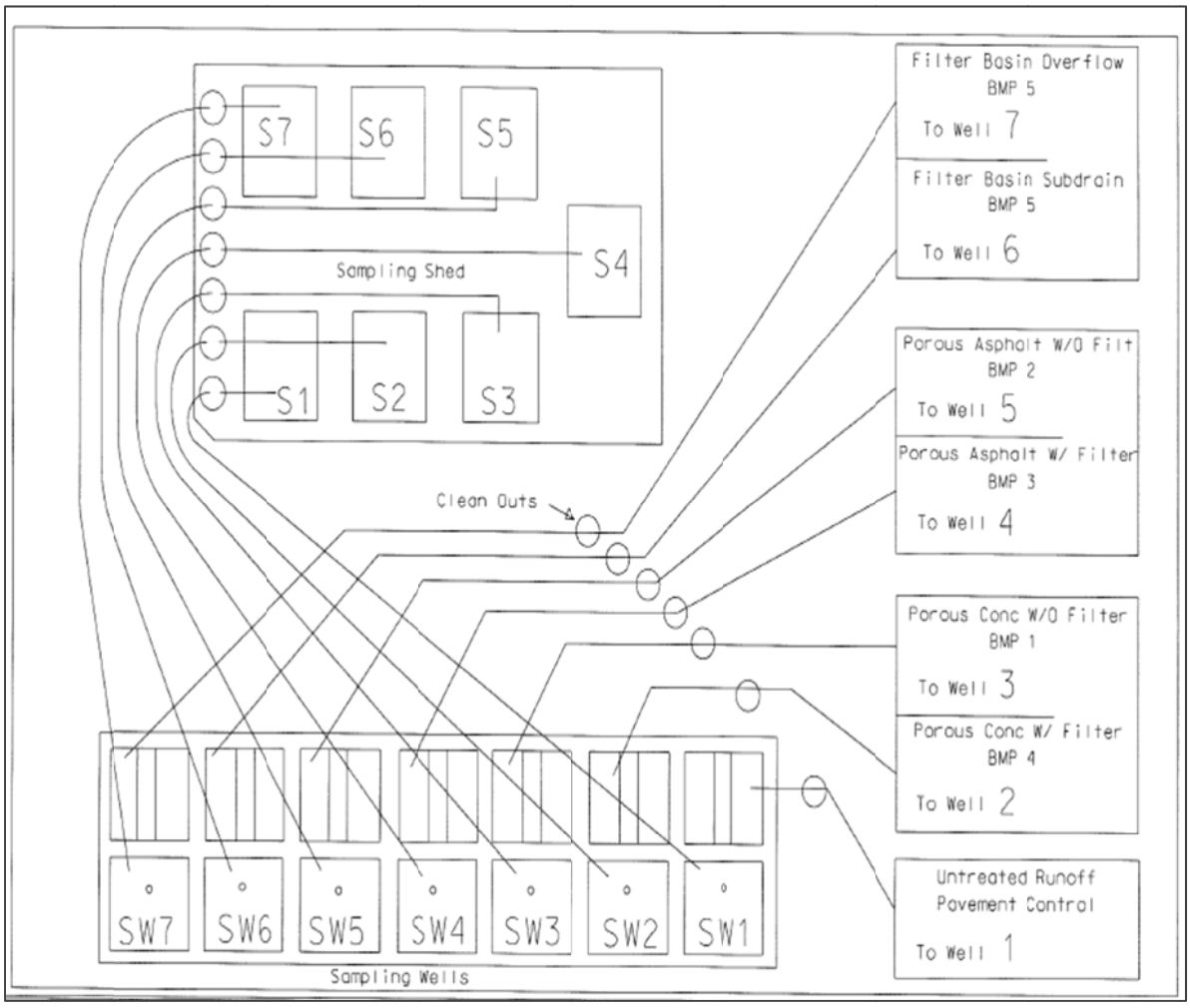


Figure 10-2: LID BMP Monitoring Center Layout and Schematic



10.3 Sampling Schedule

Three wet weather samples will be collected per year over a five-year period at each of the ten predetermined sampling locations. Refer to the RCFC & WCD LID BMP Testing Facility Monitoring Plan for mobilization criteria and dates on which sampling will not be undertaken.

10.4 Laboratory Analysis

Upon receipt of samples, the laboratory will composite the sample aliquots from each station. The composites will then be dispensed into containers of the specified volume required for analysis based on constituent type and analytical method. The appropriate preservation and preparation methods will be conducted for each parameter and samples will be analyzed for the listed constituents within their respective hold times.

11. SAMPLING METHODS

Composite samples will be collected by automated samplers. Each sample will consist of event appropriate bottles composited at the lab. Grab samples will be taken for *E. coli* sampling. Each station will have one (1) sample collected per event and a minimum of three (3) samples collected during each year of sampling. Section 2.3 of the Monitoring Plan contains an in-depth discussion of sampling methods.

Table 11-1: Sampling Locations and Sampling Methods

Sampling Location	Station Number	Matrix	BMP	Analytical Parameter	No. Samples (include field duplicates)	Sampling SOP #	Field Preserve	Maximum Holding Time: Preparation/ Analysis
Monitoring Center	1	Water	Pavement Control	Field Parameters, Bacteriological, Conventionals, Nutrients, Metals, Petroleum products	1 sample per event	Grab, Flow-weighted composite	6° C	Ranges from 7 days to 6 months
Monitoring Center	2	Water	Pervious Concrete with Filtration	Field Parameters, Bacteriological, Conventionals, Nutrients, Metals, Petroleum products	1 sample per event	Grab, Flow-weighted composite	6° C	Ranges from 7 days to 6 months
Monitoring Center	3	Water	Pervious Concrete without Filtration	Field Parameters, Bacteriological, Conventionals, Nutrients, Metals, Petroleum products	1 sample per event	Grab, Flow-weighted composite	6° C	Ranges from 7 days to 6 months
Monitoring Center	4	Water	Pervious Asphalt with Filtration	Field Parameters, Bacteriological, Conventionals, Nutrients, Metals, Petroleum products	1 sample per event	Grab, Flow-weighted composite	6° C	Ranges from 7 days to 6 months
Monitoring Center	5	Water	Pervious Asphalt without Filtration	Field Parameters, Bacteriological, Conventionals, Nutrients, Metals, Petroleum products	1 sample per event	Grab, Flow-weighted composite	6° C	Ranges from 7 days to 6 months
Monitoring Center	6	Water	Landscape Filter Basin Sub-drain	Field Parameters, Bacteriological, Conventionals, Nutrients, Metals, Petroleum products	1 sample per event	Grab, Flow-weighted composite	6° C	Ranges from 7 days to 6 months
Monitoring Center	7	Water	Landscape Filter Basin Overflow	Field Parameters, Bacteriological, Conventionals, Nutrients, Metals, Petroleum products	1 sample per event	Grab, Flow-weighted composite	6° C	Ranges from 7 days to 6 months
Enclosure 1 Landscape Filter Basin	8	Water	Landscape Filter Basin Influent	Field Parameters, Bacteriological, Conventionals, Nutrients, Metals, Petroleum products	1 sample per event	Grab, Flow-weighted composite	6° C	Ranges from 7 days to 6 months
Enclosure 2 Building 1	9	Water	Planter Box 1	Field Parameters, Bacteriological, Conventionals, Nutrients, Metals, Petroleum products	1 sample per event	Grab, Flow-weighted composite	6° C	Ranges from 7 days to 6 months
Enclosure 3, Building 1	10	Water	Roof Runoff Control	Field Parameters, Bacteriological, Conventionals, Nutrients, Metals, Petroleum products	1 sample per event	Grab, Flow-weighted composite	6° C	Ranges from 7 days to 6 months

12. SAMPLE HANDLING AND CUSTODY

Babcock will provide appropriate sample containers for the samples as indicated in Table 11-1. At the time of sample collection, the sample labels will be completed in the field with the date and time. The Sample IDs will also be entered directly onto the Field Data Log Sheets and the COC Forms. The COCs will be pre-printed along with the bottle labels. The COCs will be completed in the field with dates, times, and sample team names, and will be cross-checked with the bottles to make sure proper samples have been collected. The COC form for this Project is attached in Appendix A.

All samples bottles will be labeled with the following information:

- Project name
- Station ID (unique)
- Event number
- Sample date
- Sample time
- Bottle __ of __
- Sampler's initials
- Analyses

The following sample handling protocols will be followed when collecting samples to minimize the possibility of contamination:

- Previously unused sample bottles will be employed. Sample bottles and bottle caps will be protected from contact with solvents, dust, or other contaminants during storage and bottle handing.
- Sample bottles will be discarded after first use. New certified clean bottles will be used for each monitoring event.
- Sampling crews will make an effort, within reason, to prevent large gravel and uncharacteristic floating debris from entering the automatic sampler tubing and, ultimately, the sample containers. Stirring up sediments at the bottom of the channel is not an issue for this program, as the tubing will be attached at a point in the sampling vault and no natural channels are part of this program.
- The inside of the sampling container will not be touched to the maximum extent practicable during preparation and sampling activities. Automated equipment assists in meeting this protocol since grab samples will not be collected.
- All samples will be collecting in accordance with the sampling techniques outlined in Section 2.3 of the Monitoring Plan.
- Composite sampling requires multiple automated aliquots to be transferred into a composite bottle. After the aliquots are collected, the bottle will be immediately tipped to decant enough volume to ensure 1-2 inches of airspace in the sample bottle and the bottle will be tightly capped.
- Once sample containers are filled, they will be promptly placed on ice, (target temperature six degrees Celsius) and transported to the laboratory for processing to meet holding times. All necessary pre-processing for analysis, such as filtration and acidification, will take place in the laboratory by certified personnel.

- After the field crew collects and delivers the samples to the laboratory, the laboratory will conduct the analysis within the holding times listed in Table 12-1. These field and laboratory activities will be coordinated to ensure all samples are handled within the proper holding times and analyses are completed within holding times. With composite samples, the start of holding times is considered to be the time that the last aliquot was collected.

After the laboratory receives the water samples, the certified laboratory technicians will dispense the sample contents into containers that contain the required volume specified in Table 12-1. The laboratory will preserve the water samples using the appropriate preservatives and the laboratory will conduct the analysis within the maximum holding time limits. When applicable, the sample handling and custody procedures described are in compliance with SWAMP standard operating procedures (SOP), as defined in the SWAMP Quality Assurance Management Plan (QAMP), Appendix D "Field Collection of Water Samples".

Table 12-1: Sample Handling and Custody

Parameter	Container	Volume	Initial (Lab) Preservation	Holding Time
Total Hardness as $CaCO_3$	1 Liter Polypropylene Bottles	200 mL	HNO_3, pH <2	6 months
TDS		500 mL	Store cool at 4°C	7 Days
TSS		500 mL	Store cool at 4°C	7 Days
DOC		40 mL	Field Filtered; H_2SO_4, pH <2; Store cool at 4oC	28 Days
TOC		40 mL	H_2SO_4, pH <2; Store cool at 4oC	28 Days
E. coli	120 mL $Na_2S_2O_3$ preserved poly Bottle	100 mL	Dechlorinate ($Na_2S_2O_3$)	6 Hours
O&G	1 Liter H_2SO_4 Amber Glass Bottle	1 L	H_2SO_4, pH <2; Store cool at 4°C	28 days
Ammonia as Nitrogen	1 Liter Polypropylene Bottles	200 mL	H_2SO_4, pH <2; Store cool at 4°C	48 Hours / 28 Days[(a)]
Nitrate as Nitrogen		200 mL	Store cool at 4°C	48 Hours
Total Kjeldahl Nitrogen		200 mL	H_2SO_4, pH <2; Store cool at 4°C	7 Days / 28 Days[(a)]
Total Phosphorus		200 mL	H_2SO_4, pH <2; Store cool at 4oC	28 Days
Dissolved Ortho-phosphate		200 mL	Filtered; Store cool at 4°C	48 Hours
Total Trace Metals		200 mL	HNO_3, pH <2	6 Months
Dissolved Trace Metals		200 mL	Field Filtered; HNO_3, pH <2	6 Months
TPH (diesel)	1 Liter H_2SO_4 Amber Glass Bottle	2 L	HCL, pH<2; Store cool at 4°C	7 Days / 40 Days[(a)]
TPH (motor oil)	1 Liter H_2SO_4 Amber Glass Bottle	2 L	N/A	7 Days / 40 Days[(a)]

[(a)] The first time period represents the holding time for the preparation, preservation, or extraction required by the method; and the second time period represents the holding time for the analysis given that the appropriate preparation was conducted.

12.1 Chain-of-Custody Procedures

COCs will be pre-printed along with the bottle labels. The COCs will contain the same data as the labels, including the name of the laboratory the samples are being submitted to, and, in some cases as needed, even greater detail. The COCs will be completed in the field with dates, times, and sample team names, and will be cross-checked with the bottles to make sure proper samples have been collected. The COC form for this project is included in Appendix A.

The COC forms for the samples will be transported with the samples to the analytical laboratory. Sampled water will be kept properly chilled and transferred to an analytical laboratory within holding times. When custody of the samples is transferred to the laboratory courier, the COC will be signed and dated, and a copy will be provided to the District by the laboratory. The COCs will be reviewed by personnel at the receiving laboratories to make sure no samples have been lost in transport. The laboratories will also verify that each sample has been received within holding times.

12.2 Sample Disposal Procedures

After analysis, including QA/QC procedures, any excess sample will be disposed of by the analytical laboratories.

12.3 Corrective Action Procedures

Corrective action is taken when an analysis is deemed suspect for some reason. The corrective action varies somewhat from analysis to analysis, but the procedure typically involves the following:

- A check of procedures;
- A review of documents and calculations to identify possible errors;
- Correction of errors;
- A re-analysis of the sample extract, if sufficient volume is available, to determine if results can be improved;
- A complete reprocessing and re-analysis of additional sample material, if sufficient volume is available, and if the holding time has not been exceeded.

Any failures (e.g., instrument failures) that occur during data collection and laboratory analyses will be the responsibility of the field crew or laboratory conducting the work, respectively. In the case of field instruments, problems will be addressed through instrument cleaning, repair, or replacement of parts or the entire instrument, as warranted. Crews will carry basic spare parts and consumables with them to the field, and will have access to spare parts to be stored at their respective agency. Records of all repairs or replacements of field instruments will be maintained at the District.

The QA Officer at Babcock has procedures in place to follow when failures occur, and will identify individuals responsible for corrective action and develop appropriate documentation. Any corrective actions taken will be documented in the laboratory's hard copy deliverable or in a Corrective Action Plan. For more information on Babcock's QA procedures please refer to their QA Manual (Appendix B of this QAPP).

13. ANALYTICAL METHODS

The majority of constituents for this project will be analyzed using SWAMP required target reporting limits, as listed in Appendix 3 of the SWAMP QAMP. If laboratory suggested reporting limits are more stringent than those required by SWAMP, laboratory suggested reporting limits will be applied. Table 13-1 summarizes SWAMP required information regarding analytical methods. For details regarding the QA measure or performance criteria for each analytical method, refer to Sections 7 and 14 of this QAPP.

Table 13-1: Field and Laboratory Analytical Methods

Analyte	Matrix	Method	Target Reporting Limit*	Units
FIELD				
Conventional				
Conductivity	Water	YSI Multi-parameter Probe	±1.0	µmhos/cm
pH	Water		±0.1	pH Units
Temperature	Water		±0.1	°C
Dissolved Oxygen	Water		±0.1	mg/L
Turbidity	Water	Turbidity Meter (Hach/Sigma)	±0.1	NTU
LABORATORY				
Conventional				
Hardness as CaCO3	Water	SM 2340B	1	mg/L
Total Dissolved Solids (TDS)	Water	EPA 160.1	1	mg/L
Total Suspended Solids (TSS)	Water	EPA 160.2	0.5	mg/L
Dissolved Organic Carbon (DOC)	Water	EPA 415.1	0.6	mg/L
Total Organic Carbon (TOC)	Water	EPA 415.1	0.6	mg/L
Oil & Grease (O&G)	Water	EPA 1664A	1	mg/L
E.coli	Water	SM9221E	2	MPN/100mL
Nutrients				
Ammonia as Nitrogen (NH3-N)	Water	EPA 350.3	0.01	mg/L
Nitrate as Nitrogen (NO3-N)	Water	EPA 300.0	0.01	mg/L
Total Kjeldahl Nitrogen (TKN)	Water	EPA 351.2	0.1	mg/L
Total Phosphorous	Water	EPA 365.2	0.03	mg/L
Dissolved Ortho-Phosphate	Water	EPA 365.2	0.01	mg/L
Metals (Total Recoverable & Dissolved)				
Arsenic (As)	Water	EPA 200.8	0.5	µg/L
Cadmium (Cd)	Water	EPA 200.8	0.03	µg/L
Chromium (Cr)	Water	EPA 200.8	1	µg/L
Copper (Cu)	Water	EPA 200.8	1	µg/L
Iron (Fe)	Water	EPA 200.8	50	µg/L
Lead (Pb)	Water	EPA 200.8	0.5	µg/L
Manganese (Mn)	Water	EPA 200.8	10	µg/L
Nickel (Ni)	Water	EPA 200.8	1	µg/L
Zinc (Zn)	Water	EPA 200.8	5	µg/L
Petroleum Products				
TPH (diesel)	Water	EPA 8015	0.05	mg/L
TPH (motor oil)	Water	EPA 8015	0.05	mg/L

*Reporting limits in this table represent the SWAMP required reporting limits unless laboratory reporting limits are more stringent. Laboratory analysis of constituents will attempt to meet these reporting limits. Please note that pH, temperature, metals (dissolved and total) and petroleum products do not have SWAMP required reporting limits.

14. QUALITY CONTROL

This section addresses QA/QC activities associated with both field sampling and laboratory analyses. The field QA/QC samples are used to evaluate potential contamination and sampling error introduced prior to submittal of samples to the analytical laboratory. Laboratory QA/QC activities provide information needed to assess laboratory contamination, analytical precision, and analytical accuracy. If any QA/QC standards are not met, the appropriate corrective actions will be taken in accordance with Section 8.3 of this document and the Babcock QA Manual (Appendix B of this QAPP).

The following field quality control samples will be provided per sampling event:

1. **Field Blanks** – Field blanks verify that field conditions, field sampling activities, and air deposition are non-contaminating. A sample bottle is filled with reagent-grade, analyte-free de-ionized water in the field during a sampling event. One field blank will be collected during each event.
2. **Equipment Blanks** – Equipment blanks verify that the sampling containers and tubing are contaminant free prior to sampling. After installation of new sample tubing each year, one equipment blank will be collected by sampling de-ionized water at one station. One container per batch ordered will be blanked prior to use in sample collection.

Internal laboratory quality control checks will include the use of laboratory replicates, method blanks, MS/MSDs, laboratory control samples (LCSs), and SRMs as follows:

1. **Laboratory Replicate/Split** – A sample is split by the laboratory into two portions and each portion is analyzed. Once analyzed, the results are evaluated by calculating the relative percent difference (RPD) between the two sets of results. This serves as a measure of the reproducibility, or precision, of the sample analysis. Typically, replicate results should fall within an accepted RPD range, depending upon the analysis. One sample per batch, per storm will be a laboratory replicate.
2. **Method Blanks** – A method blank is an analysis of a known clean sample matrix that has been subjected to the same complete analytical procedure as the field sample to determine if potential contamination has been introduced during processing. Blank analysis results are evaluated by checking against reporting limits for that analyte. Results obtained should be less than the reporting limit for each analyte. One sample per batch, per storm will be a method blank.
3. **Matrix Spike and Matrix Spike Duplicates (MS/MSDs)** – Matrix spikes and matrix spike duplicates (MS/MSDs) involve adding a known amount of the chemical(s) of interest to one of the actual samples being analyzed. One sample is split into three separate portions. One portion is analyzed to determine the concentration of the analyte in question in an un-spiked state. The other two portions are spiked with a known concentration of the analytes of interest. The recovery of the spike, after accounting for the concentration of the analyte in the original sample, is a measure of the accuracy of the analysis. An additional precision measure is made by calculating the RPD of the duplicate spike recoveries. Both the RPD values and spike recoveries are compared against accepted and known method dependent acceptance limits. Results outside these limits are subject to corrective action. One sample per batch per storm will be a MS. One sample per batch per storm will be a MSD.

4. **Laboratory Control Sample (LCS)** – The laboratory control sample procedure involves spiking known amounts of the analyte of interest into a known, clean, sample matrix to assess the possible matrix effects on spike recoveries. High or low recoveries of the analytes in the matrix spikes may be caused by interferences in the sample. Laboratory control samples assess these possible matrix effects since the LCS is known to be free from interferences. One sample per batch, per storm will be a LCS.

Table 14-1: Field Sampling Quality Control

Matrix: Stormwater
Sampling SOP: RCFC & WCD LID BMP Testing Facility Monitoring Plan
Analytical Parameter(s): Hardness, TDS, TSS, DOC, TOC, O&G, Ammonia, Nitrate, TKN, Total Phosphorus, Dissolved Ortho-phosphate, Metals (Total and Dissolved), TPH (Diesel), TPH (Motor Oil)
Analytical Method/SOP Reference: Automated Composite Sampling
Number of Sampling Locations: Varied

Field QC	Frequency/Number per Sampling Event	Acceptance Limits
Equipment Blanks	1	No detectable amounts of analytes
Field Blanks	1	No detectable amounts of analytes
Trip Blanks	0	N/A
Cooler Temperature	1	6°C
Field Duplicate Pairs	0	N/A
Collocated Samples	0	N/A
Field Splits	0	N/A
Field Matrix Spikes	0	N/A
Other:	0	N/A

Table 14-2: Analytical Quality Control

Matrix: Stormwater
Sampling SOP: N/A
Analytical Parameter(s): Hardness, TDS, TSS, DOC, TOC, O&G, Ammonia, Nitrate, TKN, Total Phosphorus, Dissolved Ortho-phosphate, Metals (Total and Dissolved), TPH (Diesel), TPH (Motor Oil)
Analytical Method/SOP Reference:
Number of Sample Locations: Varied

Laboratory QC	Frequency/Number	Acceptance Limits
Method Blank	1	No detectable amounts of analytes
Reagent Blank	0	N/A
Storage Blank	0	N/A
Instrument Blank	0	N/A
Laboratory Duplicate	1	The relative percent difference between the primary sample result and duplicate sample result should meet the objective for precision listed in Table 7-2.
Laboratory Matrix Spike	1	The percent recovery should be within the accuracy acceptance limits listed in Table 7-2.
Matrix Spike Duplicate	1	The percent recovery should be within the accuracy acceptance limits listed in Table 7-2.
Laboratory Control sample	1	The percent recovery should be within the accuracy acceptance limits listed in Table 7-2.
Surrogates	0	N/A
Internal Standards	0	N/A
Others:	0	N/A

15. INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

All field equipment will be tested, inspected, and maintained according to manufacturer specifications. Sample equipment testing, inspection, and maintenance shall be performed no more than seven (7) days before a monitoring event. Replacement parts will be installed as necessary and may be stored on site in the Monitoring Center.

All laboratory equipment is tested, inspected, and maintained based on manufacturer recommendations and accepted laboratory protocols. The laboratories maintain testing, inspection, and maintenance practices as part of their method SOPs maintained in their laboratories by their Laboratory Director/QA Officer and can be provided upon request.

All field instrument testing, inspection, and maintenance frequencies are consistent with SWAMP QAMP Appendix 4. Babcock maintains instrument testing, inspection, and maintenance practices as part of the method SOPs. The District's QA Officer has reviewed these practices and finds them to be conforming to SWAMP requirements.

16. INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Calibration of field meters will be performed no more than seven (7) days prior to a sampling event, or as-needed. A calibration log will be maintained for all meters used in the field. The YSI Model 600V2 sonde with pH, temperature, conductivity, and optical dissolved oxygen probes, will be calibrated according to the manufacturer's operations manual. Calibration logs will be kept on file at the District.

All laboratory equipment is calibrated based on manufacturer recommendations and accepted laboratory protocols. The laboratories maintain calibration practices as part of their method SOPs maintained in their laboratories by their Laboratory Director/QA officer and can be provided upon request.

Calibration for all flow meters and automated samplers will be conducted prior to installation and, thereafter, no more than seven (7) days before a monitoring event. The ISCO 6712 Flow Meter and Automated Sampler will be calibrated using the procedures described in the ISCO 6712 Instrument Manual. For flow meter calibration, the recorded water level will be checked by comparing the level to actual levels while the bubbler is submersed in water of a known level. Computational calibrations cannot be performed but deviations from known values are documented and the equipment will be replaced or repaired as necessary. For automated sampler calibration, the aliquot volume will be calibrated using a graduated flask or beaker.

All field instrument calibration frequencies are consistent with SWAMP QAMP Appendix 4. Babcock maintains calibration practices as part of the method SOPs. The District's QA Officer has reviewed these practices and finds them to conform to SWAMP requirements.

17. INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

All glassware, sample bottles, and collection equipment, including tubing, will be inspected prior to use. All ordered supplies will be examined for damage as they are received. Bottles and caps will be inspected for damage prior to sampling, and only sound bottles with intact threads will be used. The container caps will be tested for tightness prior to transport of samples.

The District Project Manager will make sure sufficient field supplies are on hand prior to the start of sampling for each period. Field supplies will be stored on-site in the Monitoring Center. Laboratory supplies will be stored at the laboratories conducting the work.

Table 17-1: Inspection/Acceptance Testing Requirements for Consumables and Supplies

Project-Related Supplies/Consumables	Inspection/Testing Specifications	Acceptance Criteria	Frequency	Responsible Individual
Pre-Cleaned Sample Bottles	Open bottle	Lids screwed on bottles	100%	District
Laboratory Glassware	Dirty	Clean	100%	Babcock
Lab Solvents and Acids	Leaks	No cracks or chips	Prior to use	Babcock
Appropriate Bottle Sets	If not certified pre-cleaned then laboratory blanked	Pass blanking analysis	New bottles each monitoring event	Babcock/District
Silicone Tubing	Blanked	Pass blanking analysis	New tubing at start of fiscal year	Babcock/District
Teflon Tubing	Blanked	Pass blanking analysis	New tubing at start of fiscal year	Babcock/District

18. NON-DIRECT MEASUREMENTS (EXISTING DATA)

There are no non-direct measurements that will be incorporated in this project.

19. DATA MANAGEMENT

The District will compile the monitoring data and analytical data and provide the complete data set to SCCWRP for analysis and reporting.

19.1 Hydraulic Data

The District Project Manager is responsible for hydraulic data management and will track the data logger results, which include, stage, and instantaneous flow. Flow and rainfall will be recorded as one-minute averages. Rainfall data will be recorded during each event at campus gauge farm. During rain events, the flow meters convert instantaneous flow into total runoff volume. Data containing storm and hydrological information is electronically stored in the flow meter, with each monitoring event stored separately.

The information recorded includes:

- Flow rate, rainfall and field data at the time of each sample
- Time of peak flow rate
- Cumulative rainfall
- Rainfall intensity
- Discharge volume totals

The original electronic data logger files will be saved electronically as Flowlink files on the project file. The visual discharge and precipitation observed by field crews during the storm, and the precipitation posted for nearby sites on the National Weather Service website will be compared to the logged data. If a large discrepancy exists, all equipment will be checked for malfunction. Any other site problems, such as debris clogging the conduits, will be checked and eradicated during the monitoring event. After each storm event, the logged data will be screened for the following major items:

- A check of the meter and sampler settings associated with each data logger file, including site ID and units, to verify that correct information matches the flow data set. Incorrect settings will be re-programmed for future events.
- A data gap check to identify time periods with no recorded data during the monitoring event. Any data gaps will be identified, logged, and investigated.
- A check of the discharge start time and precipitation start time.
- A check of rainfall intensity and discharge values throughout the monitoring event to verify that the discharge increased and decreased when the rainfall intensity increased and decreased.
- A check of the number of samples and discharge to verify that the frequency of sampling increased when discharge increased.

19.2 Field Observations and Measurements

Water Quality Monitoring and Field Observations

During each event, water quality parameters (pH, temperature, and conductivity) will be measured continuously on-site during the event. At all stations, a YSI multi-parameter probe will be used to record pH, DO, EC, and temperature data. District personnel will also note and record any field observations. Any field measurements or field observations will be recorded on Field Data Sheets (see Attachment 1 of the Monitoring Plan).

The District Project Manager will review all Field Data Log Sheets for completeness, maintain the original hardcopies, and scan electronic PDF copies for storage in the project file. Photographs of the monitoring sites and equipment installations taken by field personnel will be uploaded into the project file. Calibration logs for any handheld meters utilized will be reviewed by the Project Manager and saved in the project file.

19.3 Analytical Data

The Babcock Project Manager will review all lab reports and electronic data deliverables (EDDs) for accuracy, completeness, and compatibility with SWAMP. Lab reports, PDF copies of lab reports, and EDDs will be stored by Babcock in the project file and submitted to the District in hard copy format and as an EDD within four (4) weeks of receipt of samples.

GROUP C ELEMENTS: ASSESSMENTS AND RESPONSE ACTIONS

20. ASSESSMENTS AND RESPONSE ACTIONS

The Grant Project's QA Officer has the power to halt all construction, sampling, and analytical work by the District and Babcock if the deviations noted are considered detrimental to data quality.

The District Project Manager will be responsible for the day-to-day oversight of consultant activities, laboratory analysis and data reporting by Babcock. Any failures (e.g., instrument failures) that occur during construction, data collection, and/or laboratory analyses will be the responsibility of the field crew or laboratory conducting the work, respectively. It is the responsibility of the QA Officers and/or Babcock to report any assessments and proposed corrective actions to the District Project Manager. The District QA Officer will report any assessments to SCCWRP/SMC LID Project Manager.

Three types of assessments will be performed as part of this project to ensure that the sampling and analysis activities are in accordance with the approved QAPP. They are as follows:

1. **Surveillance of Sample Collection Activities:** The District Project Manager will be responsible for oversight of sampling activities and will review field datasheets to verify that the samples were collected in accordance with QAPP requirements. The QA Officer will accompany the field crew at least once, toward the beginning of the data collection phase of the Project, and again at some later point, if deemed necessary, to audit field activities. If the QA Officer finds any of the field activities to be in violation of QAPP requirements, the QA Officer has the authority to stop these activities until corrective actions are successfully implemented. Corrective actions could include additional training to improve field team performance and QAPP compliance, or appropriate re-sampling of sites, as needed. The QA Officer will report all such actions to the Project Manager and document it in the project file.

   In the case of field instruments, problems will be addressed through instrument cleaning, repair, or replacement of parts or the entire instrument, as needed. Field crews will carry basic spare parts and consumables with them, and will have access to spare parts to be stored in the Monitoring Center. Records of all repairs or replacements of field instruments will be maintained by the District.

2. **Data Quality Assessment:** Babcock will be responsible for providing a summary of QA/QC data to the District Project Manager, who will consult with the District QA Officer to verify that the performance criteria of the QAPP were met. This will occur following receipt of each lab report from Babcock. If it is determined that the precision and accuracy objectives were not met the District Project Manager will notify the Babcock QA Officer and Project Manager. The Babcock QA Officer will review laboratory techniques to minimize errors, and samples will be re-analyzed, if possible.

Corrective action is taken when a laboratory analysis is deemed suspect for some reason. The reasons include exceedances of the RPD ranges, spike recoveries, and blanks. The corrective action varies somewhat from analysis to analysis, but typically involves the following:

- Check of procedure;
- Review of documents and calculations to identify any possible error;
- Error correction;
- Re-analysis of the sample extract, if available, to see if results can be improved;
- Complete reprocessing and re-analysis of additional sample material, if it is available.

Babcock has procedures in place to follow when failures occur, and will identify individuals responsible for corrective action and develop appropriate documentation. Any corrective actions taken will be documented in the laboratory's hard copy deliverable or in a Corrective Action Plan. For more information on Babcock's QA procedures please refer to Appendix B of this QAPP.

3. **Assessment of Data Entry:** Once the performance criteria are met and the data has been submitted to the District, the District Project Manager will review data files to ensure that errors are detected and corrected. If necessary, the District will request a revised data set from Babcock. The District will provide the data to SCCWRP for data analysis.

21. REPORTS TO MANAGEMENT

21.1 Monitoring

The District will develop a Post-Storm Technical Memorandum and a SWAMP-compatible EDD following each monitored storm. The deliverable will contain the following:

- A Post-Storm Technical Memorandum summarizing the event;
- Hydrographs containing flow, rainfall, and sample information;
- Hydraulic data in a SWAMP-compatible EDD;
- Field data sheets.

The hydrographs will be created using the data logger results, rainfall data, and sample information, and will be submitted in Microsoft Excel format. The Post-Storm Technical Memorandum and field forms will be submit in PDF format.

Babcock will provide analytical laboratory reports and a corresponding SWAMP-compatible EDD to the District within four weeks of receipt of samples.

The District will compile the hydraulic and field data and the laboratory analytical data provided by Babcock at the end of each year of monitoring. The District will provide one complete electronic deliverable to SCCWRP.

21.2 Quarterly Reporting to SWRCB

The District will provide updates to SCCWRP on a quarterly basis, 20 days after the end of each quarter. The District will describe the current status of monitoring activities and analytical results.

These quarterly progress reports will be forwarded to the SWRCB and will include a brief description of the work performed, accomplishments during the performance period, milestones achieved, monitoring results (if applicable), and any problems encountered.

21.3 Final Reporting to SWRCB

Upon completion of Project construction, the District will prepare a draft and final Project Report to SAWPA.

Upon completion of stormwater monitoring at the Project, the District will prepare a Final Technical Memorandum for SCCWRP. The technical memorandum will summarize long term monitoring activities, data quality, hydrographs, and a brief summary of results.

Table 21-1: Quality Assurance Management Reports

Type of Report	Frequency	Projected Delivery Dates(s)	Person(s) Responsible for Report Preparation	Report Recipients
Technical Memorandum	Post Event/Storm	10 days after each event	Mark Zavislak	Arlene Chun
Laboratory Analytical Result Report	Post Event/Storm	4 weeks after event/storm	Joseph Morrison	Arlene Chun
Construction Progress Report	Quarterly	20 days after the end of each quarter	Arlene Chun	Celeste Cantu (SAWPA)
Draft Project Report	End of Construction Project	End of Construction Project	Arlene Chun	Celeste Cantu (SAWPA)
Final Project Report	End of Construction Project	End of Construction Project	Arlene Chun	Celeste Cantu (SAWPA)
Annual Data Deliverable	Annual	July 31st each year	Arlene Chun	San Bernardino County Flood Control District
Draft Long-Term Technical Memorandum	End of Monitoring Program	End of Monitoring Program	Arlene Chun	San Bernardino County Flood Control District
Final Long-Term Technical Memorandum	End of Monitoring Program	End of Monitoring Program	Arlene Chun	San Bernardino County Flood Control District

GROUP D ELEMENTS: DATA VALIDATION AND USABILITY

22. DATA REVIEW, VERIFICATION, AND VALIDATION REQUIREMENTS

All analytical data will be reviewed and compared to the DQOs described in Section 7 of this QAPP, along with the applicable QA/QC practices. If results fail to meet any DQO, the District Project Manager and/or the District QA Officer will flag them for further review. Batch QA samples will be reviewed to determine the potential cause of failure to meet the DQO. Data will be separated into three categories: data meeting all DQOs (acceptable data), data failing precision or recovery criteria (further investigation warranted), and data failing to meet accuracy criteria (data is rejected).

If further investigation is warranted based on data failing precision or recovery criteria, all aspects of the data will be assessed for data quality by the District Project Manager. At that point, the data will either be accepted or rejected. If accepted, the data will be flagged with a "J" per USEPA specifications. If data fails to meet accuracy criteria, or the cause of the failure cannot be identified and rectified, the data will be excluded from inclusion in the study results. All rejected data will be retained in the Project database, and qualified as "rejected". The ultimate decision of whether to accept or reject a data point will be made by the District Project Manager in consultation with the District QA Officer.

If the analysis for more than 10% of any given analyte fails to meet the DQO, the Project Manager and QA Officer will meet to discuss the appropriateness of the DQO and any potential modifications. All proposed modifications of DQOs shall be reviewed by the SWRCB QA Officer.

23. VERIFICATION AND VALIDATION METHODS

Data verification is the process of evaluating the completeness, correctness, and conformance of the dataset against the method, procedural, or contractual requirements. The goal of data validation is to evaluate whether the data quality goals established during the planning phase have been achieved (USEPA 2002). Data quality indicators will be continuously monitored by the analyst producing the data (i.e., field and lab personnel), as well as the District Project Manager, with assistance from the District QA Officer, throughout the project to ensure that corrective actions are taken in a timely manner. Data validation is an analyte- and sample-specific process that extends verification to determine the analytical quality of the dataset (USEPA 2002). Laboratory and field personnel responsible for conducting QA analysis will be responsible for documenting when data do not meet measurement quality objectives as determined by data quality indicators.

23.1 Data Verification and Validation Responsibilities

Data collected in the field will be validated and verified by the District Project Manager and/or QA Officer. The laboratories will maintain COCs and sample manifests.

Laboratory validation and verification of the data generated is the responsibility of the Babcock Project Manager. Babcock will maintain analytical reports in a database format as well as all QA/QC documentation for the laboratory. The Laboratory QA Officer will perform checks of all of its records.

The District QA Officer and Project Manager are responsible for oversight of data collection and the initial analysis of the raw data obtained from the field and the contracted laboratory. All data records will be checked visually and recorded as checked by initials and dates.

Reconciliation and correction of any data that fails to meet the DQOs will be done by the District Project Manager in consultation with the District Project QA Officer and Project Advisors (i.e., SCCWRP, SWRCB). Any corrections require a unanimous agreement that the correction is appropriate.

23.2 Process for Data Verification and Validation

Data verification and validation for sample collection and handling activities will consist of the following tasks:

- Verification that the sampling activities, sample locations, number of samples collected, and type of analysis performed is in accordance with QAPP requirements;
- Documentation of any field changes or discrepancies;
- Verification that the field activities (including sample location, sample type, sample date and time, name of field personnel, etc.) were properly documented;
- Verification of proper completion of sample labels and COC forms, and secure storage of samples;
- Verification that all samples recorded on COC forms were received by the laboratory.

Data verification and validation for the sample analysis activities will include all of the following:

- Verification that appropriate methodology has been followed;
- Verification that instrument calibrations have been adequately conducted;
- Verification that QC samples meet performance criteria;
- Verification that analytical results are complete;
- Verification that documentation is complete.

Verification and validation of data entry includes:

- Sorting data to identify missing or mistyped (too large or too small) values;
- Double-checking all typed values;
- Verification that correct data types correspond to database fields (i.e., text for text, integers for integers, number for numbers, dates for dates, times for times, etc.).

24. RECONCILIATION WITH USER REQUIREMENTS

The data collected during this project will be used to assess the effectiveness of LID BMPs in semi-arid environments of Southern California. The SMC LID Project will use the water quality and hydraulic data from this project's LID BMP and control sites to quantify volume reduction and pollutant removal rates. Ultimately, the data will be used in the development and revision of LID BMP Design and LID Guidance and Training Manuals.

The Project's sole purpose is to provide data to the SMC LID Project and does not include analysis of BMP effectiveness. The Project will produce a Final Technical Memorandum to describe the monitoring activities, data quality, and any limitations of the data. The samples obtained will reflect conditions during wet events over a five-year period at one facility in the Santa Ana Watershed. The Final Technical Memorandum will detail those limitations and assumptions to allow the user to determine their usefulness in other applications.

25. REFERENCES

ASTM International. ASTM D 4840, "Standard Guide for Sampling Chain-of-Custody Procedures." December 10, 1999.

Code of Federal Regulations (CFR). 40 CFR 136- Guidelines establishing test procedures for the analysis of pollutants. November 2011.

Riverside County Flood Control and Water Conservation District (RCFC&WCD). "Consolidated Monitoring Plan (Revised)". June 2012.

RCFC&WCD. Santa Ana Region Annual Report, Section 11: Monitoring Annual Report. November 30, 2009.

Santa Ana Watershed Project Authority (SAWPA). State Water Board Grant Agreement No. 09-346-550. Executed July 21, 2010.

San Bernardino County Flood Control District (SBCFD). Monitoring Plan: San Bernardino Low Impact Development Training and Guidance Program. September 2008.

Appendix A

Riverside County Flood Control and Water Conservation District

Chain of Custody (COC) Forms

E.S. Babcock Sons, Inc. Environmental Laboratories
(951) 653-3351 FAX (951) 653-1662
www.babcocklabs.com

Chain of Custody Sample Information Record

Client:	RCFC & WCD	Contact:	Arlene Chun / Steve Clark	Phone No.	(951) 955.0842/955.1346
FAX No.	951.788.9965	Email:	abchun@rcflood.org / seclark@rcflood.org		
Project Name:	LID Project	Turn Around Time:	Routine / *3-5 Day Rush / *48 Hour Rush / *24 Hour Rush		
Project Location:		*Lab TAT Approval:	By:	*Additional Charges May Apply	

Additional Reporting Requests
Include QC Data Package: ☐ Yes ☐ No
FAX Results: ☐ Yes ☐ No
Email Results: ☐ Yes ☐ No
State EDT: ☐ Yes ☐ No
(Include Source Number in Notes)

Sampler Information
Name: _____
Employer: RCFC & WCD
Signature: _____

Sample ID	Date	Time	# of Containers & Preservatives: Unpreserved	H_2SO_4	HCl	HNO_3	$Na_2S_2O_3$	NaOH	NaOH / Zn Acetate	NH_4Cl	MCAA			Total # of Containers	Sample Type: Routine	Resample	Special	Analysis Requested	Matrix	Notes: Bottle #	Flow
																				1	
																				2	
																				3	
																				4	
																				5	
																				6	
																				7	
																				8	
																				9	
																				10	
																				11	
																				12	

DW = Drinking Water
WW = Wastewater
GW = Groundwater
S = Soil
SG = Sludge
L = Liquid
M = Miscellaneous

COMPOSITE
(see project list)

Relinquished By (sign)	Print Name / Company	Date / Time	Received By (Sign)	Print Name / Company

(For Lab Use Only) Sample Integrity Upon Receipt				Lab Notes
Sample(s) Submitted on Ice?	Yes	No	Temperature	
Custody Seal(s) Intact?	Yes	No	N/A °C	
Sample(s) Intact?	Yes	No	☐ Cooler Blank	

Lab No. _____

Page ____ of ____

Appendix B

Edward S. Babcock and Sons Inc.

Quality Assurance (QA) Manual

(QA appendices available upon request)

Effective July 1, 2012
(This document supersedes that which was effective July 1, 2011)

QUALITY ASSURANCE MANUAL

Of

BABCOCK LABORATORIES, INC.
DBA
EDWARD S. BABCOCK AND SONS, INC
Located at: 6100 & 6110 Quail Valley Ct., Riverside, CA 92507
Mailing address: PO Box 432, Riverside, CA 92502
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Approvals:

_____	_____
Allison Mackenzie CEO & CFO	Lawrence J. Chrystal Laboratory Technical Director
_____	_____
Stacey Fry Quality Assurance Manager	Susann K. Thomas Laboratory Director of Operations
_____	
Carol Kase Microbiology Department Manager	

In addition to the Project Managers, the above are approved signatories for E.S. Babcock & Sons, Inc. E.S. Babcock & Sons, Inc. has no parent corporation or subsidiaries and is located at 6100 and 6110 Quail Valley Court, Riverside, CA 92507.

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1.0 INTRODUCTION

This document outlines the Quality Assurance procedures and management system implemented by Babcock Laboratories, Inc., a privately owned environmental laboratory involved primarily in the testing of drinking water, wastewater, soils, and other matrices including food and bottled beverages. (http://www.babcocklabs.com). This document describes the framework by which the laboratory establishes and maintains a documented quality system appropriate to the type, range, and volume of environmental and food/beverage testing activities it undertakes. This document outlines the laboratory's policies and procedures established in order to meet the requirements set by the National Environmental Laboratory Accreditation Conference (NELAC, http://www.nelac-institute.org) for National Environmental Laboratory Accreditation Program (NELAP) accreditation facilitated by The NELAP Institute (TNI), the ISO/IEC 17025:2005 Standard "General requirements for the competence of testing and calibration laboratories" and the requirements of the "AOAC" food program. See Appendix A for copies of the laboratory's certification. Other documents and procedures will be referenced and should be consulted for specific details. For advertising purposes the use of the term "A2LA" and the "A2LA Accredited" symbol requires prior approval of QA and will be done in strict accordance with A2LA's advertising policy document (Appendix B). The quality and management system is maintained to provide accurate and dependable data for the laboratory's clients. It is the responsibility of each employee to be familiar with and implement the quality control practices of the laboratory. Additionally, management is responsible for maintaining Quality Assurance (QA) in all aspects of the operation.

2.0 COMPANY VISION AND MISSION STATEMENT

2.1 Company Vision: *Creating a positive environment where laboratory professionals proudly deliver unparalleled services.*

2.2 Mission: *The goal of Edward S. Babcock & Sons, Inc. is to produce the highest quality, most reliable environmental services and analytical data.*

3.0 OBJECTIVES

3.1 To achieve this goal the corporate officers, board of directors and managers of the company are committed to these objectives:

3.1.1 To provide professional service to clients and the community, drawing on the many years of experience in the analytical testing industry.

3.1.2 To produce scientifically valid and legally defensible data.

3.1.3 To promote ethical standards and professional integrity within our organization and the environmental community.

3.1.4 To attract and retain the best, well educated, and properly trained staff possible.

3.1.5 To promote growth of the company in a fiscally responsible and profitable manner.

4.0 FLOW OF RESPONSIBILITY:

4.1 The flow of responsibility within the laboratory follows the organizational chart. See Appendix C for Organization Charts and Appendix D for Resumes of Key Personnel.

4.1.1 The CEO is responsible for the business functions of the company.

4.1.2 The CEO oversees the office and the generation of all final reports.

4.1.3 The Laboratory Director of Operations is in control of the operations of the laboratory. The Laboratory Technical Director is in control of instrumentation, methodology and technical areas of the laboratory.

4.1.4 The QA Manager has access to the CEO and Laboratory Directors and is responsible for ensuring lab wide compliance with the NELAP/TNI standard (see NELAC Quality System Information in Appendix I) and the ISO 17025 standard.

4.1.5 The QA Auditor and QA Assistant help the QA Manager with routine analytical audits and Quality Control paper work.

4.1.6 The Project Managers are responsible for ensuring that client needs are met with respect to QC requirements and final reporting. Project Managers are also approved signatories for their assigned client reports.

4.1.7 The Inorganic Department Manager oversees the Inorganic Department Supervisor and the Metal's Department.

4.1.8 The Supervisors and Managers are accountable for the smooth operation of their sections, meeting holding time deadlines, and troubleshooting problems. They ensure the competence of all who operate specific equipment, perform analytical tests, evaluate results, and sign test reports.

4.1.9 The chemists and technicians are held responsible for following prescribed protocols in the performance of their assigned analyses, and keeping their managers apprised of any difficulties that could affect the accuracy of results or the smooth operation of the laboratory.

4.1.10 Where contracted and additional technical and key support personnel are used, the laboratory ensures that such personnel are supervised and competent and that they work in accordance with the laboratory's quality system.

4.2 The CEO is named as Deputy Laboratory Technical or Operations Director and fulfills that responsibility when one or both of the Laboratory Directors are absent. See Appendix E for a list of specific duties. If this absence exceeds 65 consecutive calendar days, CADHS-NELAP will be notified in writing. The Laboratory Director(s) are named as Deputy QA Officers and fulfill that responsibility when the QA Manager is absent.

4.3 Job descriptions for several key positions are attached to this document in Appendix E. Job descriptions for all positions are maintained in the personnel files.

4.4 The QA Department includes the QA Manager and designee(s) (i.e. QA Auditor and QA Assistant) performing tasks under the direction of the QA Manager. The members of the QA Department may also be referred to as

QA Officers. The QA Office is the location of the QA Manager's desks and is where they maintain their files.

5.0 CONTRACT REVIEW

5.1 The laboratory has established procedures for the review of requests, tenders and contracts. Before the initiation of any analytical testing program, a review of the request is required. Records of reviews are maintained for ongoing work, along with any pertinent information regarding client's requirements. An oral agreement or a written contract may be entered into to provide the client with testing services. Any differences between the request or tender and the contract shall be resolved before work is commenced. The client is to be contacted if laboratory accreditation is suspended, revoked, or voluntarily withdrawn. For more information on contract review, refer to the Review of Contracts and Tenders SOP (A13).

5.2 Laboratory Capacity

5.2.1 It is the responsibility of the Laboratory Director(s) to ensure adequate capacity for all new projects prior to commencing work. The system used to determine laboratory capacity is based on the time taken to analyze a batch of samples for a given analyte, the number of analysts and labor hours available, and the equipment at hand. Each test is monitored for frequency of request on a weekly basis. When new work is contemplated, workloads are reviewed to determine what number of samples can be added while remaining within the laboratory capacity to perform the work.

6.0 CONFIDENTIALITY

6.1 **Laboratory reports** and accompanying documents contain confidential information intended for use by the individual or entity requesting and purchasing the analytical services. Except when required by law, no

information relating to a report is released to another person or party without permission from the paying client.

6.2 Laboratory documents containing client's information are to be handled and disposed of in a discrete manner.

6.3 Permission to release information may be given by **telephone or in writing**. Documentation of consent, including the name of the person and the date/time of consent, is recorded in the client file.

6.4 **Faxes** clearly identify the intended recipient. The fax coversheet utilized by Babcock Laboratories contains a statement at the bottom of the sheet stating that the contents of the fax are confidential and intended only for the recipient. If the laboratory is familiar with a particular client, and there is agreement between the lab and the client, the cover letter may be omitted for brevity purposes.

6.5 Results transmitted via **E-mail or EDD** are also accompanied by a confidentiality statement.

6.6 Client results may be accessed via the **Internet**. These results are password protected and hosted by a server separate from the laboratory's main server.

6.7 Employees are informed of these policies during new employee orientation.

7.0 EXCEPTIONAL CIRCUMSTANCES

7.1 In the event that it is necessary to deviate from a documented policy, procedure or specification, several steps must be taken for approval of the exception. The QA Manager and Laboratory Directors meet to discuss and

research the proposed exception. When circumstances are such that the QA Manager and Lab Directors agree that permission to deviate from policy, procedure or specification is warranted, the following steps must be taken.

7.1.1 Where applicable, the client is contacted for approval of the proposed change in procedure and verbal or written approval is requested and receipt verified.

7.1.2 The agreed upon change in policy, procedure, or specification is documented and kept in the project file.

7.1.3 Copies of the change are attached to the analytical records, where applicable.

7.1.4 Copies of the change are attached to the review reports for any analyses directly related to the change.

7.1.5 Copies of the change are filed in the client report file.

8.0 COMPLAINTS

8.1 Client concerns regarding any aspect of laboratory services are directed to the Director of Client Services, the Regional Business Development Director or the Project Managers. Questions or concerns from representatives of regulatory agencies are directed to the Laboratory Directors or a manager designated as a Deputy Laboratory Director. For any question or concern, the problem is first researched and the circumstances surrounding the incident are ascertained.

8.2 Where analytical results are at issue, the data is re-verified by the QA Manager or Department Supervisor or Manager. If the sample is still available a re-analysis may be requested to verify the original data. Where an error is identified, an amended report is issued.

8.3 The laboratory will gladly afford the client cooperation to clarify any client request to include laboratory visits and QC and PT data inspections.

8.4 If the investigation of any question raises doubt about compliance with the established laboratory policies, procedures or the quality of calibrations or test, the area of concern is audited in accordance with the audit section of this document. For more information on follow up documentation, refer to the Quality Control Follow-Up Forms SOP (Q24).

9.0 RECORD KEEPING

9.1 The laboratory information management system (LIMS) maintains records of Quality Control (QC) performance data and client samples data. All electronic and hard copy records are readily retrievable. For more information on data records, refer to the Records Management SOP (A02). It is the responsibility of the QA Manager or her designees to periodically review LIMS-generated records of QC performance data and to update acceptance criteria, as needed. For more information on the QC data review, refer to the Statistical Evaluation of Quality Control Data SOP (Q03).

9.2 Analytical run records are maintained as part of batch documentation for a particular analysis. An analytical run (listed in the LIMS as a "Batch") can contain calibration standards, blanks, lab control samples (or blank spikes), replicate analyses, matrix spikes, matrix spike duplicates, and sample data analyzed as a group and may contain one or more analytical batches. Raw data contains the following information:

- 9.2.1 Sample preparation.
- 9.2.2 pH observations including preservation confirmation (unless documented in splitting)
- 9.2.3 Sample matrix on bench sheet.
- 9.2.4 Standard origin (See SOP Q05 section 4.0 for reagent origin.)
- 9.2.5 Method of analysis.

9.2.6 Initials of analysts involved with the sample clearly indicating: "prepared by," "analyzed by" or "reviewed by".

9.2.7 Date and time of analysis.

9.2.8 Instrument i.d.

9.2.9 QC results and acceptance criteria.

9.3 All records are written in ink. Analysts are instructed to write legibly.

10.0 RECORDS MANAGEMENT

10.1 All hard copy and electronic records are stored on-site, or at an independent archive facility, for at least five years. After the archive period, the records are destroyed by a reputable records archiving and disposal company. Records maintained for at least five years include:

10.1.1 LIMS electronic files.

10.1.2 Raw analytical data files, hard copy and electronic.

10.1.3 QC data files including standard verification, control charts and corrective action reports.

10.1.4 Analytical data review reports.

10.1.5 Client files (hard copy and electronic) including all final reports, Chain of Custody forms, Analysis Request Forms, and other correspondence.

10.1.6 Personnel files including:

10.1.6.1 Personnel qualifications, experience, and training records.

10.1.6.2 Initial demonstration of capability (IDOC) and demonstration of continuing proficiency (DOCP) for each analyst or analytical work group.

10.1.6.3 A log of names, initials, and signatures for all individuals who are responsible for signing or initialing any laboratory records.

10.1.6.4 A record of Standard Operating Procedure (SOP) review and comprehension.

10.1.7 Business files including accounts payable, accounts receivable and payroll data.

10.2 Records are stored according to category in standard cardboard file boxes labeled with the category of records, date range, and descriptive information. A unique container number further identifies containers stored off-site. An access log is maintained for both on-site and off-site record retrieval.

10.3 There is a document control system indicating the time period during which a procedure, manual, or document is in effect. For more information regarding record management, refer to the Records Management SOP (A02) and the SOP Modification Policy (Q23).

11.0 TEST METHODS UTILIZED BY THE LABORATORY

11.1 ESB uses appropriate test methods and procedures for all tests and related activities within its responsibility (including sample collection, sample handling, transport and storage, sample preparation, and sample analysis). The methods and procedures are consistent with the accuracy required, and with any standard specifications relevant to the calibrations or tests concerned.

11.1.1 The laboratory uses the most appropriate valid edition of a standard or method.

11.1.2 When the use of a specific test method for a sample analysis is mandated or requested, only the specified method is used.

11.1.3 When similar tests are combined in an analytical run, the most stringent method requirements are followed.

11.1.4 Where test methods are employed in a Performance Based Measurement System approach, the methods are fully

documented and validated, and are available to the client and other recipients of the relevant reports.

11.2 Test Methods currently used by Babcock Laboratories may be found in *SW-846, Test Methods for Evaluating Solid Wastes Physical/Chemical Methods*, 3rd edition Update III 1996, *Methods for the Determination of Inorganic Substances in Environmental Samples*; EPA 600-R-93/100; *Methods for the Determination of Metals in Environmental Samples*; EPA 600-R-93/100; *Methods for the Determination of Metals in Environmental Samples, Supplement I*, EPA-600/R-95/111, EPA 500 and 600 series methods included or referenced in the Federal Register; and *Standard Methods for the Examination of Water and Wastewater*, 18th, 19th, and 20th editions, APHA/AWWA/WEF; Bacteriological Analytical Manual (BAM), 8th edition; Compendium of Methods of the Microbiological Examination of Foods (CMMEF), 4th edition; AOAC Official Methods of Analysis (OMA), 18th edition, or other approved or accepted methods.

12.0 HOUSEKEEPING AND SAFETY

12.1 Each analyst is responsible for keeping his or her work areas as neat and clean as possible. Each employee is warned of potential safety problems and is advised to be familiar with the following:

12.1.1 An eye wash station is available in each of the labs.

12.1.2 A drench-type safety shower is available in each of the prep labs and in the inorganic, bacteriology, semi-volatile, and volatile labs.

12.1.3 Fire extinguishers are placed at several locations throughout the laboratory. They are easily found by signs that display their location. Analysts should be aware of the fire extinguishers located in their work areas. All fire extinguishers are serviced annually by contract with an outside company.

12.1.4 Chemical spill kits are centrally located and are available for solvents, mercury, caustics and acids.

12.1.5 First Aid kits are located in every lab. A fire blanket is located in each of the prep labs.

12.1.6 Flammable solvents are stored in an explosion proof cabinet with appropriate venting or below the hoods.

12.1.7 Evacuation plans are posted at several locations in the laboratory.

12.1.8 There is a Material Safety Data Sheet (MSDS) Library centrally located and readily accessible to all personnel in the main hallway of 6100 Quail Valley Court.

12.2 Copies of the laboratory Emergency Plans are accessible to all personnel. Copies are located in the study as well as on the NAS Server. These include a *Business Emergency Plan (BEP)*, *Chemical Hygiene Plan (CHP)*, *Fire Prevention Plan (FPP)*, and *Injury and Illness Prevention Plan (IIPP*).

13.0 SAMPLING (See Appendix F for Sampling Procedure References)

13.1 Each member of our Field Department has a detailed knowledge of proper sampling techniques, sample handling procedures, and the criteria for sample acceptability. Field Department employees are trained in the proper safety requirements and precautionary measures to be used in field activities and have read and agreed to follow Field Sampling SOP (F02). The Field Department employees are advised to discuss with the on-site supervisor (if applicable) all steps necessary in obtaining the most representative sample possible – especially in unusual sampling situations. The Field Department and Log-in employees have each read and agreed to follow the Sample Acceptability SOP (A08). Samples are collected only in approved containers. The Field Department is currently not responsible for the sample collection of food and bottled beverage products, in these instances samples are provided by the client. Sample approval is based on the following requirements:

13.1.1 **Containers must be compatible with the sample and contain an adequate volume of sample.** The sample must not cause the container to corrode and the container must not contaminate the sample. It must be of sufficient volume to hold enough sample for the required analyses – if not, multiple containers may be used, if needed.

13.1.2 **Containers must be made of approved materials.** For most uses, containers may be made of LPE plastic. Soda glass or borosilicate with Teflon is used for organic sampling. Plastic zip-lock bags or Mason jars are acceptable for many types of solid samples. For source gas emissions, tedlar bags, canisters, and absorbent traps are commonly used.

13.1.3 **Containers must be sterile for bacterial analysis.** Sterilized containers and lids are utilized for all bacterial analyses. A capacity of at least 100 ml is required. For bacteriological samples, we recommend sealing the containers in a zip-closure bag after collection for transport to the lab. Food and bottled beverage samples are submitted in their sealed product containers as provided by the client.

13.2 The next section discusses other criteria used to determine sample acceptability including sample preservation, sample temperature, sample holding time, and condition of sample seal or evidence tape (if present).

13.3 The preservation and storage of samples varies according to the analyses to be performed. Proper preservation and storage may be found in *SW-846, Test Methods for Evaluating Solid Wastes Physical/Chemical Methods,* 3rd edition Update III 1996, in the *Handbook for Sampling and*

Sample Preservation of Water and Wastewater, Sept 1982 EPA-600/4-82-029, 40CFR136 and 40CFR141.

13.4 For more information regarding sample collection, refer to the Field Sampling SOP (F02). For sample containers, preservation and holding times refer to Appendix G – SOP (Q14).

14.0 SAMPLE IDENTIFICATION, CUSTODY, AND TRACKING

14.1 All written records are in indelible ink. For more information regarding sample acceptability, receiving and log-in, refer to the Sample Acceptability SOP (A08) and the Sample Receiving/Log-in SOP (A03).

14.2 Sample Identification

The samples are labeled in the field. The identification on the label includes the following. The information must be presented in such a way that the sample is uniquely identified and includes the following:

14.2.1 Identification of the sample.

14.2.2 The sampler's name.

14.2.3 The date the sample was taken.

14.2.4 The time (24-hour clock when possible) the sample was taken.

14.2.5 The client's name.

14.2.6 Significant information regarding the analysis (e.g. tests to be performed, temperature upon sampling, chlorine residual, preservation, if the sample is a composite or grab, miscellaneous comments, etc.)

14.3 Sample seals may be used to indicate possible tampering with the sample from the time of collection until the sample arrives at the laboratory – this is especially important for samples that may be used for litigation purposes and are delivered to the laboratory by the client or a third party.

14.4 Chain of Custody

14.4.1 When necessary, a Chain of Custody form is filled out. A Chain of Custody is required whenever the potential exists that the sample may be used for litigation. An example form is included in Appendix H. This form contains all of the above information included on the label and also "Relinquished by" and "Received by" blocks for the name(s) of the person(s) who submit or release the sample and the name(s) of the person(s) who receive the sample along with the date(s) and time(s) that the custody of the sample changes hands. The Chain of Custody also includes information relating to sample acceptability.

14.4.2 Information stored in LIMS serves as an internal Chain of Custody documenting sample use within the laboratory (section 14.7). If for litigation purposes a client requires the sample to be accessed only thru a custody officer, a form is available that tracks sample custody within the laboratory. When not in use the sample is kept in a locked refrigerator. For more information on litigation samples, refer to the Legal/Evidentiary Custody for Litigation Samples SOP (A01).

14.5 Sample Receipt Form

Whenever a Chain of Custody is not submitted with a sample, a Sample Receipt Form is filled out to document sample acceptability. This form lists the sample description Babcock's laboratory number to unequivocally tie the form to the field sample. An example form is included in Appendix H.

14.6 Field Records

Field technicians maintain a logbook to document all of their sampling activities. This logbook contains pertinent information regarding collection of samples, including:

14.6.1 Name of contact

14.6.2 Location of sampling point

14.6.3 Date and time (24-hour clock) of collection

14.6.4 Field measurements

14.6.5 Comments

14.6.6 Any other information that is required by the Project Plan.

14.6.7 The field technician retains a copy of each Chain of Custody accompanying that day's samples.

14.7 Sample Tracking: Laboratory Information Management System

The laboratory has in place a LIMS for the tracking of all samples from the time they are logged in until the final report leaves the laboratory. At any step in the process, current information regarding the status of the sample can be obtained from the computer. The computer also keeps track of holding times and due dates.

14.8 Log-in of Samples

After the sample is collected, custody of the sample is turned over to the laboratory at the front counter. Log-in personnel verify sample acceptability – documenting acceptability on the Chain of Custody or a Sample Receipt Form. A Sample Acceptability checklist is posted in Log-in as a reminder of the criteria list. The client is contacted if any of the following occur:

14.8.1 The container is leaking or damaged.

14.8.2 The Chain of Custody seal is broken, if present.

14.8.3 The identification of the sample is not the same as that on the Chain of Custody (if the identification is not very different, the information is noted without necessarily contacting the client).

14.8.4 The sample is received past holding time (or likely to expire before the lab is able to perform the test).

14.8.5 The temperature of the sample exceeds method requirements.

14.8.6 The sterility of the sample container is questionable, if for bacteriological analysis.

14.9 The client must verbally authorize the lab to proceed with analysis if any of the above conditions are observed. This authorization is noted on the Sample Receipt Form or the Chain of Custody.

14.10 The Department Supervisor or Manager is informed if the samples are not preserved properly, incorrect containers are used, inappropriate sample size is provided, holding times have been exceeded, or any other problems occur so that corrective action, either in the lab or through the client, may be taken. Proper notation and warning is given before any sample is accepted under the conditions above.

14.11 Upon acceptance of the sample from the field technicians or directly from a client, the sample is logged-in.

14.12 Every laboratory number or SampleID number that is assigned corresponds to a specific sample. The computer generates this number. The information in the computer unequivocally links the sample to the field identification. Other information recorded in the computer includes the following:

14.12.1 The name of the person, company, or agency requesting the analysis.

14.12.2 The sample description (corresponding to the field identification).

14.12.3 The date and time (24-hour clock) the sample was taken and the identity of the sampler.

14.12.4 The date and time (24-hour clock) the sample is submitted to the laboratory and the identity of the person submitting the sample.

14.12.5 The identity of the person logging in the sample.

14.12.6 The sample matrix.

14.12.7 The type of sample container.

14.12.8 Sample preservation (see also the Bottle Preservation SOP A09).

14.12.9 If evidence tape and/or seal are present.

14.12.10 Analyses requested - Constituents.

14.12.11 Chain of Custody (Y or N).

14.12.12 If thermal preservation is required, the temperature of the sample at receipt. (If recently collected, is the sample on ice?)

14.12.13 Any other pertinent information (such as any abnormalities or departures from the condition specified in the test method, reporting limit requests, high level QC or QC review requests, contact details, sample preservation exceptions).

14.13 After Log-in, two items are generated by the LIMS:

14.13.1 A Work Order Report containing information such as Client ID, Laboratory Number, analyses requested, and date/time of receipt is printed. Chem and Bacti Work Orders are kept sequentially in three-ring notebooks or file folders. Office staff verifies the log-in information and initials the report. The Chain of Custody/Sample Receipt Form (including any common carrier documents received) and any other paperwork submitted with the samples are kept with the Work Order Report. These documents are pulled for inclusion with the final report when the laboratory completes the analysis.

14.13.2 A durable, water resistant, computer-generated sample label is printed and affixed to each sample. Every sample container received from the client is uniquely identified on the label with the laboratory reference number and an alpha character (A, B, C) indicating the specific container. Sample preservation is verified and, if necessary, adjusted upon receipt or at the bench

prior to analysis. For more information on sample preservation and storage, refer to the Sample Splitting, Preservation, Storage, and Disposal SOP (A06).

14.13.3 For microbiological samples, in addition to the Work Order Report and labels, the lab sheet may be printed from the LIMS.

15.0 IDENTIFICATION AND STORAGE OF SUBSAMPLES, EXTRACTS, AND DIGESTATES

15.1 Unique laboratory numbers generated by the LIMS identify all sample containers. When sub-samples, extracts and/or digestates are made, each additional container is uniquely identifiable. Sub-samples taken for preservation indicate the preservative added in addition to the SampleID number. Vials containing extracts for Organic determinations indicate the SampleID number, the Method Number and the extraction date. Digestate storage containers indicate the laboratory number and type of preparation – each preparation batch for the metal analyses on any one date is also color-coded. All sub-samples, extracts, and digestates are stored according to the applicable preservation or the test method requirements.

16.0 TRANSPORTATION OF SAMPLES

16.1 Once samples have been received, they do not leave the premises. Office employees personally place the samples in the refrigerator (temp 2-6 °C) in the proper holding section, in the proper area of the sample storage room, or in the proper analytical section of the lab. Storage of samples must follow preservation protocols. Any relevant instructions regarding storage accompanying the sample must be followed. Samples are stored away from standards, food, and other sources of potential contamination. Any pertinent information regarding the samples must be discussed with the Department Supervisor or Manager.

16.2 All analysts (names and dates) handling the sample are documented electronically in LIMS or on the paperwork associated with the sample and its analysis. Samples that have been completed are held in the storage area for at least one month – at which time they are disposed of in the proper manner. For more information concerning sample disposal refer to Pollution Prevention SOP S07. Occasionally, samples for litigation purposes might be held for a longer period of time at the request of the client or samples may be returned to the client. All doors in the laboratory are locked securely and the entry alarm is armed when no approved personnel are present.

17.0 EMPLOYEE ORIENTATION

17.1 All new employees receive orientation to the company and its mission during new hire training and orientation. Orientation includes familiarization with the Babcock Laboratories, Inc. Employee Handbook, the Quality Assurance Manual, the Ethics and Data Integrity Manual, and Laboratory Safety Training. Employees also receive training from the QA Department regarding QA procedures, NELAP standards, ISO 17025 Standards (when applicable), laboratory techniques, LIMS, and company information. See Appendix I for examples of training module outlines.

17.2 The Employee Handbook discusses the standards of conduct, which are expected of all employees, including confidentiality of information. In detailing the contents of the Ethics and Data Integrity Manual, the employee also receives instruction regarding his/her ethical and legal responsibilities and the potential penalties for improper, unethical, or illegal actions. All employees are required to sign a statement acknowledging they have been provided with this information and that they have read and are familiar with the manuals. Statements are on file in the QA Files located in the QA office and also on the computer in the QA folder on the NAS server. As stated in the Ethics and Data Integrity Manual (Appendix J), an ESB Quality Control Follow-up/Root Cause Analysis Report may be

used to document challenges presented to the Ethics and Data Integrity Program. However, if any possibility of serious potential unethical behavior has been raised, an official Ethics Investigation will be initiated and the committee will report its findings to the CEO.

18.0 STANDARD OPERATING PROCEDURES (SOPs)

18.1 ESB maintains Standard Operating Procedures (SOPs) that accurately reflect all phases of current laboratory activities such as assessing data integrity, corrective actions, handling customer complaints, and all test methods. Some features of the SOPs include:

18.1.1 These documents are internally written documents.

18.1.2 For analytical tests, copies of published methods are used initially until the internally written SOP has been developed. Any deviations from the test method are documented *in italics*.

18.1.3 Copies of all SOPs are accessible to all personnel. Personnel must read all SOPs that are applicable to their assigned tasks and sign a statement that they have done so.

18.1.4 SOPs are organized.

18.1.5 Each SOP clearly indicates the effective date of the document, the revision number and the signature(s) of the approving authority (the Quality Assurance Manager or her designee).

18.1.6 Analytical SOPs are reviewed and updated during routine method audits. Non-analytical SOPs are reviewed and, where necessary, revised to ensure continuing suitability and compliance with laboratory policies and quality control standards

19.0 THE LABORATORY METHOD MANUAL

19.1 The laboratory has and maintains in-house Methods Manuals consisting of individual SOPs for each accredited analyte or test method. For more information regarding SOPs, refer to the SOP Modification Policy SOP (Q23). These manuals consist of copies of published or referenced test

methods or the laboratory SOP. Each SOP includes or references, where applicable:

19.1.1 Identification of the test method.

19.1.2 Applicable matrix or matrices.

19.1.3 Reporting and Detection limit.

19.1.4 Scope and application, including components to be analyzed.

19.1.5 Summary of the test method.

19.1.6 Definitions (see also the Definitions SOP Q15).

19.1.7 Interferences.

19.1.8 Safety (see also the Safety SOPs S01-S07).

19.1.9 Equipment and supplies (see also the Equipment Maintenance SOP Q21).

19.1.10 Reagents and standards (see also the Reagent Quality and Documentation SOP Q05 and the Standard Quality and Documentation SOP Q08).

19.1.11 Sample collection, preservation, shipment and storage (see also the Bottle Control SOP Q13, the Holding Times/Due Dates SOP Q07, and the Sample Containers, Preservation Techniques, and Holding Times for Aqueous Matrices SOP Q14).

19.1.12 Quality control (see also the Quality Control Data SOP Q01).

19.1.13 Calibration and standardization.

19.1.14 Procedure (see also the General Laboratory Techniques SOP Q04 and the Good Automated Laboratory Practices SOP Q17).

19.1.15 Calculations.

19.1.16 Method performance.

19.1.17 Pollution prevention (see also Pollution Prevention SOP S07).

19.1.18 Data assessment and acceptance criteria for quality control measures (see also the Procedure for the Integration of Chromatographic Peaks SOP Q18).

19.1.19 Corrective actions for out-of-control data (see also the Corrective Action for Chemical Analyses SOP Q06).

19.1.20 Contingencies for handling out-of-control or unacceptable data.

19.1.21 Waste management (see also Pollution Prevention SOP S07).

19.1.22 References including instrument manual if applicable.

19.1.23 Any tables, diagrams, flowcharts and validation data.

19.2 It is the policy of Babcock Laboratories, Inc. that the Quality Control protocols specified by the Laboratory Methods Manuals be followed.

20.0 DEMONSTRATION OF PROFICIENCY

20.1 In order to demonstrate the suitability of a test method for its intended purpose, Babcock Laboratories, Inc demonstrates and documents its ability to meet acceptance criteria either specified by the method, by the Environmental Protection Agency (EPA), the State program requirements or other accrediting bodies such as A2LA. Acceptance criteria meet or exceed these requirements and demonstrate that the test method provides correct/expected results with respect to specified detection capabilities, selectivity, and reproducibility.

20.2 Microbiological Analyses

The Microbiology laboratory utilizes accepted (official) test methods or commercialized test kits for official test methods. Proficiency with the test method is demonstrated prior to first use. Microbiological test methods are validated in terms of specificity and reproducibility by the use of positive and negative controls covering all aspects of the test. The validation of

microbiological test methods is performed under the same conditions as those for routine sample analysis. Individual microbiologist demonstration of capability is required prior to unsupervised sample analysis. For details, please see the Bacteriology General Procedures and Quality Control SOP (B01).

20.3 Chemical Analyses

20.3.1 Laboratory

When initiating a new analytical method, the laboratory performs a complete data package including SOP, calibration, MDL study, and an Initial Demonstration of Capability (IDOC) as required by the method and/or the certifying agency. A follow-up is performed on any analyte that fails the laboratory acceptance criteria and an additional IDOC is performed for that analyte.

20.3.2 Work Cells

Whenever there is a significant change in the method or instrument, where Work Cells are used, the group must perform an Initial Demonstration of Capability (IDOC) as a unit. When a new analyst is added to the cell, the analyst may work with an experienced analyst until the training period is completed and four Laboratory Control Samples (LCSs) and Method Blank Samples (MBs) in four consecutive batches meet acceptance criteria. To demonstrate and document analyst proficiency, this data is recorded by the analyst using a Work Cell Change Form and submitted to the QA Department. If the new analyst cannot successfully complete the Work Cell Change, the cell must perform a new IDoC. In addition, if the entire Work Cell is changed/replaced, the Work Cell must perform an IDOC. (See instructions for IDOC in section 20.3.3.3 below).

20.3.3 Analyst Training Documentation

New employees or employees that are assigned new procedures undergo the following training:

20.3.3.1 The analyst reads the applicable SOP and is shown the procedure by the Supervisor or Manager or other designated trainer.

20.3.3.2 The analyst performs the procedure (or their part of the procedure when working with a Work Cell or Work Group) under direct supervision until the trainer is confident that the analyst can perform the procedure unsupervised.

20.3.3.3 The analyst performs an Initial Demonstration of Capability (IDOC). The IDOC is performed using either: 1) method specified procedure and criteria or, if the method does not specify 2) four aliquots of sample are analyzed at a concentration of 1-4 times the method or laboratory generated limit of quantitation. The aliquots may be either analyzed concurrently or over a period of several days (as long as they are consecutive for the analyst). The standards are from a source separate from the calibration. The average is calculated in the units used for reporting. The average and either the standard deviation or RSD are compared to method or, in the absence of method requirements, in-house acceptance criteria for recovery and reproducibility. If standard is not available for spiking, four sample aliquots are analyzed at a readable concentration and compared to in-house acceptance criteria for reproducibility. After follow-up, test parameters that fail acceptance criteria are reanalyzed with additional aliquots until they meet the criteria. During this training period, the primary or secondary trainer will co-initial any analyses of client samples by the trainee. The completed IDOC certificate along with supporting raw data is kept in the QA files.

20.3.3.4 A training log is completed to document the training of the new analyst, including information such as the analyst name, trainer name, method, date SOP read, and date of IDOC or other demonstration.

20.3.3.5 The QA Department reviews proper documentation and calculations of the new analyst. The Demonstration of Capability Certificate Statement is approved by the Lab Director, and it is filed by the QA Department.

20.3.3.6 Annually, the analyst must perform a Demonstration of Continuing Proficiency (DOCP), as detailed in the Quality Control Data SOP (Q01). If the analyst has performed an IDOC during that calendar year, the IDOC will satisfy the requirement for that calendar year. If the analyst is part of a Work Cell that adds an employee with a Work Cell Change Form or has performed an IDOC those procedures will satisfy the requirement for that calendar year.

20.3.3.7 Demonstration of Capability Certification Statements -IDOC, DOCP, and Work Cell Change Form records are kept in the QA files.

Note: The training procedure is intended to ensure that personnel are adequately experienced in the duties they are expected to carry out and are receiving any needed training. The Laboratory Directors or Lab Manager certifies that personnel with appropriate education and/or technical background perform all tests for which the laboratory is accredited. Employees are chosen for specific tasks based on their abilities and experience. Refer to A12 Employee Training Procedure SOP for more information.

21.0 METHOD DETECTION LIMIT

21.1 The **method detection limit (MDL) or Limit of Detection (LOD)** is verified statistically for each analytical method and for aqueous and non-aqueous matrices, as applicable. A minimum of seven replicates of a spiked matrix are processed and analyzed at a concentration of 2.5-5 times the estimated method detection limit or per method specifications. The standard deviation is calculated. The statistical method detection limit is the standard deviation multiplied by the student's T factor for the number of replicates at a 99% confidence level and multiplied by any preparation or dilution factor (the student's T factor for seven replicates at a 99% confidence level is 3.14). The reporting limit (or limit of quantitation (LOQ)) must be equal to or above the calculated statistical MDL except for special organic analyses (see Q01 for reporting limit requirements). MDL studies for each analytical procedure are performed per method requirements or whenever major changes in the instrument or procedure occur.

21.2 On an annual basis the laboratory must confirm the validity of either the LOD (for results reported as J flag values) or the LOQ.

21.3 Confirmation of LOD

21.3.1 The validity of the LOD is confirmed by qualitative identification of the analyte(s) in a QC sample in each quality system matrix containing the analyte at no more than 2-3X the LOD for the single analyte tests and 1-4X the LOD for multiple analyte tests. This verification is performed on every instrument that is to be used for analysis of samples and reporting of data.

21.3.2 An LOD study is not required for any component for which spiking solutions or quality control samples are not available, or when test results are not to be reported to the LOD. Where an LOD study is not performed, the laboratory may not report a value below the Limit of Quantitation.

21.4 Confirmation of LOQ

21.4.1 The validity of the LOQ is confirmed by successful analysis of a QC sample containing the analyte(s) of concern in each quality system matrix 1-2 times the claimed LOQ. A successful analysis is one where the recovery of each analyte is within the established test method acceptance criteria or client data quality objectives for accuracy.

21.4.2 The LOQ study is not required for any component or property for which spiking solutions or quality control samples are not commercially available or otherwise inappropriate (e.g., pH) or if the LOD has already been confirmed.

22.0 PROFICIENCY TESTING (PT) SAMPLES

22.1 Babcock Laboratories, Inc. participates in PT studies at least twice each year in each field of accreditation (per matrix-technology/method-analyte/analyte group) in order to maintain accreditation. Certified samples are purchased, where available, from a National Voluntary Laboratory Accreditation Program (NVLAP) approved vendor. PT samples for microbiology food and bottled beverage testing methods such as pathogens are obtained from AOAC International. AOAC's PT program provides PT samples at a rate of four times per year. AOAC PTs for food and bottled beverage analyses are completed at a minimum of two activities per method/test type and/or technology per year. The lab's entire scope is covered over a four-year period at minimum.

22.2 For environmental PT samples, if the laboratory receives a "Not acceptable" result for a PT sample, a "Corrective Action: ESB PT Follow-up Form" is completed. The data is reviewed and the findings documented. These are reviewed by a QA Manager, signed by the Laboratory Director, and a copy is mailed to the accrediting authority/certifying body (for

DMRQA studies, a copy is also sent to any affected DMRQA clients upon client request). If the laboratory receives a "Not acceptable" result for two out of three of the last PT samples, the laboratory will order supplemental PT samples from an approved vender (such as Environmental Resource Associates or Absolute Standards) at least 15 calendar days apart from the closing date of one study to the shipment date of another study for the same field of proficiency testing, until a history of passing two out of three PT samples is reestablished. Proficiency testing raw data and reports are retained in accordance with the laboratory records management policy. For more information regarding our PT program, please refer to the Proficiency Testing SOPs (Q26 & Q27).

22.3 For food testing and bottled beverage PT samples, if the laboratory receives an "Unsatisfactory" of "Failed" result for a PT sample, the Root Cause of the unsatisfactory result is promptly investigated. The investigation is complete once the problem has been rectified and the lab is able to achieve satisfactory performances for the test/method in question.

23.0 QUALITY CONTROL OF LABORATORY CONDITIONS

23.1 For details on laboratory technique, equipment, and instrumentation, see the Equipment Maintenance SOP (Q21) and the General Laboratory Technique SOP (Q04). The following is a general summary however, the current Q04 or Q21 SOP will supersede.

23.2 Equipment and Instrumentation

23.2.1 Examples of chemical instrumentation include Gas Chromatographs, Gas Chromatograph/Mass Spectrometers, Ion Chromatographs, Ion Chromatographs/ Mass Spectrometer/ Mass Spectrometers, High Performance Liquid Chromatograph, Inductively Coupled Plasma Emission Spectrophotometer, Inductively Coupled Plasma/Mass Spectrometer, Infra-red Spectrophotometer, UV-Visual Spectrophotometers, Total

Organic Carbon Analyzer, nephelometers, recorders, and integrators. Bacteriological equipment includes incubators, autoclaves, fecal water baths, agar water baths, dry ovens, microscopes and a mini-Vidas. A list of current equipment, manufacturer, model, serial numbers, date received, date placed in service, condition when received, and laboratory location is kept on file. See Appendix K for equipment list.

23.2.2 All instruments/equipment are calibrated and maintained in accordance with manufacturer's specifications, method requirements, and well-established quality assurance practices. (See Appendix L: Calibration and Quality Control Criteria Charts for method specific calibration information.) A copy of the manufacturer's instructions, when available, is kept with the instrument. Equipment is operated by authorized personnel only. The analyst using the instrument/equipment maintains the instrument in clean and operating order. Problems are reported immediately so that they can be corrected. When an instrument is taken out of use due to a maintenance problem, a sign is placed on the instrument indicating the instrument is out of service. All major instruments are kept on maintenance contracts. Maintenance logs are kept for all major analytical equipment. All maintenance procedures routine and nonroutine are clearly documented in the log. When a new instrument is placed into service it is first calibrated and checked to establish that it meets the laboratory's specification requirements and complies with the relevant standard specifications. MDL and IDoC studies are performed, and a new instrument checklist must be completed and approved by QA prior to sample analysis. For more information regarding equipment, refer to the Equipment Maintenance SOP (Q21).

23.2.3 The temperatures of refrigerators, ovens, and incubators are monitored daily and recorded in a notebook along with the initials of the person performing the check. The temperatures of water baths are monitored daily (when in use). All thermometer calibrations are checked annually against an NIST certified thermometer at a level that is appropriate for its use. If a thermometer is broken, the calibration of the replacement is checked in such a way as to be NIST traceable before use. All calibration checks are recorded and any correction applied to the thermometer is recorded. A label indicating the calibration status is applied to each thermometer.

23.2.4 All glassware is rated as Class A. All glassware is cleaned to meet the sensitivity of the test method (e.g. acid rinsed for metal determination or solvent rinsed for organic determination). See the appropriate analytical SOP for the glassware cleaning procedure required by that method.

23.2.5 Balances are calibrated and cleaned annually by an outside vendor. The sensitivity, reproducibility, and internal consistency are checked within the laboratory daily using certified weights. These weights are calibrated at least annually and the weight calibration certificates are in the QA files.

23.2.6 The pH meters are calibrated with each use using 7.0 and 10.0 buffers and verified by a 4.0 buffer.

23.2.7 The fume hood filter quality and velocities are monitored and recorded quarterly. Fume hoods are serviced annually.

23.3 Environmental Conditions

23.3.1 The laboratory ensures that the environmental conditions do not invalidate the results or adversely affect the required quality of any measurement. Measures have been implemented to isolate sensitive analyses and guard against cross contamination including restricting access to areas such as volatile analysis when solvent vapor contamination is a possibility. The laboratory adheres to specific environmental conditions specified in a test method or by regulation and where specified, documents compliance.

23.3.2 The laboratory monitors for contamination by processing a Method Blank with every analytical batch. In the event of contamination, environmental tests are stopped, and corrective action is taken. The client is notified if it is believed the contamination has affected the client's sample result.

23.3.3 The laboratory takes into account factors that contribute to the total uncertainty of measurement in developing environmental test methods and procedures, in the training and qualification of personnel, and in the selection and calibration of the equipment it uses.

23.3.4 See section 24.2.2.4.4 or SOP Q03 "Statistical Evaluation of Quality Control Data" for details on uncertainty of measurement.

23.4 Reagents and Standards

23.4.1 Reagent water meets or exceeds ASTM Type II specifications. It is produced by a triple-stage commercial ion-exchange resin system. If higher quality water is desired, the water is then passed through a "Nanopure" system. All chemical reagents are ACS quality or better. Reagents are discarded and prepared fresh as required. The reagent name and date prepared shall serve as the unique identifier. If a second identical reagent is made on a given

day, it will be designated with an additional letter so that the name and date remain unique. All standards are prepared from ACS reagents or purchased already standardized by a nationally known chemical manufacturer such as Baker, Eastman Kodak, B & J, Merk, Supelco, Mallinkrodt, Aldrich, Sigma, etc. The date received is recorded in the chemical inventory. The date opened is recorded on the bottle. New standard solutions are compared to a standard of a different manufacturer or lot number. If they fail to agree within method-acceptable criteria, then either the standard is re-made or both standards are compared to another standard from a third source.

23.4.2 A standard log is maintained either in a logbook or LIMS and a reagent logbook is maintained to document the traceability of standards and reagents and record the manufacturer, lot number, concentration, preparer, and date of preparation. Whenever a new product is ordered, it is checked to verify that it meets specific method requirements.

23.4.3 For further details on the handling and use of reagents and standards, refer to the Reagent Quality and Documentation SOP and the Standard Quality and Documentation SOP (Q05 and Q08, respectively).

24.0 QUALITY CONTROL OF ANALYTICAL PROCEDURES

24.1 See the Quality Control Data SOP (Q01) and Bacteriology General Procedures and Quality Control (B01) for details and Appendix M for QA References.

24.2 Chemical Determinations:

24.2.1 Method QC

Calibration curves and linearity checks are run as prescribed in the applicable method for each procedure and for all parameters. All quality control requirements of each method must be met.

24.2.2 Batch QC

24.2.2.1 A batch is a set of 20 or fewer samples of a similar matrix that are processed together with the same method and personnel, using the same lots of reagents.

24.2.2.2 A Laboratory Control Sample (LCS) or Blank Spike (BS), a Method Blank (MB), a Matrix Spike (MS) and Matrix Spike Duplicate (MSD), sample Duplicate (Dup), or Laboratory Control Sample Duplicate (LCSD) may be analyzed for each batch per method requirements. A Dup is analyzed in place of the MS and MSD for gravimetric or titrimetric analyses. Where the method does not require MS/MSD or Dup, an LCS duplicate (LCSD) may be used to gather precision data instead. Note: Other documents may refer to these QC samples in different ways. For example, EPA 500 series methods refer to an LCS as a Laboratory Fortified Blank (LFB) and an MS as a Laboratory Fortified Matrix (LFM). Element refers to an LCS as a Blank Spike (BS).

24.2.2.3 Batch Controls:

24.2.2.3.1 The MB is used to assess the preparation batch for possible contamination during the preparation and processing steps. The MB shall be processed along with and under the same conditions as the associated samples to include

all steps of the analytical procedure. The MB documents the purity of any reagents or waters used. Under NELAP rules, a MB shall consist of a matrix that is similar to the associated samples and is known to be free of the analyte of interest.

24.2.2.3.2 The LCS is used to evaluate the performance of the total analytical system, including all preparation and analysis steps. The LCS is analyzed at a minimum of 1 per preparation batch. Exceptions would be for those analytes for which no spiking solutions are available. The LCS is a controlled matrix, known to be free of analytes of interest, spiked with known and verified concentrations of analytes.

24.2.2.4 Sample Specific Controls

24.2.2.4.1 Sample specific controls determine the effect of the sample matrix on method performance. They are designed as data quality indicators for a specific sample using the designated test method. These controls do not evaluate laboratory performance of an entire batch. Examples include: MS, MSD, Dup and surrogate spikes (Surr).

24.2.2.4.2 MS/MSD indicates the effect of the sample matrix on the precision and accuracy of the results generated using the selected method. The information is sample/matrix specific and

would not normally be used to determine the validity of the entire batch.

24.2.2.4.3 Duplicates are replicate aliquots of the same actual sample taken through the entire analytical procedure to indicate the precision of the results for the specific sample using the selected method. They provide a usable measure of precision only when the target analytes are found in sufficient quantity in the sample chosen for duplication.

24.2.2.4.4 The evaluated MS recoveries (or duplicate data in the absence of MS data) are in our estimation a valid approximation of method uncertainty for that matrix. MS data is an indication of correctness and reliability of the environmental tests including contributions from: human factors, accommodation and environmental conditions, environmental test methods and method validation, equipment, measurement traceability, sampling, and the handling of samples. MS and duplicate recoveries are presented to the user in a standard report. See SOP Q03 section 5.0 for more information.

24.2.2.4.5 For some analyses such as microbiological analyses certified under ISO 17025 requirements an alternative procedure for estimating the uncertainty of measurement is utilized. This procedure compiles all the factors listed above

and statistically derives a calculated measurement of uncertainty through the use of a software program provided by an outside vendor such as Calibration Laboratory Assessment Program (CLAS). See SOP Q03 section 6.0 for more information.

24.2.2.4.6 Surrogate compounds represent the various chemistries of the target analytes in the method. They are deliberately chosen because they are unlikely to occur as an environmental contaminant.

24.2.2.5 Other QC

24.2.2.5.1 External QC reference samples are obtained from an outside source for inclusion in our procedures for method verification. External QC reference samples from an appropriate source, such as Environmental Resource Associates or Absolute Standards, are analyzed semi-annually.

24.2.2.5.2 Internal standards are routinely included with determinations of metals and organics; also methods of addition may be incorporated. An internal standard (IS) is a pure compound that is not a contaminant in the sample and is added to a sample or sample extract in a known amount. The IS is used to measure the relative responses of target analytes and surrogates that are in the same sample. When an IS is used, it is added to the samples and QC samples or their extracts.

24.2.2.5.3 Non-routine samples with complex or unfamiliar matrices might need special QC, such as additional procedural spikes or two or more dissimilar methods of analysis. All batch QC is reviewed daily.

24.3 Bacteriological Determinations:

There are general procedures and quality control (QC) requirements that are unique to Bacteriological Determinations. These include sample container sterility checks, glassware cleaning procedures, housekeeping requirements, media maintenance/preparation/QC, dilution water requirements, instrument calibration, monitoring of incubators/water bath/dry oven, autoclave use and QC documentation (including the use of biological indicators of sterilization efficiency), reference culture requirements, and quality control analyses. For details, please refer to the Bacteriology General Procedures and Quality Control SOP (B01).

25.0 STATISTICAL EVALUATION OF DATA FROM CHEMICAL ANALYSES

25.1 The laboratory has quality control procedures for monitoring the validity of analytical tests undertaken. The resulting data is recorded in such a way that trends are detectable (refer to the Statistical Evaluation of Data SOP (Q03)), and when practical, statistical techniques are applied to the reviewing of the results (please refer to section 26).

25.2 All samples are analyzed within analytical batches. An analytical batch includes the QC samples discussed in Section 24 and any calibration and instrument checks required by the method.

25.3 Calibration curves for most analyses are a minimum of three points. Some methods require additional points in the calibration curve. Calibration requirements that are specified in the applicable test method must be met. See Appendix L for Calibration and Quality Control Criteria Charts.

25.4 The data from LCS's, MS's, MSD's, Duplicates, and Surrogates are used for statistical evaluation. This is based on the following examinations:

25.4.1 From duplicates, both of spikes and samples, precision data is calculated and the **Relative Percent Difference (RPD)** is determined. The equation is:

$$\text{Relative Percent Difference} = \frac{|A - B|}{\left(\frac{A + B}{2}\right)} \times 100$$

Where *A* is the analytical result for the matrix spike (or sample) and *B* is the analytical result for the matrix spike duplicate (or sample duplicate).

25.4.2 From results of the **MS/MSD** (S) accuracy data is calculated and the **percent recovery (%Rec)** is determined. The equation is:

$$\text{Percent Recovery} = \frac{|\text{M - A}|}{\text{Q}} \times 100$$

Where M is the matrix spike analytical result, A is the analytical result of the (unspiked) sample, and Q is the amount of spike added.

25.4.3 An **LCS percent recovery (%Rec)** is calculated by comparing the LCS analytical result (A) to the "True" value, which is the expected value of the spike (Q) (or the historical average of the control).

$$\text{Percent recovery} = \frac{\text{A}}{\text{Q}} \times 100$$

If the percent recovery is not within the laboratory acceptance criteria, the analysis is considered to be “out of control” and will not continue until the cause is found and corrective measures are taken. Any affected

samples associated with the out-of-control LCS are reprocessed for re-analysis or the results are reported with appropriate data qualifying codes.

25.4.4 The **relative standard deviation (RSD)** may be determined from the QC data using the following equation:

$$\text{Relative Standard Deviation} = \frac{S}{\overline{X}} \times 100$$

Where:

$$S = \sqrt{\frac{\sum (X - \overline{X})^2}{N - 1}}$$

Where S is the standard deviation, $\overline{X}$ is the mean of the observed value, X is the observed value, and *N* is the number of observations.

25.5 Control charts are generated in the LIMS. For details, please refer to the Statistical Evaluation of Data SOP (Q03).

26.0 DATA REDUCTION AND VALIDATION

26.1 To ensure the quality of the data, several review steps are incorporated into the data review process. For details refer to the Data Review and Validation SOP (Q10). In summary, the first level of review is the analyst who preliminarily assesses whether the batch QC acceptance criteria are met, adds qualifiers as appropriate and checks calculations, units, significant figures and dilution or concentration factors. The Peer Reviewers performs the second level of review. The Department Supervisor or Manager review follows, including a check to determine if proper relationships exist among the parameters in the sample. The Standard Methods SM 1030 F procedure may be also used along with the following:

26.2 Mineral Balances

Equation (1) for Total Cations (me/L)

Ca + Mg + Na + K + NH_3-N = total cations

Equation (2) for Total Anions (me/L)

CO_3 + HCO_3 + OH + SO_4 + Cl + NO_3 + F = total anions

Equation (3) for Calculated TDS (mg/L)

Calculated TDS = Ca + Mg + Na + K + Cl + SO_4 + NO_3 + F + SiO_2
+ (0.6 $\times$ Total Alkalinity as $CaCO_3$)

The measured TDS may be higher than the calculated TDS because a significant contributor may not be in the calculation.

Equation (4) for Cation/Anion Balance

$$\text{Balance Acceptance Criteria} = 100 \times \frac{(\text{total cations - total anions})}{(\text{total cations + total anions})}$$

The result should be 100 $\pm$ 5%.

Equation (5) for Calculated Specific Conductance

EC (Calc) = (total cations + total anions) $\times$ 50

(Both the total anion and total cations should be 1/100 of the measured EC value.) The calculated EC is expected to be within 10% of the measured EC. Thus:

Equation (6)

$$0.9 \leq \frac{EC_{calculated}}{EC_{measured}} \leq 1.1$$

If the ratio of TDS to conductivity falls below 0.55, the lower ion sum is suspect and reanalyzed. If the ratio is above 0.7, the higher ion sum is suspect and reanalyzed. If reanalysis causes no change in the lower ion sums, an unmeasured constituent, such as nitrite or organic acids may be present at

significant levels. If poorly disassociated calcium and sulfate ions are present, the TDS may be higher than the EC. The acceptance criterion is as follows:

Equation (7)

$$\frac{TDS_{measured}}{EC_{measured}} = 0.55 - 0.70$$

and/or

$$\frac{TDS_{calculated}}{EC_{calculated}} = 0.55 - 0.70$$

Reference: Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WEF, 18th edition

26.3 Demand Ratios

A general rule of thumb is:

BOD = 0.40-0.60 of COD

TOC = 0.40 of COD (approximately)

TOC = 0.60 of BOD (approximately)

26.4 Nutrient Relationships

Total Nitrogen = Organic Nitrogen + Inorganic Nitrogen

Inorganic Nitrogen = NO_3-N + NO_2-N + NH_3-N

Kjeldahl Nitrogen = Organic Nitrogen + NH_3-N

Organic Nitrogen = Kjeldahl Nitrogen - NH_3-N

The above nitrogen relationships are checked to ensure proper calculations have been performed.

26.5 Trace Organic Contaminants:

TOX = Volatile Organic Halogens + Non-volatile Organic Halogens

Volatile Organic Halogens = Polar + Non-polar Volatile Organic Halogens

Non-volatile Organic Halogens = Polar + Non-polar Non-volatile Organic Halogens

Non-polar Volatile Organic Halogens are measured from EPA Methods 524, 624, or 8260.

Non-polar Non-volatile Organic Halogens are measured from EPA Method 525, 625, or 8270 analysis.

From the above relationships, the following is performed:

TOX $\geq$ Non-polar (Volatile + Non-volatile) Organic Halides

26.6 The Inorganic Department Manager, Supervisor, or Lab Director approves the results in the computer when all analyses requested on the sample are completed.

27.0 FINAL REPORT REVIEW

27.1 For some reports the QA Manager or a Project Manager (or other authorized person) will also review the data just prior to generating the final report. These reports are generally given an extra review due to project-specific requirements such as an analyte list or reporting limit that is not typical, such as a request to report of J-flag values, or a request for a higher level QC (see Section 29 for further details on reporting of results). The initials and date of review are recorded on the Work Order report or recorded in LIMS as part of the data audit trail.

27.2 After the final report is generated, the Project Managers (or other authorized signatory) will be responsible for final review and signing of the report. Electronic Signatures are utilized for reports that are delivered electronically to clients.

27.3 Each reviewer (Analyst, Peer Reviewer, Supervisor or Manager, QA Manager/Project Manager, and Laboratory Director) verifies that the data have been reported accurately, clearly, unambiguously, and objectively.

28.0 CORRECTIVE ACTION FOR OUT-OF-CONTROL QC

28.1 For details on corrective action, see the Corrective Action SOP (Q06) and the SOP for the method. The following is a general summary however, the current Q06 or method SOP will supersede.

28.2 For Chemical Determinations

28.2.1 Corrective action is necessary when the upper or lower control limits for the test parameters have been exceeded for laboratory control samples or when processed blanks show an unacceptable level of contamination.

28.2.2 The first step taken when QC results are "out of control" is to recheck all mathematical calculations including such items as concentration and/or dilution factors and calibration curve readings.

28.2.3 If the first step fails to solve the problem then the reagents are checked for proper chemical reaction, for example, the esterification potency for EPA Method 8151.

28.2.4 Reagents and glassware are checked for contamination. Reagent blanks are checked containing the acids used in metal digestion or the solvents used in organic analysis.

28.2.5 Standards are checked for proper concentration. New standards from a different supplier/lot number are prepared to check against the standards used during the analysis in question.

28.2.6 When a batch of data is transferred or manually entered into the laboratory database and later found to be in error OR the need for re-running for verification a follow-up is initiated by the analyst, with corroboration from the Peer Reviewer, Supervisor or Manager. The answers in the database are flagged as suspect until the problem can be resolved and the status remains at pending. Samples affected are either reanalyzed or verified. If the problem is not corrected, or the holding time has been exceeded or there is insufficient sample for a follow-up—the client is notified so that it can be determined if the site should be resampled. If suspect results are reported, the report is flagged with a note indicating the problem.

28.3 For Bacteriological Determinations

28.3.1 Corrective action is necessary when QC cultures show atypical response or when check sample results exceed the given acceptance criteria. The associated samples and quality control data are reviewed to verify sterility and findings are documented on the associated lab sheet(s), in LIMS or a follow-up form.

28.4 For All Analyses

28.4.1 Quality Control Follow-Up Forms are generated when QC problems cannot be corrected during the run and documented in the analytical data itself. Quality Control Follow-Up Forms are available to document the situation and resolution, refer to the Quality Control Follow-Up Forms SOP (Q24) for further details. As appropriate for the test method in question, further corrective actions, such as troubleshooting instrumentation and re-calibration may be performed.

28.4.2 Quality control data is analyzed for all analyses. When this quality control data is found to be outside pre-defined criteria, planned action is taken to correct the problem and to prevent the reporting of incorrect results.

29.0 REPORTING OF RESULTS

29.1 Analytical Chemistry Reporting Procedure

The final copy of the report contains all information necessary for the interpretation of the test results and all information required by the method user presented in a simplified and straight forward manner– including the following information:

29.1.1 A report title.

29.1.2 The name of the laboratory.

29.1.3 The address of the laboratory.

29.1.4 The phone number of the laboratory.

29.1.5 Laboratory identification number.

29.1.6 Unique page identification.

29.1.7 Name and address of client and project name, if applicable.

29.1.8 Description and unambiguous identification of test sample—including the client identification code.

29.1.9 Analytical results including units and reporting limit (RDL).

29.1.10 Identification of any quality control failure within the batch that might affect the validity of the result by use of appropriate data qualifiers.

29.1.11 The reported units for samples are as received, unless identified as “dry” (corrected for dry weight).

29.1.12 Qualification of results derived from samples that did not meet acceptance requirements – such as improper container, holding time or preservative.

29.1.13 Date of receipt of sample, name of the submitter, date and time of sample collection, name of the sampler (if known), date(s) and time(s) of analytical test(s), and analyst(s) initials.

29.1.14 Identification of the test method used or a description of any non-standard test used.

29.1.15 Any other information relevant to the specific test.

29.1.16 Definition of data qualifiers.

29.1.17 The approval signature and title of the signatory (or electronic equivalent).

29.1.18 A statement attesting to the quality standards that are applied to the generation of analytical results or where applicable, reasons that the analysis did not conform to NELAP specifications.

29.1.19 Where applicable, clear indication of numerical results with values outside of quantitation limits.

29.1.20 Where applicable, a statement to the effect that the results relate only to the items tested or to the sample as received by the laboratory.

29.1.21 Where relevant, a statement that the certificate or report shall not be reproduced except in full, without the written approval of the laboratory.

29.1.22 Where applicable, clear identification of all data provided by outside sources, such as subcontracted laboratories, clients, etc.

29.1.23 Where applicable, amended reports include a case narrative or cover letter indicating that they are amended, the reason for amendment, and the date of the previous report that they supersede.

29.1.24 Where applicable, Non-NELAP accredited work is clearly identified by including a note in the analyte name, or by a “*” in

the units of the affected analyte, along with a definition footer in the report.

29.1.25 Where applicable, the laboratory provides all the required information to their client for use in preparing monthly regulatory reports.

Note: A summary report is available upon request. If some of the above information is not presented in this report format it is readily available from the laboratory.

29.2 Reporting Records

All paperwork that is submitted by the client and the original Chain of Custody forms are attached to the work order. This is stored in the client files.
Whenever format allows, electronic copies of amended reports are traceable internally by a date and time stamp.

29.3 Subcontracted Analyses

29.3.1 The laboratory clearly indicates to the client its intention to subcontract laboratory work in its contract bids and bid quotes.

29.3.2 When a subcontract lab is utilized, clients are sent the original reports from the subcontract lab. Babcock Laboratories, Inc. does not report subcontracted results on company letterhead (with the exception of transcribed results onto state forms for reporting to the state Office of Drinking Water. This is clearly noted on the report.)

29.3.3 All subcontracted analyses are to be performed by a NELAP accredited laboratory or by a laboratory that meets applicable statutory and regulatory requirements for performing the tests (i.e. a CA ELAP certified laboratory). Subcontract laboratories' current certifications are kept on file in the office of the Regional Business Development Director.

29.3.4 Subcontract laboratories are audited periodically. Audits consist of a two to three person panel over a 4 hour time period, reviewing laboratory documents, touring the facility, and questioning staff to determine if NELAP and Babcock quality standards are being upheld.

29.3.5 Subcontract results are reviewed prior to sending to the client. Verification of analysis reporting levels in the form of a calibration standard at the RL is kept on file.

29.3.6 For more information refer to the Review of Contracts and Tenders SOP (A13).

29.4 Mandated Verbal Notification to Water Systems

29.4.1 The laboratory notifies the water system personnel immediately if Coliform is found in the presence/absence Coliform test, there are any Coliform positive tubes, or the sample is declared invalid due to a turbid culture with the absence of gas production using either the multiple tube fermentation technique or the presence/absence Coliform test. Following the Total Coliform Rule, follow-up samples are taken until the samples are negative for Coliform (see the Microbiology Notification and Reporting Procedures SOP BO8, for further details).

29.4.2 The laboratory notifies the water system personnel if a final drinking water nitrate result exceeds the MCL of 45 mg/L (as NO_3, or 10 mg/L as N). Notification is performed within 24 hours of obtaining a verified result. Once notified, the client must resample and the laboratory must reanalyze within a 24 hour period. Refer

to Inorganic Ions by Ion Chromatography SOP I19 for further details.

29.4.3 The laboratory notifies the water system personnel if a final drinking water perchlorate result exceeds the MCL of 6ug/L. Notification is performed within 48 hours of obtaining a verified result. Once notified, the client must resample and the laboratory must reanalyze within a 48 hour period. Refer to Perchlorate by Ion Chromatography SOP I19B for further details.

29.5 Quality Control Reports:

29.5.1 QC data are available for all chemical batches and are reported to the client upon request. Each project will be assigned a type of data package (or QC Level) based on the objectives of their project and this will determine the amount of QC data included in the final report.

29.5.2 The **Level I or "short report**" data packages are created from data in the Laboratory Information Management System (LIMS, Element). Level I data packages receive our general data review procedure and include Client Information, Work Order, Sample Information, Analyte(s), Result, Reportable Detection Limit (RDL), Units, Method, Analysis Date, and Analyst information. Data qualifier flags will only appear as needed.

29.5.3 The **Level II or "standard report"** data packages are created from data in the LIMS. Level II data packages receive our general data review procedures and review by a Project Manager or QA Manager (the Work Order Report will indicate that the report "Needs QC"). Standard reports include all elements of the short report. In addition, the Batch Quality Control data for the QC

samples are provided. The Batch ID and Method appear as the heading above each set of Batch QC. Each QC sample will have information on the Date Prepared, Date Analyzed, Analyte(s), Result, Reportable Detection Limit (RDL), and Units. As discussed in Section 24, the QC samples will vary by method but LIMS reports may include data on the Blanks, Laboratory Control Samples/Spikes, Laboratory Control Samples/Spikes Duplicates, Matrix Spikes, Matrix Spike Duplicates, and Sample Duplicates. Where applicable, the following data are included with each type of QC sample:

29.5.3.1 Laboratory Control Samples/Spikes:

29.5.3.1.1 Spike Level and

29.5.3.1.2 Accuracy (Percent Recovery [%Rec] and %Rec Limits)

29.5.3.2 Laboratory Control Samples/Spikes Duplicates:

29.5.3.2.1 Spike Level

29.5.3.2.2 Accuracy (%Rec and %Rec Limits), and

29.5.3.2.3 Precision (Relative Percent Difference [RPD] and RPD Limit)

29.5.3.3 Matrix Spikes:

29.5.3.3.1 Source Result,

29.5.3.3.2 Spike Level, and

29.5.3.3.3 Accuracy (%Rec and %Rec Limits)

29.5.3.4 Matrix Spike Duplicates:

29.5.3.4.1 Source Result,

29.5.3.4.2 Spike Level,

29.5.3.4.3 Accuracy (%Rec and %Rec Limits), and

29.5.3.4.4 Precision (RPD and RPD Limit)

29.5.3.5 Sample Duplicates:

29.5.3.5.1 Source Result and

29.5.3.5.2 Precision (RPD and RPD Limit)

29.6 Higher level data packages are created from data in the LIMS and also include special data packages created by a Project Manager. Higher level data packages receive our general data review procedures and review by a Project Manager. **Level III** data packages include all elements of the standard report with the addition of run logs/bench sheets and calibration curves. **Level III+** data packages include all elements of the standard report with the addition of run logs/bench sheets, calibration curves, and raw data (chromatograms etc.). **Level IV** data packages include all elements of the standard report with the addition of run log/bench sheet, calibration curves, raw data (chromatograms etc.), and standard logs. **Custom** QC packages, electronic versions of the data, and other variations are also available to meet the specific needs of each project and will be established on client/project basis.

29.7 In addition, reports are available with **J-flag** data. J-flag reports include estimated values for results that fall between the Method Detection Limit (MDL) and Reportable Detection Limit (RDL). The MDL is listed for each analyte. A J-flag report receives our general data review procedures and a review by a Project Manager or QA Manager (the Work Order Report will indicate that the report needs "J-flag").

30.0 AUDITS

30.1 Method Audits

Audits of all analytical methods are performed periodically and in accordance with a predetermined schedule, conducted by the Quality Assurance Department to ensure that its operations continue to comply with quality assurance policies, the requirements of the management system, method and NELAP or ISO 17025 requirements. QA Department personnel are independent of the activities being audited (See Appendix O for example Audit Forms).

30.2 Internal Quality System Audits

The QA Manager and/or other trained and qualified personnel conduct an annual audit of the laboratory with relation to both the NELAC Chapter 5 and ISO 17025:2005 requirements to determine that the laboratory operation continues to comply with the laboratory's quality and management systems. The current NELAP Quality System Checklist as well as the A2LA "C204" Specific Checklist - Combined ISO-IEC 17025 and Food and Pharmaceutical Testing Laboratory Accreditation Program Requirements are used together to conduct this audit. Laboratory documentation used to satisfy these requirements are referenced on the checklists. Results of these audits are reported to management for review. If results cast doubt on the correctness or validity of the laboratories calibrations or test results, the laboratory shall take immediate corrective action and shall immediately notify, in writing, any client whose samples were involved. For more information regarding these audits, please refer to the Audit Standard Operating Procedure (Q16).

30.3 Managerial Audits

The QA Manager conducts a review, annually, of its quality and management system as well as its testing and calibration activities. The purpose of this annual review is to ensure the quality and management's systems continuing suitability and effectiveness and to introduce any necessary changes or continuous improvements in the effectiveness of the quality system, management system and laboratory operations. The review addresses the suitability of policies and procedures, reports from managerial and supervisory personnel, the outcome of recent internal audits, assessments by external bodies, the results of interlaboratory comparisons or proficiency tests, any changes in the volume and type of work undertaken, feedback and complaints from clients, corrective and preventive actions, outcome of Root Cause Analysis investigations including recommendations for continuous improvement and other relevant factors such as Quality Control activities, resources, and

staff training. The laboratory has a procedure for review by management and maintains records of review findings and actions. For more information regarding these audits, please refer to the Audit Standard Operating Procedure (Q16).

30.4 Audit Reviews

All audit and review findings and any corrective actions that arise from them are documented. The laboratory management ensures that these actions are discharged within the agreed time frame.

31.0 Quality Assurance Manual – Updates and Reviews:

31.1 This QA Manual is designed to be compliant with NELAC requirements (see NELAC Quality System Information Section 5.4.2.3 in Appendix I for list of requirements) and ISO 17025 requirements. The contents of this manual are reviewed annually (at a minimum) by the QA Manager and the Laboratory Directors for compliance to applicable regulations – ensuring that it reflects existing practices within the laboratory.

31.2 The QA Manual clearly indicates the revision month and the effective date. The effective date indicates that at midnight at the start of the effective date the new manual goes into effect.

31.3 All signatory personnel within the laboratory document their approval by signing of each new version of this document prior to its release.

31.4 The QA Manager maintains an archive of previous versions of this document.

31.5 All employees read the effective revision of the QA Manual and are familiar with its contents. Each employee signs a statement that he/she

has read the QA Manual and declares his/her intention of complying with the requirements contained within Babcock Laboratories, Inc QA Manual.

32.0 APPENDICES

A. Copies of Certifications

B. P101-Reference to A2LA Accredited Status-A2LA Advertising Policy

C. Organizational Chart

D. Resumes of Key Personnel

E. Job Descriptions of Key Personnel

F. References for Sampling Procedures

G. Sample Preservation and Holding Times

H. Sample Forms: Chain of Custody and Sample Receipt

I. Training Module Outlines

J. Ethics and Data Integrity Manual

K. Equipment List & Facility Maps

L. Calibration and Quality Control Criteria Charts

M. References for QA Procedures

N. NELAC Quality System Information - excerpts from Chapter 5 & ISO 17025 Information-excerpts from standard

O. Documentation Audit Forms

P. Sample Transportation for Third Party Couriers (SOP F14)

Q. ESB UCMR3 Quality Assurance Project Plan (QAPP)

Appendix A Copies of Certifications

Appendix B P101-Reference to A2LA Accredited Status-A2LA Advertising Policy

Appendix C Organizational Chart

Appendix D Resumes of Key Personnel

Appendix E Job Descriptions of Key Personnel

Appendix F References for Sampling Procedures

Appendix G Sample Preservation and Holding Times

Appendix H Sample Forms:
Chain of Custody and Sample Receipt

Appendix I Training Module Outlines

Appendix J Ethics and Data Integrity Manual

Appendix K Equipment List & Facility Maps

Appendix L Calibration and Quality Control Criteria Charts

Appendix M References for QA Procedures

Appendix N NELAC and ISO 17025 Quality System Information

Appendix O Documentation Audit Forms

Appendix P Sample Transportation for Third Party Couriers (SOP F14)

Appendix Q Babcock UCMR3 Quality Assurance Project Plan (QAPP)

Resumes of Key Personnel - available upon request

Lawrence Chrystal
Allison Mackenzie
Marianna Etcheverria
Cathleen Iijima
Cyndi Moore
Mark Tracy
Stacey Fry
Carol Kase
Susann Thomas
Peggy Bishara
Donna Aviles
Enrique Aguilar
Fred Kent
William Bayle
Julia Sudds
LuAnn Thomas
James Schaupp
Lorenzo Rodriguez
Robin Glenney
Hsin-Yi Lee

Note: This is the last page of the QA Manual (version effective July 1, 2012)