

**Hydromodification Susceptibility
Documentation Report and
Mapping: Santa Ana Region**

January 18, 2017

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1 INTRODUCTION

This documentation report is part of the larger study for Riverside County Flood Control and Water Conservation District (District) to develop the Watershed Action Plan as required by the current Riverside County Santa Ana Region (SAR) Municipal Separate Storm Sewer System (MS4) Permit Order No. R8-2010-0033, NPDES No. CAS 618033 (MS4 Permit). This project includes the expansion of existing SAR maps to include lined and unlined channels and streams within the SAR Permit area with the goal of identifying those segments of existing stream channels that may be vulnerable to development impacts as required by the MS4 Permit.

1.1 Background

The Riverside SAR MS4 Permit identifies that the District and cities within the SAR (Permittees) shall develop a Watershed Action Plan (WAP) to address the entire Permit Area (see Figure 1). The District is the Principal Permittee for coordination of compliance with the MS4 Permit and is engaged in developing the components of the WAP on behalf of the Permittees. According to Section I of the MS4 Permit, as of 2006 the population of the Permit Area is approximately 1.2 million, occupying an area of approximately 1,396 square miles. The Permittees' MS4s include an estimated 59 miles of above ground channels and 75 miles of underground storm drain channels. The MS4 Permit regulates urban and stormwater runoff from the urban areas within the Santa Ana Regional Water Quality Control Board's jurisdiction, which makes up approximately nineteen percent (19.1%) of the County. All other portions of Riverside County are regulated by the San Diego or Colorado River Basin Regional Water Quality Control Boards.

The WAP will assist the Permittees, as well as the development and environmental communities in the SAR, to integrate water quality and water conservation policies. It also encourages the capture and infiltration of stormwater into groundwater basins and the recharge of Lake Elsinore with treated runoff. According to Section XII.B of the MS4 Permit, the objective of the WAP is to address watershed scale water quality impacts of urbanization in the Permit Area associated with Urban Total Maximum Daily Load (TMDL) Waste Load Allocations (WLAs), stream system vulnerability to Hydromodification from Urban Runoff, cumulative impacts of development on vulnerable streams, preservation of Beneficial Uses of streams in the Permit Area, and protection of water resources, including groundwater recharge areas.

As part of the WAP, the Permittees are required to develop a Hydromodification Management Plan (HMP) which includes the delineation of the existing unarmored or soft-armored stream channels in the Permit Area that are identified to be vulnerable to Hydromodification from New Development and Significant Redevelopment projects.

1.2 Hydrologic Condition of Concern (HCOC)

The findings of the MS4 Permit (Section II.G) indicate that an HCOC exists when a site's hydrologic regime is altered and there are significant impacts on downstream stream channels and aquatic habitats, alone or in conjunction with impacts of other projects. Significant development has taken place in Riverside County in the last decade and urban development generally increases runoff volume, velocity, of runoff and the amount of Pollutants in the runoff.

Unmitigated high volumes and velocities of discharges from MS4 facilities associated with New Development into natural watercourses from developed areas without needed controls can alter the natural rate of change of a stream and may adversely impact aquatic ecosystems and stream habitat and may cause stream bank erosion and physical modifications. These changes are the result of Hydromodification.

According to Section XII.E.9 of the Permit, a New Development and Significant Redevelopment project does not cause a HCOC if any one of the following conditions is met:

1. The project disturbs less than one acre and is not part of a common plan of development.
2. The volume and the time of concentration of stormwater runoff for the post-development condition is not significantly different from pre-development condition for a 2-year return frequency storm (a difference of 5% or less is considered insignificant). This may be achieved through Site Design and Treatment Control BMPs.
3. All downstream conveyance channels to an Adequate Sump (e.g., Prado Dam, Lake Elsinore, Canyon Lake, Santa Ana River or other lake, reservoir or natural resistant feature) that will receive runoff from the project are engineered and regularly maintained to ensure design flow capacity, and no sensitive stream habitat areas will be affected; or not identified in the Permittees' Hydromodification sensitivity maps required in Section XII.B, and no sensitive stream habitat areas will be affected.
4. The Permittees may request a variance from these criteria based on studies conducted by the Southern California Monitoring Coalition (SMC), Southern California Coastal Watershed Research Project (SCCWRP), California Association of Stormwater Quality Agencies (CASQA), or other regional studies.

1.3 Goals and Objectives

The goal of this study was to conduct a screening level analysis to identify and map stream channel segments that may be vulnerable to Hydromodification as required by the MS4 Permit. The purpose of mapping the susceptible stream channel segments was to develop a comprehensive map of the MS4 Permit area to assist the District, Co-Permittees, and project proponents to determine whether or not a project will drain to a potentially susceptible stream channel segment and may be subject to the HCOC requirements.

The study was divided into eight tasks:

1. Research and data collection;
2. Delineate and map existing stream channel segments;
3. Define and categorize groups of existing stream channel segments based on common characteristics;
4. Verify groups using provided data and site visits;
5. Identify an appropriate definition for an "engineered and regularly maintained" stream channel segment;
6. Conduct Susceptibility Assessment of the stream channels to identify segments that may be susceptible to Hydromodification;
7. Delineate and map existing hydrology watershed boundaries to stream channel segments that may be susceptible to Hydromodification; and
8. Create the comprehensive HCOC Applicability Map of the MS4 Permit area.

This report documents the methodologies used to determine whether an existing stream channel segment may be susceptible to Hydromodification due to future development. It discusses the delineation of the existing stream channel segments and the watershed areas in the MS4 Permit area. It also provides two

maps: Existing Stream Channel Delineation Map and HCOC Applicability Map as required by Sections II.G.10 and XII.B.4 of the MS4 Permit.

2 EXISTING CHANNEL DELINEATION MAP

This section discusses how the existing stream channels were delineated. It also discusses the grouping system used for the stream channel segments and provides the Existing Stream Channel Delineation Map, see Map 1.

2.1 Research and Data Collection

Data requests were provided to the Permittees (see Table 1) to assist in the collection of background data needed for the delineation of existing channels. The information collected from the Permittees included: aerial photographs, topography, as-built plans, Geographic Information System (GIS) data bases, drainage studies, Federal Emergency Management Agency (FEMA) floodplain studies, and more. The data provided by the Permittees was reviewed and verified for accuracy.

Table 1: Permittees

Principal Permittee	RCFC&WCD (District)	
Co-Permittees	1. Beaumont	9. Lake Elsinore
	2. Calimesa	10. Menifee
	3. Canyon Lake	11. Moreno Valley
	4. Corona	12. Norco
	5. County of Riverside	13. Perris
	6. Eastvale	14. Riverside
	7. Hemet	15. San Jacinto
	8. Jurupa Valley	

2.2 Delineation of Existing Stream Channels

The goal of this task was to delineate all regional stream channels (above and below ground) within the Permit Area. Local stream channels were also mapped if it was found pertinent to determining if a subwatershed drained to a stream channel segment potentially vulnerable to Hydromodification or if "all downstream conveyance channels to an Adequate Sump that will receive runoff from the project" are not vulnerable to Hydromodification.

The existing stream channels were predominately delineated using the District's GIS shapefile called: RCFC_FACILITIES_LINE. This shapefile provided GIS linework for all District above and below ground stream channels. Below ground stream channels are channel segments that convey stormwater in underground drainages structures. Typical underground drainage structures are made of reinforced concrete, corrugated metal, or material of equivalent shear resistance.

Additional stream channels were delineated using GIS shapefiles provided by the Co-Permittees and National Hydrography Dataset (NHD). This additional data was used to fill in gaps found in heavily urbanized and natural areas.

The shapefiles were verified through an investigation of as-built plans and aerial photography. Some stream channel delineations were added solely based on the aerial photography investigation. Any stream channel delineations in question were verified by site visits.

2.3 Existing Stream Channel Groups

To complete the initial mapping, the existing stream channels were categorized into five groups to better describe the individual stream channel segments by common traits. The groups are described below:

1. **Engineered, Fully Hardened and Maintained (EFHM):** This group includes constructed facilities that are fully armored (e.g., concrete, soil cement, riprap rock, etc.) on three sides and verified by as-builts, aerial photographs and/or a site visit. This group includes piped and boxed stream channel segments. The facility must also be maintained and designed based on an engineering criteria (e.g., a specific storm event.)
2. **Engineered, Partially Hardened and Maintained (EPHM):** This group includes constructed facilities that have some armoring (e.g., concrete, soil cement, riprap rock, turf reinforcing mats, etc.) on less than three sides and verified by as-builts, aerial photographs and/or a site visit. The armoring can include bank and/or invert lining that has been placed based on engineering criteria. The facility must also be maintained.
3. **Engineered, Earthen and Maintained (EEM):** This group includes constructed facilities that do not contain armoring but have been engineered to be stable systems and are verified by as-builts. The facility must also be maintained. This group is intended to be channel segments constructed for flood conveyance, which generally have a design capacity in excess of a 10-year storm event.
4. **Not Engineered and Earthen (NEE):** This group includes constructed facilities that are modified by anthropogenic activities, which may include floodplain encroachments by development, culverts, bridges, privately owned bank and/or invert stabilization (such as riprap or other forms of bank protection, roads, etc.) and other man-made modifications to the natural channel system that are not necessarily continuous or designed to meet any specific engineering standard, but have modified the natural hydrologic characteristics of the facility. The improvements may or may not be maintained.
5. **Natural (NAT):** This group includes stream channel facilities that are in a natural state, where the geometry has not been modified. The stream channel facility may or may not be maintained.

2.4 Categorization of Existing Stream Channel Groups

A desktop study was conducted to categorize each individual stream channel segment into one of the above groups. The desktop study included an examination of as-built plans and aerial photography. The segments that were in question were field verified. Field verification included visiting an accessible location along the segment of stream channel. Photographs and notes were taken in regards to the stream channel segment condition and armoring.

Any stream channel facilities that could not be accessed and/or were still in question were discussed and verified with the Permittee with jurisdictional responsibility for the facility.

3 SUSCEPTIBILITY ASSESSMENT

This section discusses the definition for an "engineered and regularly maintained" stream channel and the characteristics of stream channels that are identified to be not susceptible to adverse impacts from Hydromodification.

3.1 Definition for "Engineered and Regularly Maintained"

To satisfy Condition iii from Section XII.E.9.b of the MS4 Permit (refer to Section 1.2 of this Report), an "engineered and regularly maintained" stream channel must be defined. The basic definition is a stream channel facility constructed for storm water conveyance that is owned and maintained by a responsible agency and is not susceptible to adverse impacts from Hydromodification, but a more comprehensive definition is hard to establish because it is subjective. After careful consideration, this study has combined the five stream channel groups (EFHM, EPHM, EEM, NEE, and NAT) into two categories: Potentially Susceptible and Not Susceptible to Hydromodification. The groups themselves can then be used as the term's definition.

The five groups were combined into the two categories as shown below:

1. Not Susceptible

- a. EFHM – The risk for adverse impacts caused by Hydromodification is insignificant due to the armoring of the stream channel segment and the engineered design which would prevent erosion and degradation of the channel.
- b. EPHM - The risk for adverse impacts caused by Hydromodification is very low due to the partial armoring of the stream channel segment and the engineered design which would significantly lower the risk of erosion and degradation of the channel.
- c. EEM - The risk for adverse impacts caused by Hydromodification is low due to the engineered design of the stream channel segment which would lower the risk of erosion and degradation of the channel.

2. Potentially Susceptible

- a. NEE – It cannot be verified that the stream channel segment could handle the changes in runoff volume and duration associated with New Development or Significant Redevelopment without degradation. The risk for adverse impacts caused by Hydromodification is potentially significant. Future technical studies could determine the level of risk of Hydromodification in individual stream channel segments.
- b. NAT – The findings of the MS4 Permit indicate that these stream channel segments are vulnerable to Hydromodification resulting from runoff from New Development or Significant Redevelopment. The risk for adverse impacts caused by Hydromodification is potentially significant. The level of risk may be determined through future technical studies.

3.2 Adequate Sump

An Adequate Sump is a river, reservoir, or basin that provides significant regional flood protection for the downstream watershed areas and mitigates flows such that any New Development or Significant Redevelopment project upstream will not cause a significant change in the downstream flow conditions.

The MS4 Permit identifies Prado Dam, Lake Elsinore, Canyon Lake, and the Santa Ana River as Adequate Sumps.

The Permittees reserve the right to add additional facilities if they are identified to meet the above definition of an Adequate Sump. Mystic Lake, and Lake Matthews have been identified as reservoirs and basins that meet the Adequate Sump criteria. In the future, additional updates to the associated maps may be required in order to reflect the identification of additional Adequate Sumps.

3.3 San Jacinto River

Based on the hydrology assessment and analysis of the 3.8 mile reach of the San Jacinto River upstream of Canyon Lake, it has been determined that the San Jacinto River is a natural resistant feature that exhibits the following characteristics:

- Drainage area higher than 100 square-miles and a 100-year peak discharge higher than 20,000 cfs;
- The natural hydrology and sediment loading of different watercourses within the SAR are significantly impacted by the upstream impoundments, which regulate downstream flow;
- Permittees participate in the National Flood Insurance Program and enforce a floodplain management ordinance to regulate development in mapped flood hazard areas; and
- The low-gradient of this segment of the San Jacinto River are results in deposition of coarse-grained sediments.

Under the existing and future hydrologic conditions, there will be no scouring of the bed and bank of the stream. The additional lines of evidence show that the San Jacinto River is not an HCOC:

- The river has a flat slope and a wide alluvial floodplain;
- A review of historical aerial photographs did not identify lateral migration of the streambed, even though historical urbanization has occurred;
- The production of bed sediment occurs in the San Jacinto Mountain, thus future development in the alluvial floodplain will not impact the production and conveyance of bed sediment to the downstream reaches;
- Field observations did not identify erosion within the bed and banks of the channel. Deposition of sediment within the streambed indicated that the stream exhibits aggradation;
- Dense vegetation is present within the streambed, particularly within the low-flow channel. The vegetation provides a higher resiliency to erosive forces.
- Bed sediment is composed of coarse sand and very fine gravel, which are typical in an alluvial floodplain environment. The bed is predominantly composed of very fine gravel ($D_{50} = 6\text{mm}$), which provides a high resiliency to erosive forces; and
- The rapid stream assessment concluded that the 3.8-mile segment has a low-risk for future erosion.

The San Jacinto Assessment and is included as Attachment A.

4 APPLICABILITY CRITERIA

This section describes the HCOC applicability criteria and discusses the methodology for determining watershed areas where HCOC requirements may be applicable. The results of the HCOC Applicability Assessment are used to develop a comprehensive map of the MS4 Permit area which identifies those areas that are tributary to potentially susceptible stream channel segments and where runoff from New Development or Significant Redevelopment may cause a HCOC. The HCOC Applicability Map (see Map 2) provides a delineation of the potentially susceptible stream channel segments and the watershed areas that are applicable to the HCOC requirements.

4.1 Delineation of Existing Hydrology Watershed Boundaries

The existing hydrology watershed boundaries were delineated using a desktop approach. The NHD GIS shapefile called: NHDArea, provided GIS linework for the Santa Ana River Basin watershed. The NHD data was compared with Drainage Area Plans and GIS data provided by the Permittees (drainage areas and local system storm drain data) and USGS topography.

The watershed boundaries were simplified using the collected data to delineate areas tributary and adjacent to stream channel segments that are not potentially susceptible to Hydromodification.

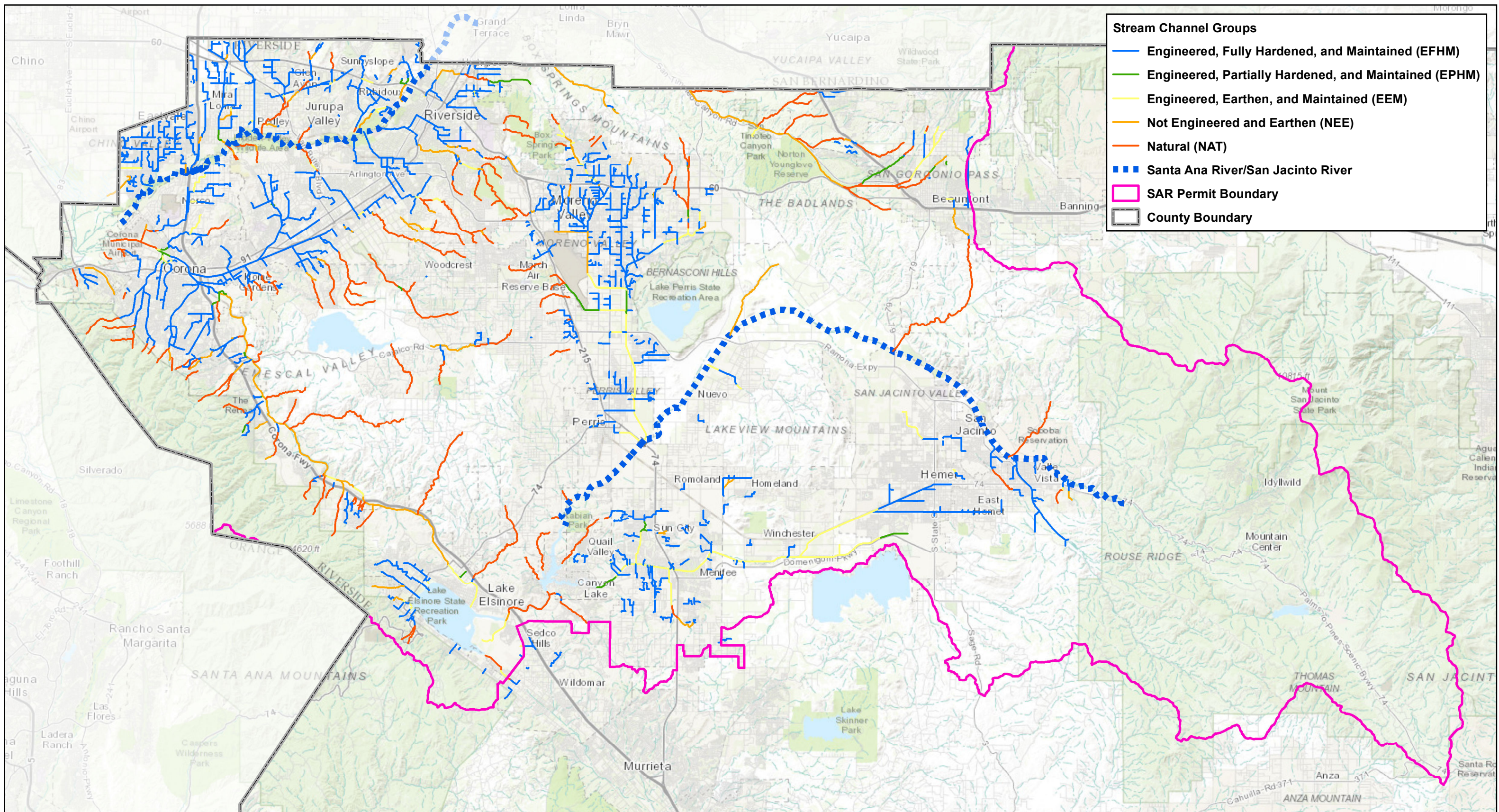
4.2 HCOC Applicability Map

The Permit Area has been divided into two different watershed areas: Applicable and Not Applicable. The Not Applicable watershed areas would potentially be excluded from the HCOC requirements. New Development and Significant Redevelopment projects in the "applicable areas" shall continue to determine applicability in accordance with the HCOC requirements in Section XII.E.9 of the MS4 Permit.

- Applicable Watershed Areas – Watershed areas that drain to susceptible stream channels, where future New Development and/or Significant Redevelopment projects may adversely impact downstream erosion, sedimentation, or stream habitat by increasing the volume and/or duration of storm runoff.
 - Susceptible stream channels include watershed areas tributary to:
 - Non-Engineered, Earthen Stream Channels (NEE); and
 - Natural Stream Channels (NAT).
 - New Development and Significant Redevelopment projects that are located within an Applicable Watershed Area should reference the HMP or WQMP for the specific qualifying criteria to meet the HCOC requirements.
- Not Applicable Watershed Areas - Watershed areas that drain directly to an Adequate Sump (e.g., Santa Ana River, Lake Elsinore, Canyon Lake, and Prado Dam) or naturally resistant feature such as the San Jacinto River (see Section 3.3) via a drainage facility that is not susceptible to Hydromodification.
 - Not Susceptible drainage facilities fall under the term "Engineered and Regularly Maintained" per the Permit and includes:
 - Engineered, Fully Hardened and Maintained Drainage Facilities (EFHM);
 - Engineered, Partial Hardened and Maintained Drainage Facilities (EPHM); and
 - Engineered, Earthen and Maintained Drainage Facilities (EEM).

- For New Development or Significant Redevelopment projects in a Not Applicable watershed area, if the site does not drain directly to a mapped stream channel, then the project must show that all downstream conveyance channels to the mapped segment are "engineered and regularly maintained" facilities. Refer to the HMP or WQMP for the specific qualifying criteria to meet the HCOC requirements.

MAP 1



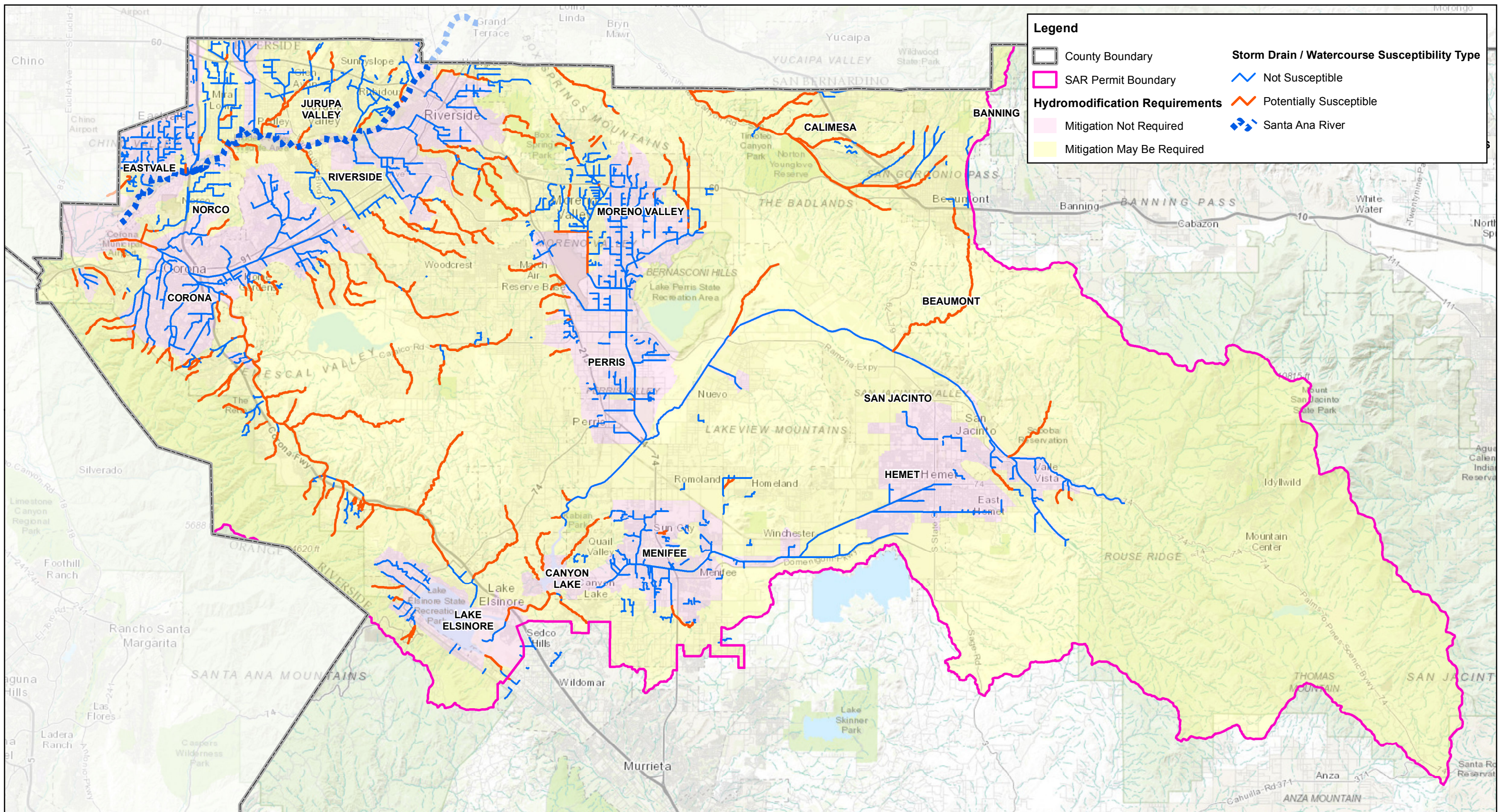
0 2.5 5 10 Miles

Revised February 2017

Existing Storm Drain / Watercourse Delineation Map SAR Permittees

Map 1

MAP 2



0 2.5 5 10 Miles

Updated February 2017

HCOC Applicability Map SAR Permittees

Map 2

Attachment A

San Jacinto River Study

September 16, 2016

Submitted by:

Santa Ana Region MS4 Permittees

1 INTRODUCTION

The Upper San Jacinto Subwatershed is located on the northeast portion of the SAR. The headwaters of the San Jacinto River originate in the San Jacinto Mountains of San Bernardino County. The downstream point of the Upper San Jacinto Subwatershed is at the confluence of Bautista Creek, Poppet Creek, and the San Jacinto River in the city of San Jacinto. The subwatershed drainage area to this confluence encompasses 190 square miles. The upper portion of the San Jacinto River flows through the San Bernardino National Forest and unincorporated land of Riverside County. The upper portion of the San Jacinto River is about 23 miles long and ranges from the outlet of Lake Hemet and the confluence herein specified.

The middle and lower San Jacinto subwatershed is located within the central part of the Santa Ana River (SAR) watershed. The downstream point of the lower San Jacinto subwatershed is the outlet of Lake Elsinore. The drainage area of the middle and lower San Jacinto subwatershed encompasses 510 square miles (approximately 700 sq. miles including the upper subwatershed). The combined middle and lower segments of the San Jacinto River are 35 miles long. Major tributaries to the subwatershed include Potrero Creek, Perris Valley Channel, and Salt Creek Channel. The San Jacinto River flows through the cities of San Jacinto, Perris, Menifee, Canyon Lake, and Lake Elsinore. The upper and middle and lower subwatershed areas are included in Figure 1 below.

The findings of the municipal separate storm sewer system (MS4) Permit (Section II.G) indicate that a Hydrologic Condition of Concern (HCOC) exists when the hydrologic regime of a Priority Development Project (PDP) site is altered resulting in hydromodification of downstream channels and aquatic habitats, alone or in conjunction with impacts of other PDPs.

The San Jacinto River is an example of the following:

- The *Flood Insurance Study: Riverside County, California and Incorporated Areas* (Federal Emergency Management Agency (FEMA), 2014) reports a 100-year 24-hour peak discharge of 24,500 cubic-feet per second and a 692 square-mile watershed at Canyon Lake Spillway;
- The natural hydrology and sediment loading of the San Jacinto River is significantly modified by the reservoirs and Lakes, which provide significant peak flow attenuation and control the sediment discharge. These impoundments include Lake Hemet, Mystic Lake (due to continued subsidence increasing the storage capacity), Canyon Lake, Lake Elsinore (due to reconfiguration of the Lake) and a number of federal and locally built facilities.
- Lower gradients are observed in the San Jacinto River downstream of the existing Army Corps Levee, downstream of the confluence with Bautista Creek to Canyon Lake (less than 0.001 feet/foot). The low-gradient of the San Jacinto River results in deposition of coarse-grained sediments.
- The San Jacinto River exhibits a wide floodplain as illustrated in Figure 6. This floodplain is managed by the Permittees through floodplain management ordinances consistent with the requirements of the National Flood Insurance Program.
- Finally, the SAR is located within the Peninsular Zone per the California Geological Survey. The geology of the Peninsular Zone is characterized by the granitic rocks intruding the older metamorphic rocks, which contributes to the erosion and deposition of coarse-grained sediment

within the San Jacinto River. The San Jacinto River Watershed exhibits similar macro-scale geomorphic trends as the watersheds of Large Rivers within San Diego County.

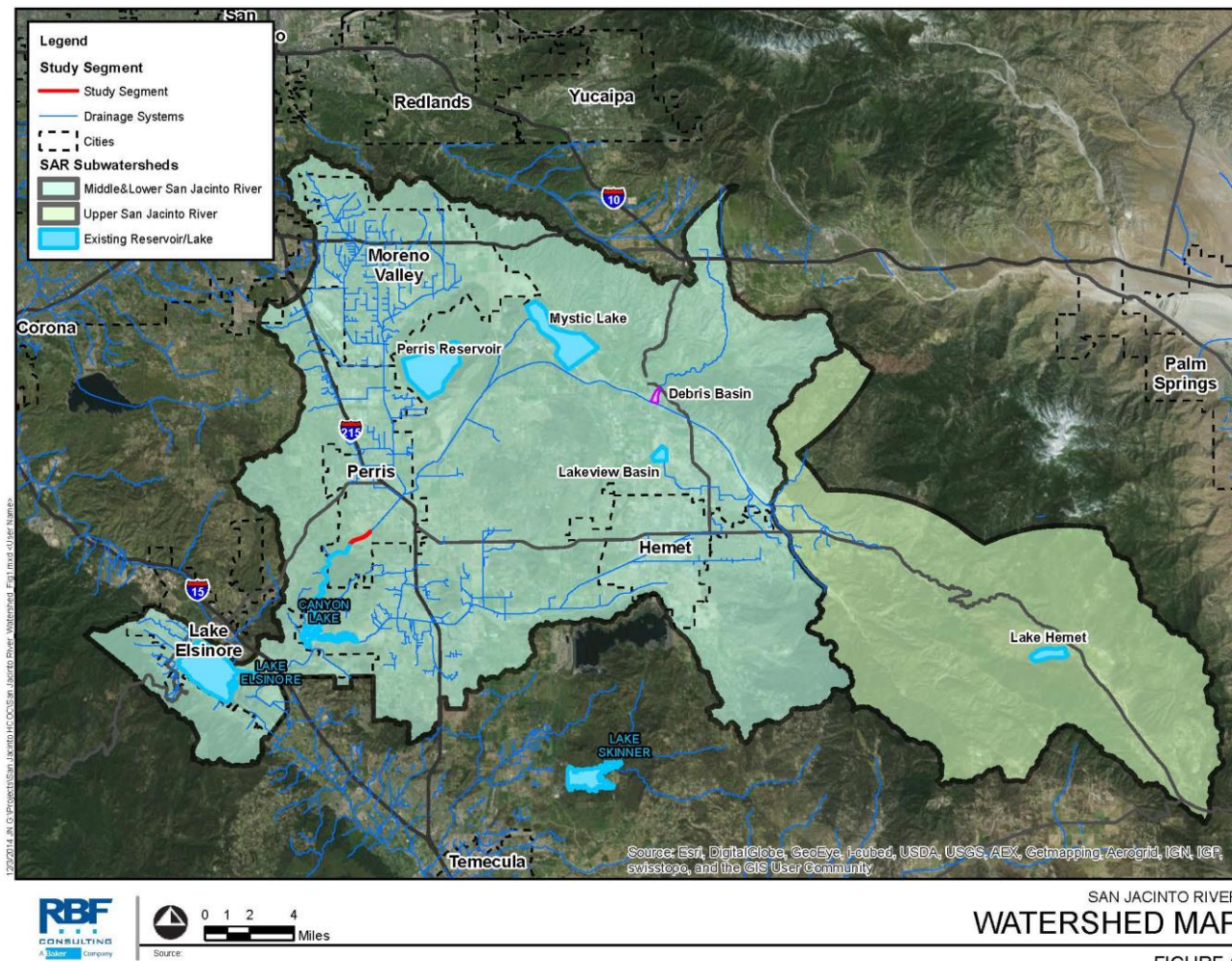
At the request of the Santa Ana Regional Water Quality Control Board (Santa Ana Regional Board), a stream stability study for the 3.8-mile segment of the San Jacinto River upstream of Canyon Lake was performed (Figure 1) to show that the San Jacinto River is not an HCOC. The reach is representative of the conditions observed along the San Jacinto River, downstream of the confluence with Bautista Creek. The analysis demonstrates that both drainage and stream characteristics provide a basis to exempt the San Jacinto River from the HCOC mitigation requirements.

Investigations included:

- A thorough understanding of the hydrology of the San Jacinto River and its hydraulic infrastructure;
- A review of the sediment processes within the watershed by performing a Geomorphic Landscape Units (GLU) analysis as recommended by Southern California Coastal Watershed Research Project (SCCWRP);
- A review of historical aerial photographs, 1962-2010, depicting the geomorphological evolution of the stream segment, along with adjacent urbanization;
- Field observations of channel morphology, vegetation, bed sediment, and signs of channel degradation if any, at three field assessment sites that are representative of the conditions observed along the 3.8-mile segment;
- A review of both bed sediment and vegetation cover, in terms of resiliency to scouring, at three field assessment sites;
- A Rapid Stream Assessment (RSA) characterizing the future risk for channel degradation.

Figure 1 shows the location of the 3.8 mile study reach and watershed boundaries.

Figure 1 - Watershed Map



2 HYDROLOGY & GEOMORPHICALLY SIGNIFICANT FLOWS

Lake Hemet is the major water storage facility within this subwatershed. The dam was established in 1895 downstream of the Garner Valley Basin and operates on the principles of water supply. In addition to regulating the flow rate downstream the dam acts as a major debris basin.

Mystic Lake provides regulation of flow in the middle and lower San Jacinto River. Mystic Lake is a 200-acre ephemeral lake in the San Jacinto Valley that lies parallel to the San Jacinto River. The lake acts as a natural sump where flows from the San Jacinto River flow into the lake area during moderate to high storm events. Information provided by the Riverside County Flood Control and Water Conservation District (District) indicates that an earthen levee near Mystic Lake was constructed to contain low-flows (5-year storm events and below) within the San Jacinto River channel. Lower frequency events overtop the levees and flow into Mystic Lake. The Application for a Letter of Map Revision (LOMR) for a portion of the San Jacinto River was prepared for submittal to FEMA (Webb, 2010). The LOMR identifies that, when there is significant flooding into the San Jacinto River, flows will "break out" of the low flow channelization of the river and flow towards Mystic Lake. A relatively small amount of runoff is allowed to flow along the channel to the south. Once Mystic Lake is full, storm runoff flows around the small hill that is in the middle of the floodplain. The San Jacinto River comes back together near Davis Road, and flows then progress downstream towards Railroad Canyon. Flood flows recharge the San Jacinto Wildlife Area Waterfowl sites located on the southeastern parts of Mystic Lake's bed (California Department of Fish and Wildlife Project).

Other physical modifications that affect flow include the construction of the California Interstate 215 Freeway Bridge over the San Jacinto River, which constricts flow creating a backwater condition upstream of the Railroad Canyon Gorge. The existing bridge and culvert crossing have a relatively small conveyance capacity compared to the 100-year flow rate of the San Jacinto River. The road embankment causes a significant backwater upstream of Ramona Expressway. This backwater extends over several thousands of acres into the Mystic Lake area. Within this backwater is a significant storage area that can attenuate peak flows (and corresponding water surfaced elevations) downstream of Ramona Expressway (Webb, 2010).

The stream discharges along San Jacinto River were obtained from FEMA and the District. Table 1 summarizes the 10 year and 100-year peak discharges measured on the San Jacinto River. The peak flow rate along the study reach is in excess of 24,500 cfs for a 100-year storm event. This flow rate exceeds previous standards that have been used to exempt streams from Hydromodification requirements throughout the state. The peak discharges reported in the 2014 Flood Insurance Study were computed on the assumption that Mystic Lake is full, to conservatively ensure the level of flood protection required by the District enrollment in the National Flood Insurance Program.

Table 1 – 2014 Flood Insurance Study Peak Discharge

River Name	Concentration Point	Drainage Area	100-year Flow Rate	10-year Flow Rate
		(sq. mi)	(cfs)	(cfs)
San Jacinto River	At Canyon Lake Spillway	692	24,500 ¹	1,200 ¹

San Jacinto River	At Escondido Freeway (I-215)	509	22,403 ¹	8,737 ¹
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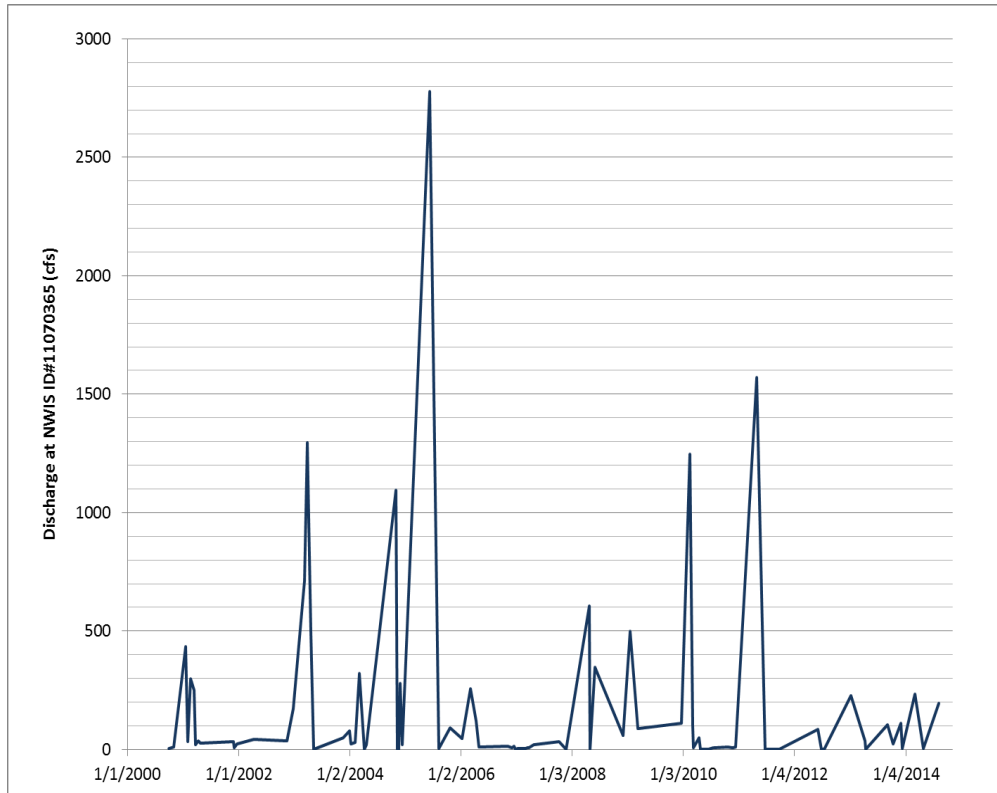
1 – 2014 FEMA Flood Insurance Study

An evaluation of USGS Streamgage 11070365, located 2,900 feet downstream of Goetz Road on the San Jacinto River, was performed to characterize the actual peak discharges resulting from the engineered levees in the San Jacinto River adjacent to Mystic Lake, the backwater effects caused by the Ramona Expressway bridge and culvert, while not hypothetically assuming that Mystic Lake is full. Limited available data at USGS Streamgage 11070365 extends from October 01, 2000 to November 07, 2014. The maximum discharge observed at the streamgage was approximately 2,780 cfs in December 2005.

A Flood Frequency Analysis (FFA) was performed on daily discharges at gage #11070365. The FFA assumed partial duration series, a 48-hour interval separating two independent events, and the Cunnane plotting position. The assumptions are consistent with FFAs performed on streams in Southern California for flood events that are more frequent than the 10-year flood event. The 2-year discharge and the 10-year discharge equaled 544 cfs and 1,658 cfs, respectively. These actual peak discharges are used as the basis for assessing the resiliency of bed and banks to erosive forces in Section 7.

The selection of the 2-year discharge and 10-year discharge is supported by the current state of the science on hydromodification in Southern California. The 2-year discharge has been identified as the dominant discharge by Leopold (1964), i.e. which performs the most work cumulatively on the channel that may result in channel degradation and serves as the basis to the SAR HMP. Additional studies have identified the range of geomorphically-significant flows, i.e. the range of flows that perform 95-percent of the cumulative work on the channel (10-percent of the 2-year discharge to the 10 year discharge). Conservatively, hydraulic computations and the rapid stream assessment of this stream stability study are based on the upper boundary of the range of geomorphically-significant flows, i.e. the 10-year discharge. The construction of Lake Hemet, the operation of historical levees to the San Jacinto River adjacent to Mystic Lake, and the backwater effects caused by the Ramona Expressway bridge all play a major part in attenuating flows into the lower reach of San Jacinto River as seen on the flow records at the streamgage(s) of Figure 2.

Figure 2 - USGS Gage #11070365



3 SEDIMENT DISCHARGE

The evaluation of the sediment discharge along the study reach was prepared using the guideline developed by SCCWRP entitled "Hydromodification Screening Tools: GIS-Based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge" dated March 2010. The report states that three factors were found to exert the greatest influence on the variability of sediment production rates in a watershed:

1. Geology Types;
2. Land Cover; and
3. Hillslope Gradient

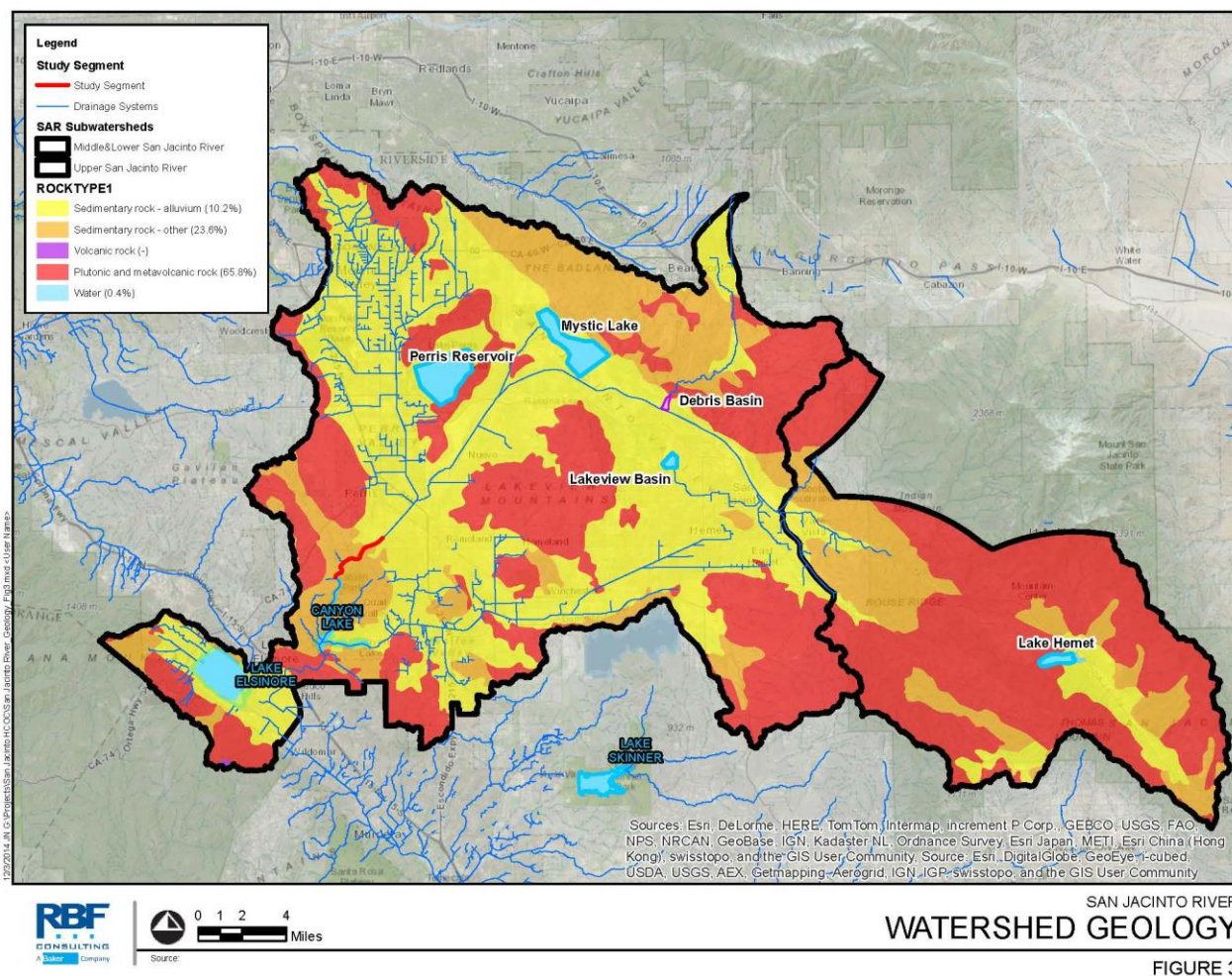
The SCCWRP report used the three factors to create GLUs. In this study the factors were investigated separately.

3.1 Geology Type

The Upper San Jacinto River Subwatershed is dominated by plutonic and metavolcanic rocks (65.8%) in the upper reaches. Lower reaches of the upper San Jacinto River subwatershed, as well as the Lake Hemet plateau, are for the most part made of sedimentary rock, including alluvium, gneiss, argillite, and sandstone. Sedimentary rocks have the highest relative potential for erosion. The presence of Lake Hemet contributes to the capture of coarse grained sediments detached from reaches upstream of the Lake; the clear reservoir outflow increases the potential for erosion along the lower reaches.

The soils present within the middle and lower San Jacinto River valley consist primarily of sedimentary rocks (67.6%). Sedimentary rocks notably account for 50.7% of alluvium and have the highest relative potential for erosion. Plutonic and metavolcanic rocks account for 32.4% of soil types within the middle and lower subwatershed, notably on the Santa Rosa Hills and the Lakeview Mountains that are in proximity to the San Jacinto River. The soil types in the San Jacinto River watershed are illustrated in Figure 3.

Figure 3 - San Jacinto River Watershed Geology Types

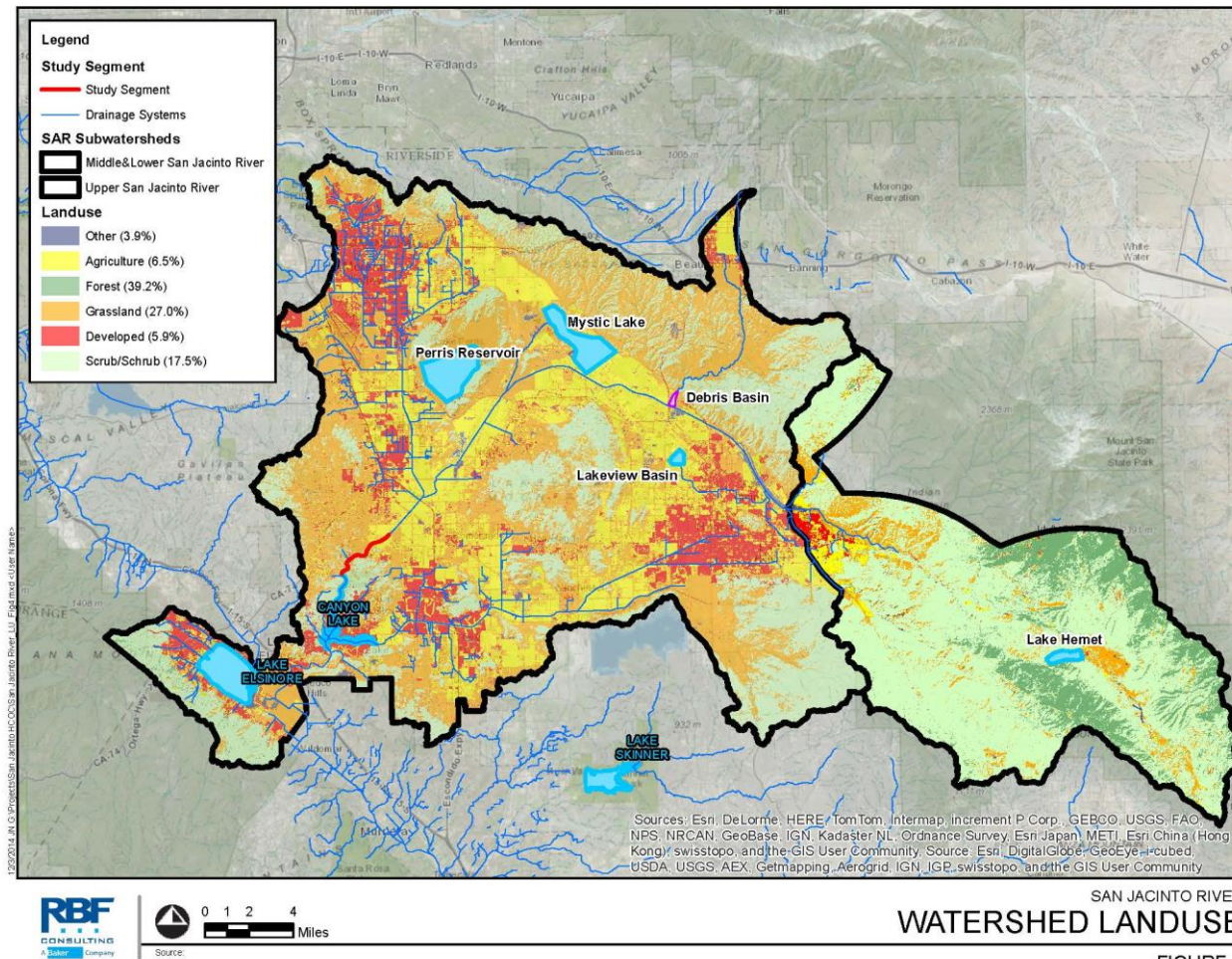


3.2 Land Uses

Urbanization potentially leads to reduced sediment supply to a receiving channel, increased runoff discharge and volume, and decreased infiltration. The development of several communities within the subwatershed tributary to the study segment has resulted in an increase in the imperviousness and associated increase in the frequency and flow experienced in the channel. Areas of urban land use (31.6% of the middle and lower San Jacinto River subwatershed) are concentrated within Moreno Valley, the Hemet area down gradient from the Santa Rosa Hills, Menifee and Canyon Lake, as well as the northwest side of Lake Elsinore. Agriculture and grassland remain the predominant land uses within the lowlands of the middle and lower subwatershed, constituting more than 49.1% of the area. Aerial photographs confirmed that several segments of the San Jacinto River have been channelized to convey runoff from the observed urban development.

The Upper San Jacinto Subwatershed is for the most part undeveloped. Valle Vista, along with pockets of development in the upper reaches of the subwatershed, account for 5.9% of the entire drainage area located within Riverside County. Undeveloped areas include forest (39.2%), scrub/shrub (17.5%), grassland (27.0%), and agriculture (6.5%). The low levels of development have contributed to the maintenance of the natural hydrologic response of the subwatershed. The land use types in the San Jacinto River watershed are illustrated in Figure 4.

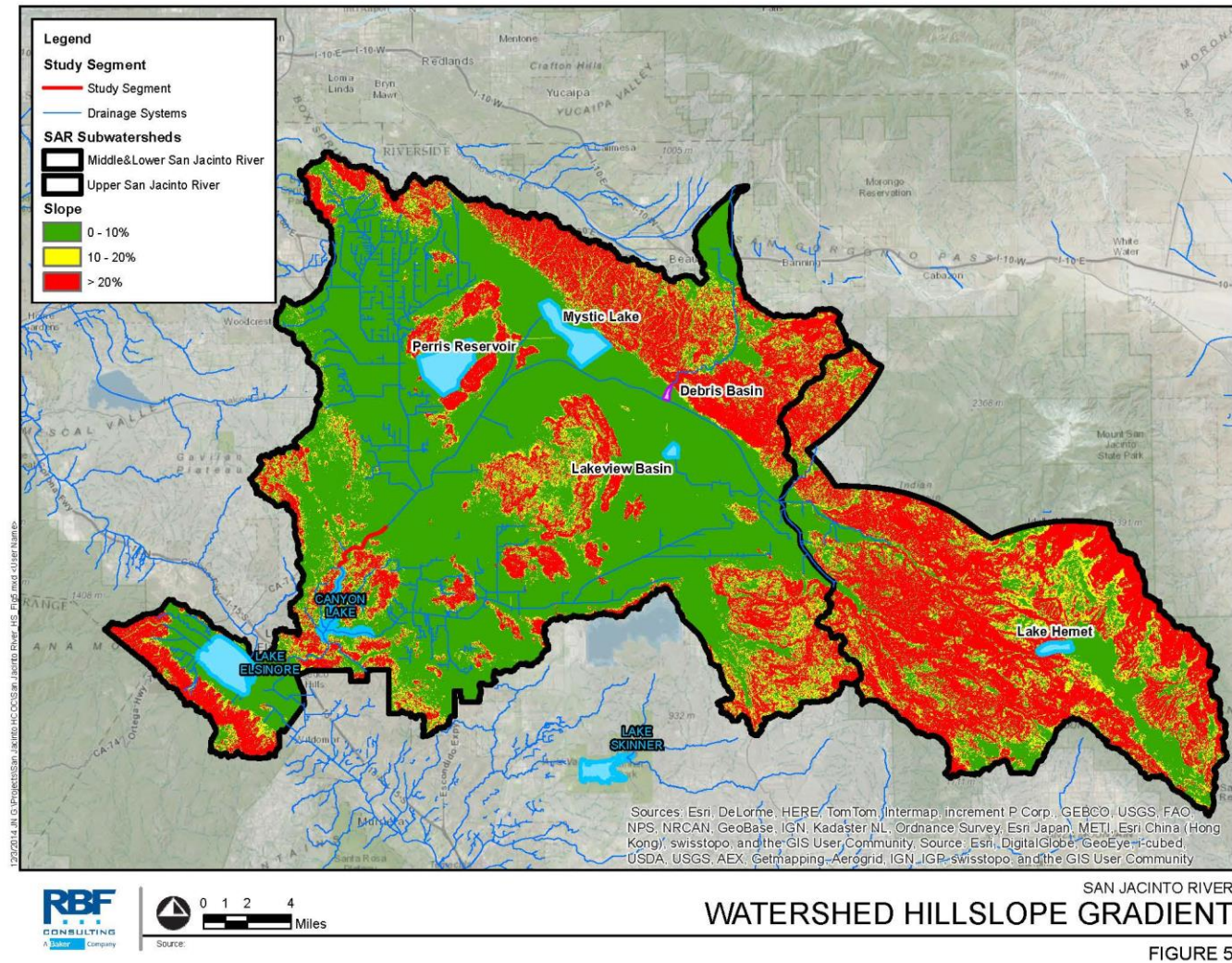
Figure 4 - San Jacinto River Watershed Land use Types



3.3 Hillslope Gradient

The subwatershed areas with a hillslope gradient greater than 21% provide the highest potential for erosion. These areas are concentrated on the upper reaches of the San Jacinto River near the San Jacinto Mountains, the Santa Rosa Hills, the Lakeview Mountains, and the Santa Ana Mountains surrounding Lake Elsinore. Majority of the middle and lower subwatershed has a hillslope gradient of 0-10% and has a lower potential for sediment production. While the majority of the developed land is located in the lower sediment production areas, the construction of the impoundments mentioned in section 1 have effectively obstructed a majority of the coarse sediment produced in high yield areas from reaching the downstream watercourse. The hillslope gradients for the San Jacinto River watershed are illustrated in Figure 5.

Figure 5 - San Jacinto River Watershed Hillslope Gradients



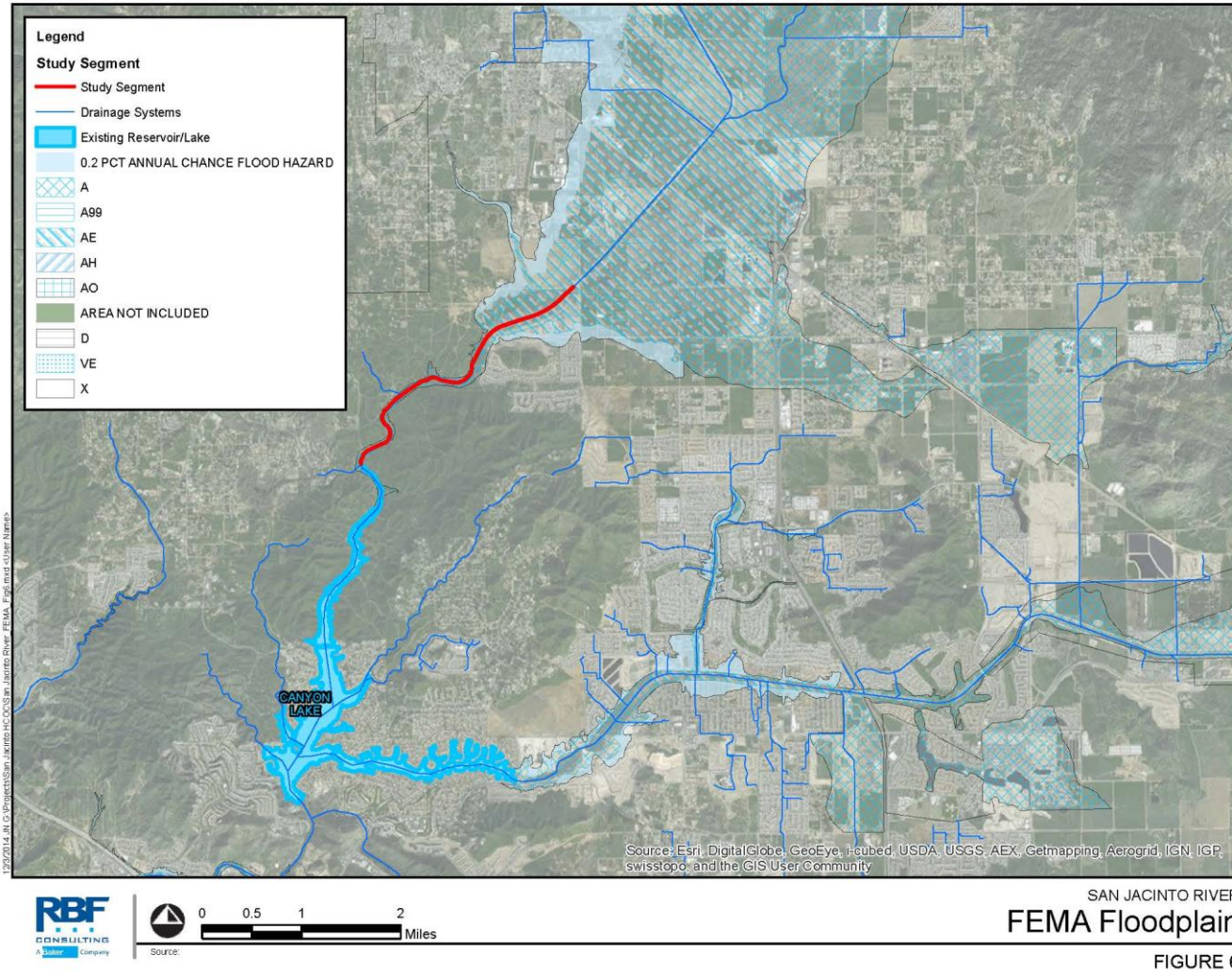
3.4 Sediment Assessment

Most of the sediment within San Jacinto River watershed is produced by the upper watershed where open space land use and steeper slopes are predominant. Most of the sediment produced is captured by Lake Hemet, Mystic Lake, I-215 Freeway Bridge, and a number of federal and locally built facilitates and therefore a small fraction is transported downstream to the lower and middle reaches of the river.

4 CHANNEL FLOODPLAIN

A review of the FEMA Flood Insurance Study (FIS), effective Flood Insurance Rate Maps (FIRMs) dated 08/18/2014 and historical FIRMs dated, 04/15/1980, 11/20/1996, and 08/28/2008 for the study segment indicate little to no change in the floodplain limits. Portions of the floodplain have been revised based on improvements that allow for new development along the study segment.

Figure 6 - FEMA Floodplain (FIRM 06065C2032G, 06065C2055H)



5 HISTORICAL EVOLUTION & LATERAL MIGRATION

A qualitative overview of historical movement and trends was conducted using a sequence of historical aerial photographs (1962-2010), focusing on the planimetric form and relative width as well as the encroachment of urban development and agricultural operations. The results of this historical assessment identified the channel shape as remaining consistent, with no lateral migration being observed.

The 2013 Riverside County Progress Report (RCTLMA, 2013) identifies that significant housing development has occurred within the San Jacinto River watershed between 1980 and 2013. For instance, housing has increased by a factor of 5 and a factor of 6 in the City of San Jacinto and in the City of Perris, respectively. Between 1980 and 2014, the historical aerials do not show any significant lateral migration. As illustrated in Figure 7, there is some lateral migration of the channel, which can be attributed to the ortho-rectification of the historical aerial photographs and the angle at which they were taken. Figure 8 shows that both the width of the stream and the distance to the reference marks have not changed over time.

Historical aerial photographs also show no noticeable erosion on the bed and banks of the channel. In addition, the vegetation within the streambed has remained dense and consistent over time along the study reach. Historical aerial photographs are included in Appendix A.

Figure 7 - Historical Streambank Comparison

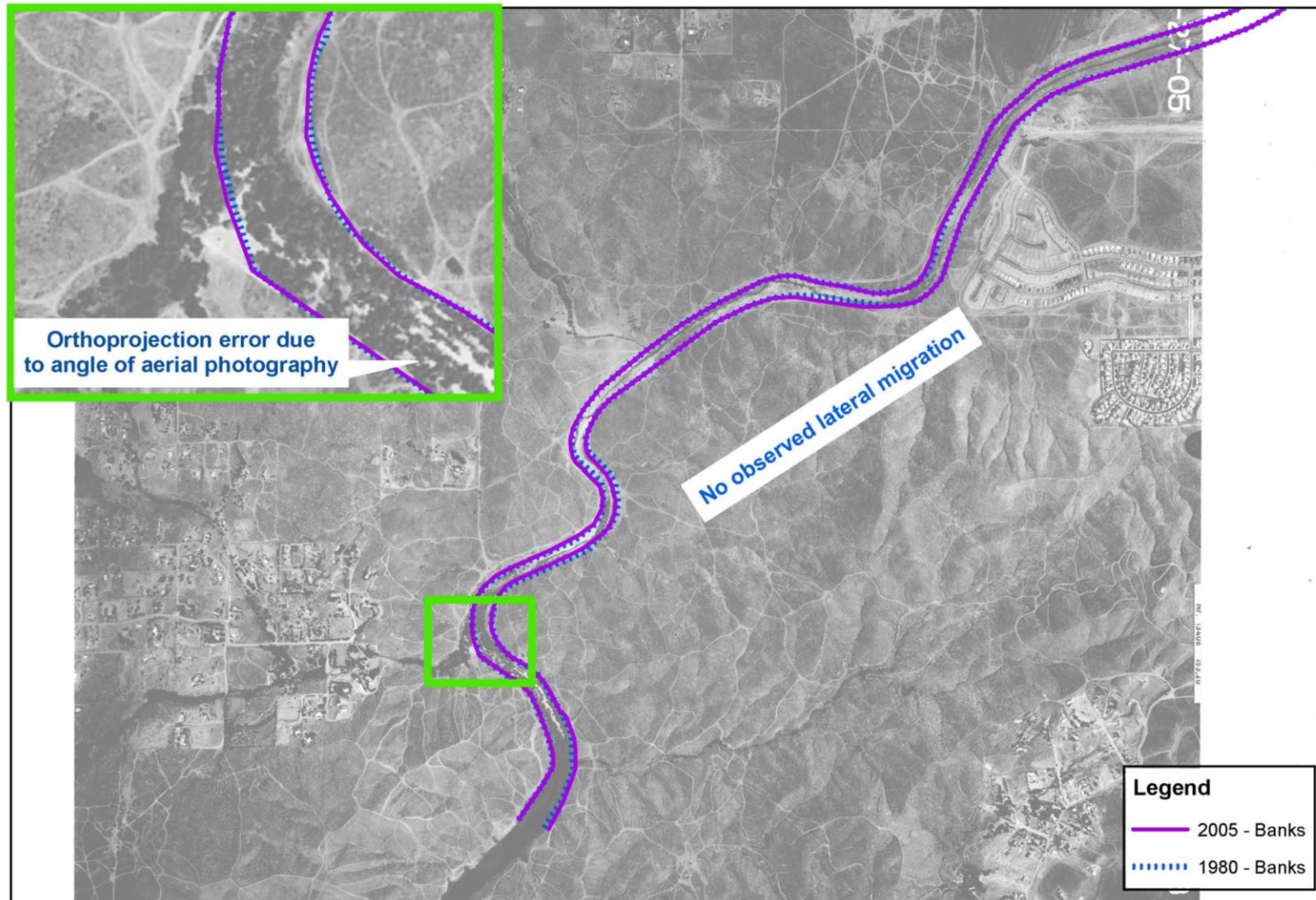
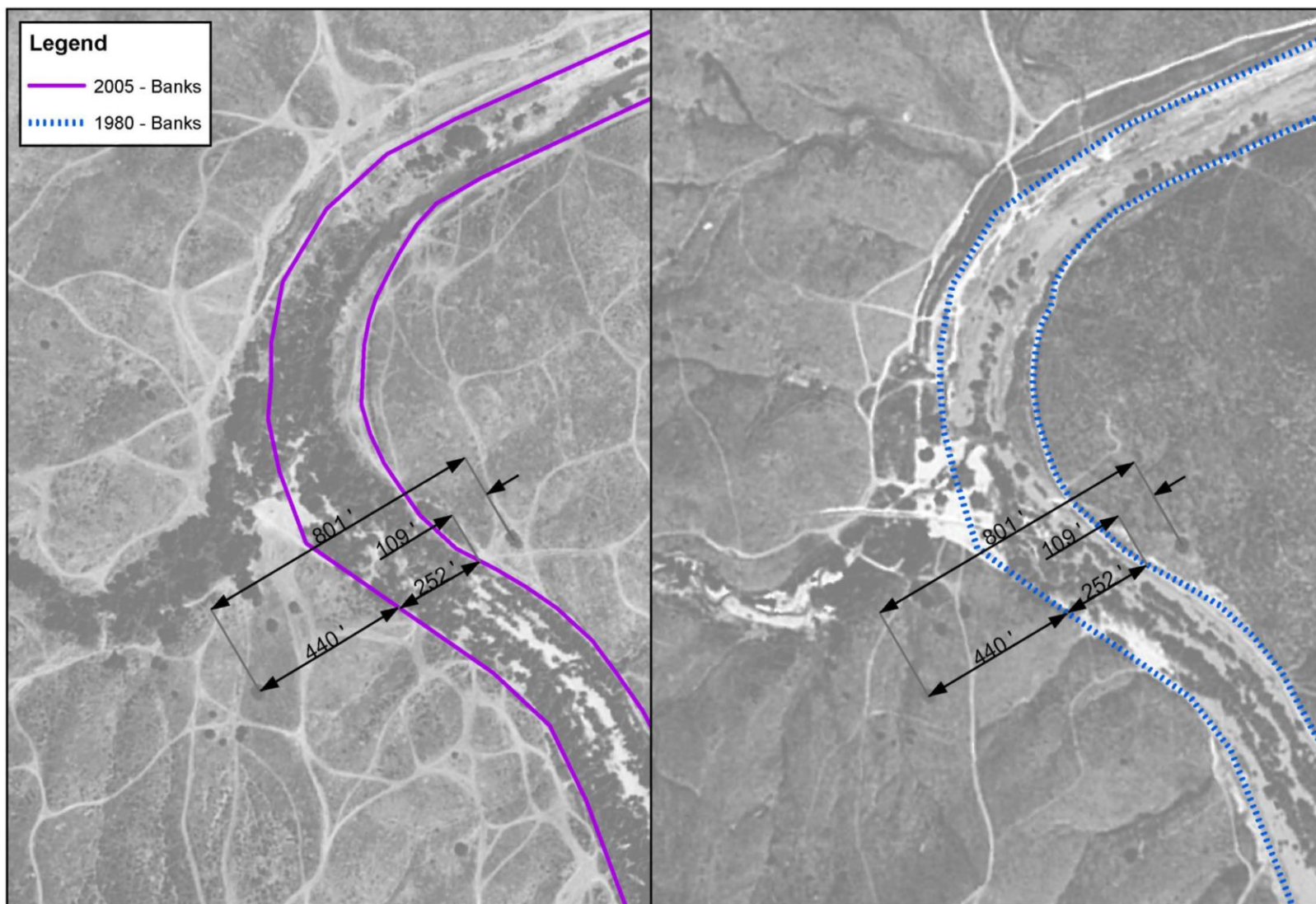


Figure 8 - No Lateral Migration



6 FIELD ASSESSMENT

A field assessment was conducted at three sites within the study segment to show that the San Jacinto River is not an HCOC. The geomorphologic condition of the stream segment is based on channel platform/planform and stream features.

The lower San Jacinto River is a meandering channel. Meandering channels act as a natural grade control feature by elongating the channel length and decreasing the slope. The channel slope for the study segment is approximately 0.02%. As the water meanders energy is lost and velocities reduced.

As part of the development of the Canyon Lake community, the upper 1.4-mile of the study segment was improved prior to 1980 to provide 100-year flood protection to the community adjacent to the left bank of the San Jacinto River. The improvements included straightening of a wide and flat channel, construction of a levee on the left bank, establishment and maintenance of vegetation, and creation of a low-flow channel of dense vegetation. Both field assessment sites 1 and 2 are within a segment of improved channel.

Field assessment site 3 is 2.4-mile downstream of field assessment site 2. At this location, the San Jacinto River flows through a canyon of defined topography, meanders, and includes tall and dense vegetation.

The three field assessment sites were selected as they are representative of the conditions found along the 3.8-mile stream segment. Below is a description of the field observations made at each of the field assessment sites.

Figure 9 shows the location of the field assessments.

Figure 9 – Field Assessment Locations



Site 1: The channel at this field assessment site shows no signs of headcutting or channel incision. The channel is fairly vegetated with grass, and trees have grown within the low-flow channel. This location is 3,000 feet downstream of Goetz Road. There is a dip crossing roadway 200 feet downstream of this location. These features act as a hard point and resist erosive forces which help with channel stabilization. The channel width is approximately 200-ft with a bank height of approximately 20-ft. The site location is along an engineered earthen section/levee. The low-flow channel at this location has a capacity of approximately 150 cfs.



Vegetation on the channel banks



Low Flow channel – Looking upstream



Looking downstream at dip crossing

Site 2: This field assessment site is located within the segment of improved channel. There is no active erosion or headcuts visible, the channel is moderately vegetated and the toe of the natural channel bank is in good condition. There is a dip crossing roadway 2,500-foot upstream of this site location. This feature could act as a grade control by reducing the stream slope and flow velocity. The channel bottom width is approximately 130-ft with a height of approximately 25-ft. The low-flow channel is approximately 15-ft wide by 5-ft high. The low-flow channel at this location has a capacity of approximately 340 cfs.



Low-flow channel looking upstream



Moderately uniform vegetation.



Channel bed



Channel Banks

Site 3: This field assessment site contains some bedrock features along with dense vegetation. There are limited signs of toe erosion along the channel bank (less than 0.5'). The bed sediment is composed of coarser sediment ($D_{50} = 6 \text{ mm}$), as determined by a pebble count analysis. The channel width is uniform at this location. Low-flow channels are braided and separated by tall trees and dense vegetation, although the dominant discharge will submerge the entire bed uniformly. The low-flow channel at this location has a capacity of approximately 870 cfs.



Left bank looking upstream – wide floodplain



Coarse material along low-flow channel invert



Coarse material along low-flow channel invert



Dense vegetation along channel

7 BANKS AND STREAMBED ASSESSMENT

7.1 Bank conditions

Channel banks are a significant parameter in determining channel resistance to erosion. Based on the field assessment and desktop aerial study the reach of the San Jacinto River consists of earthen banks with moderate to dense vegetation. Vegetation typically plays a major role in river mechanics which include flow resistance, strengthening of channel banks and restricting sediment. The study reach is 60%-90% covered with vegetation.

Field observations did not identify any noticeable erosion at the three locations along the streambed or on the banks, with the exception of a minimum toe erosion (less than 0.5 feet) of the low flow braided channel at Field Assessment Site 3. The dense and established vegetation provides resiliency to stresses engendered by geomorphically-significant flows. In addition, the field observation identifies coarse bed sediment at field assessment site 3.

Bed sediment deposition was observed in the low-flow channel at the three field assessment sites, and is an indication of potential aggradation of the bed profile.

Table 2 – San Jacinto River Bank and streambed conditions

Field Assessment Site	1	2	3
Bank Conditions			
Bedrock	No	No	No (gravel in low flow bed)
Bank protection	Good (Vegetated)	Good (Vegetated)	None
Vegetation	Dense (60 to 90%)	Dense (60 to 90%)	Dense (40 to 60%)
Stratification	No	No	No
Bank erosion	None	None	None
Toe erosion	None	None	None
Streambed Conditions			
Headcuts	No	No	No
Degradation	No	No	Less than 0.5' in low flow channel
Downstream hardpoint	Yes (dip crossing)	No	No

Sediment source	No	No	Yes
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7.2 Sediment Composition and Allowable Velocity

The watershed soil characteristics were established to assess the erosion potential incorporating vegetative/land cover and soil. Surface pebble count was performed on October 20, 2014 at the three field assessment sites and found that the channel invert consisted of sand to medium cobble particles.

At field assessment Site 1 ($D_{50} = 1.5$ mm) and Site 2 ($D_{50} = 2.0$ mm), bed sediment is composed primarily of very coarse sand. Uniform flow computations performed using HEC-RAS show a water surface elevation of 8.57 feet and 8.67 feet for the 10-year flow event, respectively. Uniform flow computations performed using the Flowmaster normal depth model determined a mean flow velocity of 2.40 feet per second and 2.01 feet per second for the 10-year flow event, respectively. Comparatively, the 2014 FEMA FIS for the study segment shows the velocity ranging from 6.2 feet per second to 12.1 feet per second within the 100-year floodway.

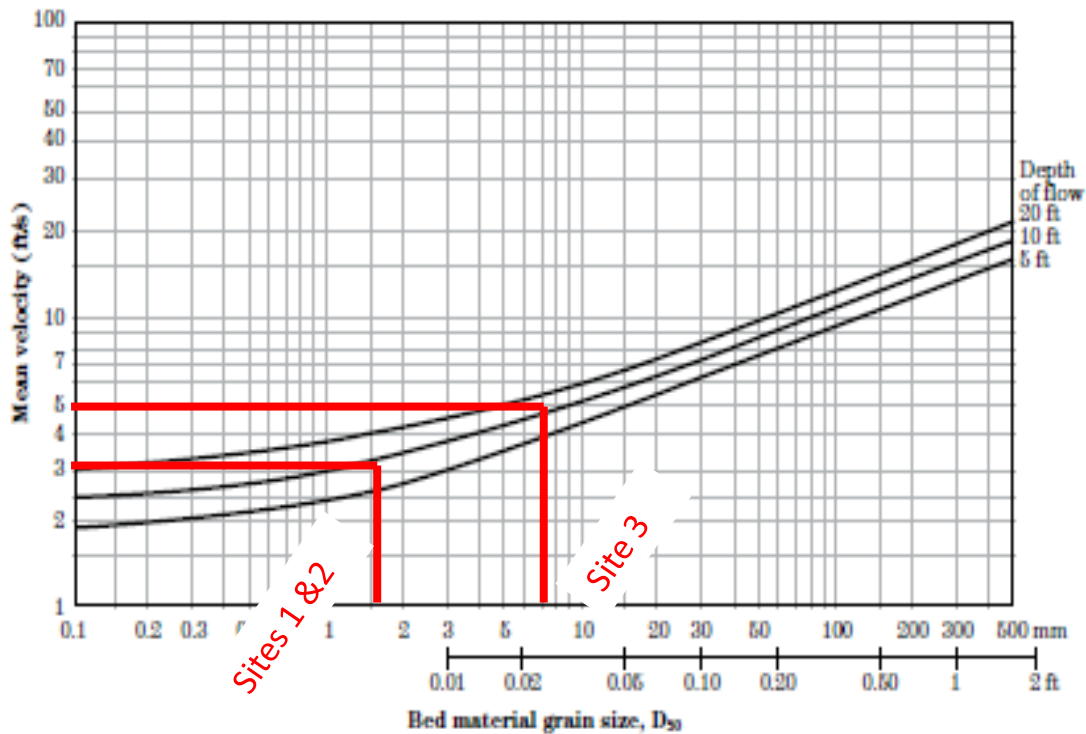
At field assessment Site 3 ($D_{50} = 6$ mm), bed sediment is primarily composed of fine gravel. Uniform flow computations performed using HEC-RAS show a water surface elevation of 14.58 feet for the 10-year flow event. Uniform flow computations performed using the Flowmaster normal depth model determined a mean flow velocity of 3.36 feet per second for the 10-year flow event, respectively.

The *Allowable velocity-depth grain* chart developed by United States Army Corp of Engineers (USACE) (1991b) identifies the allowable mean velocity of unprotected and non-vegetated stream bed that will not engender any scouring. The chart accounts for the average sediment grain size and the depth of flow. At field assessment site 3, the allowable mean velocity is of 5 feet per second, if the stream was fully unvegetated. At field assessment Sites 1 and 2, the hypothetical allowable mean velocity is of 3 feet per second. Practically, the allowable mean velocity is higher because of the established and maintained vegetation (see Section 6.3).

The evaluated stream segment lies within the alluvial floodplain of the San Jacinto River watershed. Because of its topographic location, the field-verified longitudinal slopes are lower than 0.05-percent, thus the mean velocities associated with the 10-year event do not exceed the allowable mean velocities at the three field assessment sites.

Figure 10 - Allowable velocity-depth grain chart (USACE, 1991)

Figure 8-3 Allowable velocity-depth grain chart



7.3 Role of Vegetation Allowable Velocity

As part of the development of master-planned community adjacent to the East bank of the study segment, the channel was improved to provide a 100-year flood protection to the community. Channel improvements included the implementation of vegetation to stabilize soils and offer additional resiliency against potential scouring and the construction of a levee to protect the community.



Established vegetation on the channel bed



Left bank levee protecting the community

The established and maintained vegetation provides a higher allowable velocity without observing any scouring at field assessment Sites 1 and 2. USACE (1991b) provided allowable velocity criteria for nonscouring channel, which are consistent with the findings of the United States Department of Agriculture (USDA) Agricultural Handbook #667 (1987). At field assessment Sites 1 and 2, grass and vegetation provides an allowable velocity of 4 to 6 feet per second without scouring.

Uniform flow computations at field assessment Sites 1 and 2 show mean flow velocities for the 10-year flow event of 2.4 feet per second and 2.01 feet per second, respectively (see Flowmaster normal depth model results in Appendix B). For the higher boundary of the range of geomorphically significant flows, no scouring is expected at field assessment Sites 1 and 2 because of the heightened resiliency to shear stress provided by the established and maintained vegetation.

7.4 Rapid Stream Assessment

A Rapid Stream Assessment (RSA) was performed for the Study segment. This methodology was created by WEST Consultants (see Appendix D) and also used for stream classification in the San Bernardino County Stormwater Program. The *Channel Assessment and Classification* study was reviewed by the Santa Ana Regional Board (Appendix C of the Phase II Watershed Action Plan, May 2013). The Rapid Stream Risk Classification (RSRC) for Hydromodification Mapping assessed the study segments based on 6 criteria:

1. **Shear Ratio (SR)** - An indicator of channel's bed shear stress sensitivity to increased discharge; Aggradation of bed sediment was observed at each of the three field assessment sites. In addition, the channel was improved and is maintained to prevent from any scouring to occur at locations 1 and 2.

Table 3 - RSA Shear Ratio Results

Stream Name	Field Assessment Site	Slope	H _o	Q _o	SR	Aggradation	Engineered	Risk
San Jacinto River	1	0.0003	8.57	1658	1.30	Yes	Yes	Low
	2	0.0003	8.67	1658	1.23	Yes	Yes	Low
	3	0.0002	14.5 8	1658	1.15	Yes	No	Medium

H_o – Normal Depth based on bankfull discharge.

Q_o – Bankfull Discharge (design discharge)

Risk – Indicates the channel potential to degradation based on shear ratio.

2. Entrainment Ratio (ER) - Represents the channel erosion potential;

As identified in Section 6.2, the presence of maintained vegetation at field assessment Sites 1 and 2 allows for high permissible flow velocities, which are higher than the mean flow velocity associated with the 10-year flow event. Similarly, Section 6.3 identifies that very fine gravel is found at field assessment Site 3, which allows for high permissible flow velocities.

Table 4 - RSA Entrainment Ration Results

Stream Name	Field Assessment Site	D50 (mm)	D50 (ft)	V (fps)	ER	Risk
San Jacinto River	1	1.5	0.00	2.4	0.03	Low
	2	2	0.01	2.01	0.01	Low
	3	6	0.02	3.36	0.02	Low

D50 – Median bed sediment size

V – Average velocity of flow within the channel

ER – Entrainment ratio

3. Geotechnical Stability Number - measures the lateral channel stability;

Samples of the soil composing the banks were tested for cohesiveness. However, both aggradation of bed sediment was observed at each of the three field assessment sites. In addition, at field assessment sites 1 and 2 the channel was improved and is maintained to prevent scouring.

Table 5 - RSA Geotechnical Stability Number (GSN) Results

Stream Name	Field Assessment Site	H _o	H _o /H _c (GSN)	Aggradation	Engineered	Risk
San Jacinto River	1	8.57	0.45	Yes	Yes	Low
	2	8.67	0.46	Yes	Yes	Low

	3	14.58	0.77	Yes	No	Low
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Ho – Normal Depth based on bankfull discharge.

Hc – Critical Bank Height based on cohesion of the in-situ soil properties.

Risk – Measures the potential for bank failure. A low-risk classification indicates the channel banks are engineered to withstand erosive forces.

4. **Confinement Class Number** - measures the amount of room that exists for the channel to actively move lateral and is useful indicator of a channel's vulnerability to erosion;

At field assessment Sites 1 and 2, the improvements of the channel included the construction of a levee offering a 100-year flood protection to the community adjacent to the left bank (looking downstream). The curvature of the channel being rectilinear, it is not expected that the channel will migrate laterally and erode the improved right bank.

At field assessment Site 3, the river flows from an alluvial floodplain to a canyon of more pronounced topography. Because of the curvature of the stream, it is expected that the stream may slightly migrate laterally.

Table 6 - RSA Confinement Class Number Results

Stream Name	Field Assessment Site	W	B	W/B	Risk
San Jacinto River	1	200	17.7	11.30	Medium
	2	316	50	6.32	Medium
	3	217	21.4	10.14	Medium

W – Valley bottom width

B – Channel width

5. **Banks and Streambed Conditions** – identifies the ability of the banks and streambed to resist to erosive stresses

The analysis is described in Section 6.1 and the results are summarized below.

Table 7 - RSA Banks and Streambed Condition Results

Stream Name	Field Assessment Site	Bank Risk	Streambed Risk
San Jacinto River	1	Low	Low
	2	Low	Medium
	3	Low	Medium

Bank Risk - This criterion is based on detailed field observations. In general, the following factors that contribute to banks' resistance to erosion would classify as low-risk: bank stabilization in good condition, presence of bedrock, dense vegetation, highly consolidated bank material, no stratification, no signs of active erosion, toe in good condition. The opposite would classify as high-risk.

Streambed Risk - This criterion is based on detailed field observations to assess the streambed sedimentation/erosion characteristics. A low-risk classification is triggered by the following factors: not braided or sand bed, highly armored, erosion resistant bedrock, no active headcuts, small degradation (< 1 ft.), presence of downstream hard point in good condition (< 100 ft. away), no widening, no aggradation, no obvious sources of sediments from bank failures of upstream sources. The opposite classifies as high-risk.

The overall risks of future erosion determined by the Rapid Stream Assessment are summarized in Table 8. There is a low risk of future erosion at each of three field assessment sites. The low risk for future erosion is supported by channel geometry (large width, flat slope), the presence of dense and maintained vegetation, the presence of coarse bed sediment, and observed aggradation of the bed.

Table 8 - RSA Risk Results

STREAM NAME	FIELD ASSESSMENT SITE	CLASSIFICATION
San Jacinto River	1	Low
	2	Low
	3	Low

8 CONCLUSION

Based on the hydrology assessment and analysis of the 3.8 mile reach of the San Jacinto River upstream of Canyon Lake, it has been determined that the San Jacinto River is a natural resistant feature that exhibits the following characteristics:

- Drainage area higher than 100 square-miles and a 100-year peak discharge higher than 20,000 cfs.
- The natural hydrology and sediment loading of different watercourses within the SAR are significantly impacted by the upstream impoundments, which regulate downstream flow.
- Permittees participate in the National Flood Insurance Program and enforce a floodplain management ordinance to regulate development in mapped flood hazard areas.
- The low-gradient of this segment of the San Jacinto River results in deposition of coarse-grained sediments.

Under the existing and future hydrologic conditions, there will be no scouring of the bed and bank of the stream at each of the three field assessment sites. The additional lines of evidence support that the San Jacinto River is not an HCOC:

- The river has the characteristic geomorphology of a large river, including a flat slope and a wide alluvial floodplain;
- A review of historical aerial photographs did not identify lateral migration of the streambed, even though historical urbanization has occurred;
- The production of bed sediment occurs in the San Jacinto Mountain, thus future development in the alluvial floodplain will not impact the production and conveyance of bed sediment to the downstream reaches;
- Field observations at the three field assessment sites did not identify erosion within the bed and banks of the channel. Deposition of sediment within the streambed indicated that the stream exhibits aggradation;
- Dense vegetation is present within the streambed, particularly within the low-flow channel. In addition, the 1.4-mile segment of improved channel exhibits permanent and maintained vegetation over its streambed and banks. The vegetation provides a higher resiliency to erosive forces.
- Bed sediment is composed of coarse sand and very fine gravel, which are typical of large rivers in alluvial floodplain environment. At field assessment site 3, the bed is predominantly composed of very fine gravel ($D_{50} = 6\text{mm}$), which provides a high resiliency to erosive forces;
- The rapid stream assessment concluded that the 3.8-mile segment has a low-risk for future erosion.

The lower San Jacinto River watershed has a very low-gradient which limits the discharge velocity along the channel and decreases the erosive energy that would be shown in steeper streams. The 52-year (1962-2014) historical aerial photographs evaluated show no significant change and the floodplain over the study reach is fairly consistent.

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