Hydromodification Susceptibility Documentation Report and Mapping

Santa Margarita Region

April 2014

Prepared for:

Santa Margarita Region Copermittees

Prepared by:

RBF Consulting

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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
Adequate Sump	An Adequate Sump can be defined as a large river, reservoir or basin that provides significant regional flood protection for the downstream watershed areas and mitigates flows such that upstream PDPs would not cause a significant change in Hydromodification of the receiving channel segments.
Copermittees	County, District, and Cities of Murrieta, Temecula and Wildomar
County	Riverside County
District	Riverside County Flood Control and Water Conservation District
EEM	Engineered, Earthen and Maintained (EEM): This group includes constructed channel segments that are not armored but have been improved to be resistant to Hydromodification as verified by review of as-built plans. The channel segment must also be maintained to control invasive vegetation and to correct any significant localized scouring identified during routine inspections. This group is intended to include channel segments constructed for flood conveyance, which generally have a design capacity in excess of a 10-year storm event.
EFHM	Engineered, Fully Hardened and Maintained (EFHM): This group includes channel segments that are fully armored (e.g. concrete, soil cement, rock rip rap, etc.) on three sides and verified by as-builts, aerial photographs and/or a site visit. This group includes piped and boxed channel segments. The channel segment and associated armoring must also be designed based on an engineering criteria (e.g. a specific storm event.) and maintained as designed. Copermittees typically engineer the EFHM channels to completely contain the 100-year ultimate flow conditions and remain stable under these flow conditions. Copermittees inspect the facilities regularly to maintain the improvements per design.
EPHM	Engineered, Partially Hardened and Maintained (EPHM): This group 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 by as-built plans, aerial photographs and/or a site visit. The armoring may include bank and/or invert lining that has been placed based on engineering criteria. The channel segment and associated armoring must also be maintained.
gb	Gabbro and dark dioritic rocks
GIS	Geographical Information System
Gr-m	Granite and metamorphic rocks
GrMz	Mesozoic granite, quartz monzonite, granodiorite, and quartz diorite
HMP	Hydromodification Management Plan
HMP Performance Standard	The Hydrologic Performance and Sediment Supply Performance Standards
HRU/GLU Analysis	Hydrologic Response Units/Geomorphic Landscape Units
Hydromodification	A method to avoid accelerating or exacerbating existing sediment transport. Where

Management	receiving channels are in a state of dynamic equilibrium, Hydromodification Management may prevent the onset of erosion, sedimentation, lateral bank migration, or impacts to in-stream vegetation.
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).
J	Shale, sandstone, minor conglomerate, chert, slate, limestone
m	Undivided pre-cenozoic metasedimentary and metavolcanic rocks
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.
MS4	Municipal Separate Storm Sewer System
NAT	Natural (NAT): This group 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.
NRCS	Natural Resource Conservation Service
NEE	Not Engineered and Earthen (NEE): This group includes natural and constructed channel segments that are modified by anthropogenic activities, which 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.
NHD	National Hydrography Dataset (NHD) is used to portray surface water on The National Map through GIS to represent the drainage network with features such as rivers, streams, canals, lakes, ponds, coastline, dams, and stream gauges.
PDP	Priority Development Project
Q or Qw	Flow
QPc	QPc
SCCWRP	Southern California Coastal Water Research Project
SDRWQCB	San Diego Regional Water Quality Board
SMR	Santa Margarita Region

SWAMP	Surface Water Ambient Monitoring Program: tasked with assessing water quality in all of California's surface waters. The program conducts monitoring directly and through collaborative partnerships and provides numerous information products, all designed to support water resource management in California.
SSMP	Standard Stormwater Mitigation Plan, also known as WQMP (Water Quality Management Plan)
USGS	United States Geological Survey

1 INTRODUCTION

This documentation report is part of the larger study for the Santa Margarita Region (SMR) Copermittees to develop a Hydromodification Management Plan (HMP) as required by the 2010 SMR Municipal Separate Storm Sewer System (MS4) Permit Order No. R9-2010-0016, NPDES No. CAS 0108766 (2010 SMR MS4 Permit). This report specifically deals with the SMR, also known as the Santa Margarita Hydrologic Unit, within Riverside County and includes the expansion of existing SMR maps. The updated maps provide information on the channel segments within the SMR with the goal of identifying those that may be vulnerable to Hydromodification as required by the 2010 SMR MS4 Permit. The report also identifies areas with the potential for restoration or rehabilitation.

1.1 Background

According to *Surface Water Ambient Monitoring Program (SWAMP) Report on the Santa Margarita Hydrologic Unit*, by the Southern California Coastal Water Research Project (SCCWRP, 2007), the Santa Margarita River is one of the largest unregulated rivers in Southern California. The Santa Margarita River watershed is also one of the least developed in Southern California, where approximately 74% of the 750-square mile watershed is within Riverside County. The Santa Margarita River discharges to the Pacific Ocean through San Diego County, and entire watershed is under the jurisdiction of the San Diego Regional Water Quality Board (SDRWQCB).

The 2010 SMR MS4 Permit requires the Riverside County Flood Control and Water Conservation District (District), County of Riverside (County), and the cities of Murrieta, Temecula, and Wildomar (collectively, Copermittees) to develop and implement a HMP to address the SMR (see Figure 1). The District is the Principal Copermittee for coordination of compliance with the 2010 SMR MS4 Permit and is engaged in developing the components of the HMP on behalf of the Copermittees.

According to Section F.1.h of the 2010 SMR MS4 Permit, the objective of the HMP is to manage increases in runoff discharge rates and durations from all Priority Development Projects (PDPs). The HMP must be incorporated into the Standard Stormwater Management Plan (SSMP) (referred to as the Water Quality Management Plan (WQMP) by the Copermittees) and implemented by each Copermittee so that estimated post-project runoff discharge rates and durations must not exceed predevelopment discharge rates and durations for a range of runoff flows.

The 2010 SMR MS4 Permit defines PDPs as:

(a) All new development projects that fall under the following categories or locations:
   a. A project that creates 10,000 square feet or more of impervious surfaces;
   b. Automotive repair shops;
   c. Restaurants;
   d. All hillside development greater than 5,000 square feet;
   e. Development located within or directly discharging to Environmentally Sensitive Areas;
   f. Impervious parking lots 5,000 square feet or more and potentially exposed to runoff;

   g. Streets, roads, highways and freeways of 5,000 square feet or more of impervious surface; and
   h. Retail gasoline outlets.

(b) Redevelopment projects that create, add or replace at least 5,000 square feet of impervious surfaces; or
(c) A project that results in the disturbance of one acre or more of land.

1.2 Hydromodification

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.

The degree to which a channel will degrade 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. Critical shear stress is the shear stress threshold above which motion of bed sediment load is initiated. Only the flows that generate shear stress in excess of the critical shear stress of the bank and bed sediments cause significant movement of bed sediment load. Urban development may increase the discharge rate, amount and timing of runoff, and associated shear stress exerted on the channel by the runoff and can trigger channel degradation in the form of incision (channel downcutting), widening (bank erosion), or both. Flow velocities that generate shear below critical shear stress levels have little or no effect on the channel stability.

Where receiving channels are already unstable, Hydromodification Management can be thought of as a method to avoid accelerating or exacerbating existing problems. Where receiving channels are in a state of dynamic equilibrium, Hydromodification Management may prevent the onset of erosion, sedimentation, lateral bank migration, or impacts to in-stream vegetation.

The 2010 SMR MS4 Permit includes requirements that influence the methodology chosen in development of the HMP. The Permit requires the Copermittees to develop an HMP for all PDPs (with certain exemptions) and develop a HMP Performance Standard including a geomorphically significant flow range that ensures the geomorphic stability within the channel. Supporting analyses for a PDP must be based on continuous hydrologic simulation modeling. Similarly, the loss of sediment supply due to a PDP must be considered.

According to Section F.1.h.4 of the 2010 SMR MS4 Permit, each Copermittee has the discretion to exempt a PDP from HMP Performance Standards where it:

(a) Discharges stormwater runoff into underground storm drains discharging directly to water storage reservoirs and lakes;

(b) Discharges runoff into 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 runoff into other areas identified in the HMP as acceptable to not need to meet the requirements of Section F.1.h of the 2010 SMR MS4 Permit by the SDRWQCB Executive Officer.

1.3 Goals and Objectives

The goal of this study was to conduct a screening level analysis to identify and map channel segments that may be potentially susceptible to Hydromodification. The purpose of mapping the susceptible channel segments was to develop a comprehensive map of the SMR to assist the Copermittees, and users to determine whether or not a PDP will drain to a channel segment potentially susceptible to Hydromodification and may be required to provide Hydromodification Management.

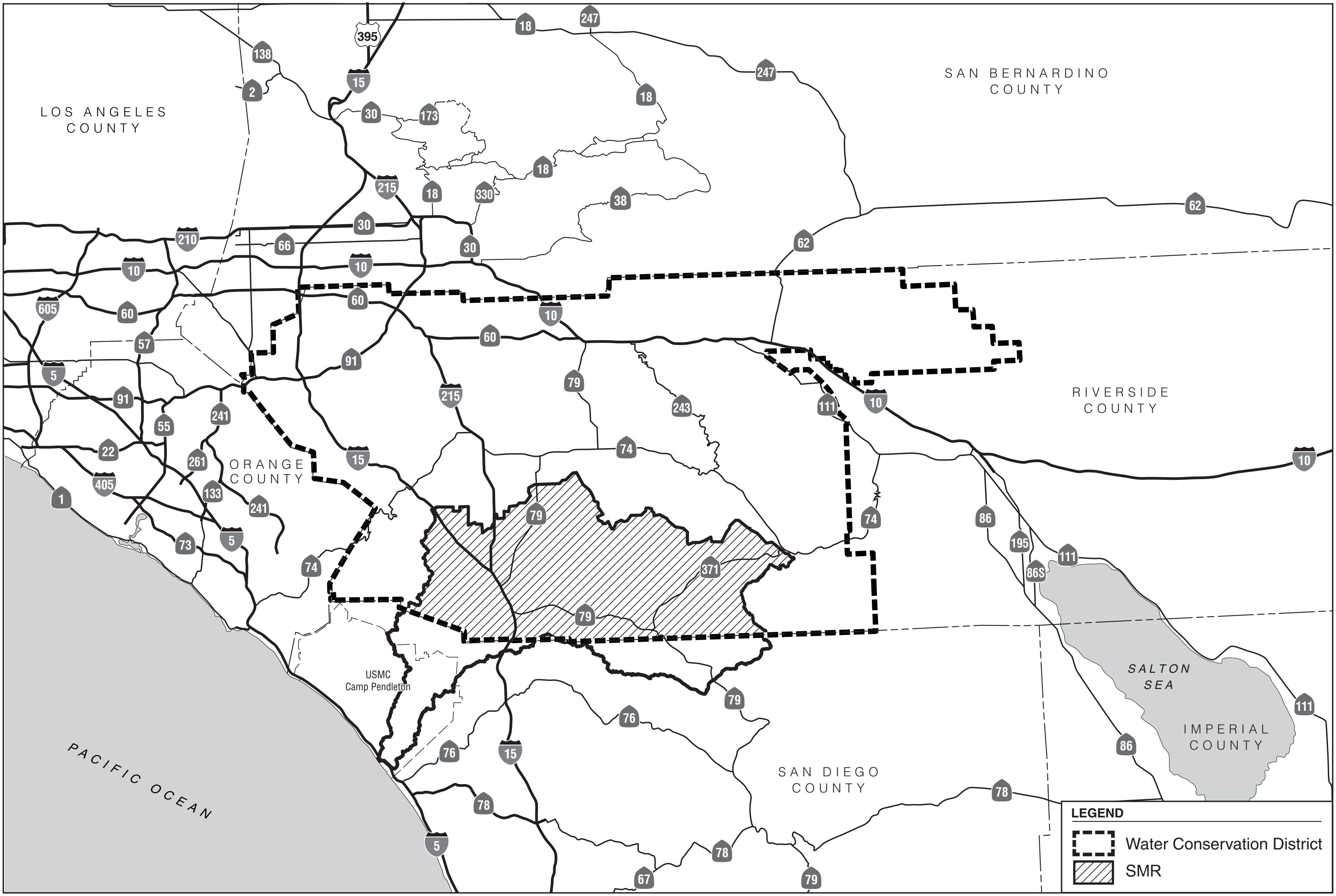
Additionally, this study identifies areas within the SMR for potential opportunities to restore or rehabilitate channel segments with historic Hydromodification of receiving waters that are tributary to documented low or very low Index of Biotic Integrity (IBI) scores for Hydrologic Response Unit (HRU) and Geomorphic Landscape Unit (GLU) analyses.

The study was divided into eleven tasks:

1. Research and data collection;
2. Delineate and map existing channel segments;
3. Define and classify existing channel segments in groups based on common characteristics such as bed and banks material composition, level of maintenance, and if the channel segment has been engineered;
4. Verify channel segment groups using provided data and site visits;
5. Identify possible exemptions under Section F.1.h.1.4.c;
6. Conduct Susceptibility Assessment of the channels to identify segments that may be susceptible to Hydromodification;
7. Delineate and map existing channel segments in the SMR that may be susceptible to Hydromodification;
8. Create the comprehensive Hydromodification Applicability Map of the SMR;
9. Identify locations of documented Low or Very Low IBI scores;
10. Identify areas within SMR for potential opportunities to restore or rehabilitate channels; and
11. Conduct Geographic Information System (GIS)-based HRU/GLU analysis of the identified areas from Task 10.

This report documents the methodologies used to determine whether an existing channel segment may be susceptible to Hydromodification due to a PDP. It discusses the delineation of these existing channel segments and the SMR areas, potential areas for restoration or rehabilitation, and the HRU/GLU analysis. It also provides two maps: Existing Channel

Delineation Map and Channel Susceptibility & Areas Exempted from Hydromodification Requirements Map.



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HYDROMODIFICATION SUSCEPTIBILITY DOCUMENTATION REPORT AND MAPPING
SMR COPERMITTEES

Location Map

Figure 1

RBF
A Baker Company

2 EXISTING CHANNEL DELINEATION MAP

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

2.1 Research and Data Collection

Data requests were provided to the Copermittees to assist in the collection of background data needed for the delineation for susceptibility to Hydromodification of existing channels. The information collected from the Copermittees included: aerial photographs, topography, as-built plans, GIS databases, drainage studies, Federal Emergency Management Agency floodplain studies, and more. The data provided by the Copermittees was reviewed and verified for accuracy.

2.2 Delineation for Susceptibility to Hydromodification of Existing Channel Segments

The goal of this task was to delineate all channels segments for susceptibility to Hydromodification within the SMR. MS4 facilities were also mapped if found pertinent to determining if a subwatershed drained to a channel segment potentially vulnerable to Hydromodification.

The existing channel segments were predominately delineated using the District's GIS shapefile called: RCFC_FACILITIES_LINE. This shapefile provided GIS linework for all District channel segments.

Additional channel segments were delineated using GIS shapefiles provided by the Copermittees and National Hydrography Dataset. 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 channel segment delineations were added solely based on the aerial photography investigation. Any channel segment delineations in question were verified by site visits.

2.3 Existing Channel Segment Groups

To complete the initial mapping, the existing channel segments were categorized into five groups to better describe each segment by common traits. The groups matched the methodologies used in other areas of Riverside County and are described below:

1. **Engineered, Fully Hardened and Maintained (EFHM):** This group includes channel segments that are fully armored (e.g. concrete, soil cement, rock rip rap, etc.) on three sides and verified by as-builts, aerial photographs and/or a site visit. This group includes piped and boxed channel segments. The channel segment and associated armoring must also be designed based on an engineering criteria (e.g. a specific storm event.) and maintained as designed. Copermittees typically engineer the EFHM channels to completely contain the 100-year ultimate flow conditions and remain

stable under these flow conditions. Copermittees inspect the facilities regularly to maintain the improvements per design.

2. **Engineered, Partially Hardened and Maintained (EPHM):** This group 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 by as-built plans, aerial photographs and/or a site visit. The armoring may include bank and/or invert lining that has been placed based on engineering criteria. The channel segment and associated armoring must also be maintained.

3. **Engineered, Earthen and Maintained (EEM):** This group includes constructed channel segments that are not armored but have been improved to be resistant to Hydromodification as verified by review of as-built plans. The channel segment must also be maintained to control invasive vegetation and to correct any significant localized scouring identified during routine inspections. This group is intended to include 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 natural and constructed channel segments that are modified by anthropogenic activities, which 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.

5. **Natural (NAT):** This group 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.

2.4 Categorization of Existing Channel Segment Groups

A desktop study was conducted to categorize each 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 channel segment. Photographs and notes were taken in regards to the channel segment condition and armoring.

Any channel segments that could not be accessed and/or were still in question were discussed and verified with the Copermittee with jurisdictional responsibility for the segment.

3 HYDROMODIFICATION SUSCEPTIBILITY ASSESSMENT

This section discusses the susceptibility to Hydromodification of the existing channel segments and how they fit within the requirements of Section F.1.h of the 2010 SMR MS4 Permit.

3.1 Channel Segment Hydromodification Susceptibility

Sections F.1.h.4.a and F.1.h.4.b of Section F.1.h of the 2010 SMR MS4 Permit specify that a Copermittee has the discretion to not require a PDP to comply with Hydromodification Performance Standards if a PDP is directly tributary to a channel that is an underground storm drain (fully concrete lined) or whose bed and bank are concrete lined all the way from the point of discharge to water storage reservoirs and lakes. Section F.1.h.4.c provides the option to identify other criteria that would allow the Copermittees the same discretion.

The five existing channel groups discussed in Section 2 of this report were combined into the two categories: Not Susceptible and Susceptible to Hydromodification. The criteria used to determine the categories is similar to that used in other areas of Riverside County and Southern California and are shown below:

1. Not Susceptible

    a. EFHM – The risk for adverse impacts caused by Hydromodification is insignificant due to the armoring of the channel segment and the engineered design which would prevent Hydromodification.

2. Susceptible
   For channels deemed identified as susceptible per Provision F.1.h.(4) of Section F.1.h of the 2010 SMR MS4 Permit , the User may put forth other low-flow thresholds for individual PDPs. A site-specific low-flow threshold must be identified based on the conditions set forth in Appendix I.
    a. EPHM - The risk for Hydromodification is very low due to the partial armoring of the channel segment and the engineered design.
    b. EEM - The risk for Hydromodification is low due to the engineered design of the channel segment.
    c. NEE – It cannot be verified that the channel segment could handle the changes in runoff volume and duration associated with the PDP without Hydromodification. The risk for Hydromodification is potentially significant. Future technical studies could determine the level of risk of Hydromodification.
    d. NAT –The risk for Hydromodification is potentially significant. The level of risk may be determined through future technical studies.

3.2 Adequate Sump

An Adequate Sump can be defined as a large river, reservoir or basin that provides significant regional flood protection for the downstream watershed areas and mitigates flows such that upstream PDPs would not cause a significant change in Hydromodification of the receiving channel segments.

Both Vail Lake and Skinner Lake result in a major reduction of downstream peak flows in all storm events. According to the Philip Williams & Associates report, "for the watershed as a whole, compared with "natural conditions" there is a compensating effect on peak flood flows between the increased runoff from existing and future development and the storage effect of the large reservoirs. Those channels on which the reservoirs are located show large decreases in existing/future flows compared with natural conditions." For that reason, Vail Lake and Skinner Lake can be classified as "water storage reservoirs or lakes" and this study would categorize them as Adequate Sumps.

The Copermittees reserve the right to add additional facilities if they are identified to meet the above definition of an Adequate Sump. Updates to the associated maps may be required if additional Adequate Sumps are identified.

3.2.1 Large Rivers

As the size of a watershed increases, the potential for a PDP to increase and/or continuing unnatural rates of erosion of channel beds and banks, silt pollutant generation, or other impacts to beneficial uses and stream habitat due to increased erosive force within the watershed decreases. Therefore large rivers are less likely to be susceptible to Hydromodification and can be defined as an Adequate Sump; however, the definition of a "large river" is subjective. For the purposes of this assessment, the threshold used is described in the County of San Diego HMP, dated January 13, 2011, which states on Page 6-5 that "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."

In order to determine which channel segments would constitute large rivers, the following sources were investigated:

- Federal Emergency Management Agency, *Flood Insurance Study: Riverside County, California and Incorporated Areas*, dated August 2008.
- Philip Williams & Associates, *Santa Margarita Watershed Study: Hydrology and Watershed Processes*, dated October 26, 1998.

The Philip Williams & Associates report was found to be the most recent and thorough hydrology study for the Santa Margarita River Watershed. Philip Williams & Associates utilized the HEC-1 hydrology modeling program and ran analysis of three different conditions: natural, existing, and ultimate. A total of 60 different analyses were run on the watershed due to the three conditions, multiple storm events, and the assumed condition of Vail and Skinner Lake. The flow rates cited in this report were taken from the "existing conditions with historic December-April Mean Storage for Vail and Skinner Lakes (24 hour storm duration and Santa Margarita scale precipitation)" from the Philip Williams & Associates report (see Appendix A and B). It was believed that this condition best modeled the "typical" 100-year storm event at each of the concentration points.

The channel segments listed in Table 1 were identified to meet the drainage area and flow rate criteria. The location at which the channel exceeds the criteria is also listed. They are classified as not susceptible channels for the purposes of determining which watershed areas may be subject to the Hydromodification requirements.

Table 1: Large Rivers within SMR

River Name	Concentration Point	Hydrology Node	Drainage Area	100-year Flowrate
		(#)	(sq. mi)	(cfs)
Murrieta Creek	Below Warm Springs Creek	61	121	29,120
Temecula Creek	Vail Outflow	Vail	317	41,474
Santa Margarita River	At Origin	41	589	62,513

The potential susceptibility to Hydromodification of each of the mapped channel segments is indicated on Map 2: Channel Susceptibility & Areas Exempted from Hydromodification Requirements Map. This susceptibility assessment provides the foundation for identifying areas within the SMR that are potentially exempt or not exempt to the Hydromodification requirements.

4 APPLICABILITY CRITERIA

This section discusses the methodology for identifying areas within the SMR that are potentially exempt or not exempt from the Hydromodification requirements. The results of the assessment are used to develop a comprehensive map of the SMR which identifies those areas that are tributary to channel segments potentially susceptibl to Hydromodificatione. The Channel Susceptibility & Areas Exempted from Hydromodification Requirements Map (see Map 2) provides a delineation of the channel segments potentially susceptible to Hydromodification and the watershed areas in the SMR that are potentially exempt or not exempt from the Hydromodification requirements.

4.1 Delineation of Existing Hydrology Watershed Boundaries

The existing hydrology watershed boundaries were predominately delineated using the National Hydrography Dataset (NHD) GIS shapefile called: *NHD Area*, provided by the District. This shapefile provided GIS linework for the entire Santa Margarita River Watershed. The NHD data was verified and updated using: master plans of drainage, previous drainage studies, GIS data provided by the Copermittees (drainage areas and MS4 data), United States Geological Survey (USGS) topography, and Intermap topography.

The watershed boundaries were simplified using the collected data to delineate those areas tributary to channel segments that are potentially susceptible to Hydromodification.

4.2 Channel Susceptibility & Areas Exempted from Hydromodification Requirements Map

The SMR has been divided into two different watershed areas: Potentially Not Exempt and Potentially Exempt. The Potentially Exempt areas of the SMR would potentially be excluded from Hydromodification requirements. PDPs in the Potentially Not Exempt areas will continue to determine the applicability of Hydromodification requirements consistent with the SMR HMP.

- Potentially Not Exempt Areas – SMR areas that drain to channels potentially susceptible to Hydromodification, where future PDPs may adversely impact downstream erosion, sedimentation, or channel habitat by increasing the volume and/or duration of storm runoff. This includes watershed areas tributary to the following categories of channels:
    - NEE; and
    - NAT, and
    - EPHM; and
    - EEM.

    - PDPs that are located within a Potentially Not Exempt Area should reference the SMR HMP for the specific HMP Performance Standards.
    - For channels deemed identified as susceptible per 2010 SMR MS4 Permit Provision F.1.h.(4), the User may put forth other low-flow thresholds for individual PDPs. A site-specific low-flow threshold must be identified based on the conditions set forth in Appendix I.

    - Potentially Exempt Areas – Areas of the SMR that drain directly to an Adequate Sump (e.g. Vail Lake and Skinner Lake) or Large River (see Section 3.2.1) via a channel segment that is not susceptible to Hydromodification. This includes areas of the SMR tributary toEFHM;

- For PDPs in a Potentially Exempt Area of the SMR, if the site does not drain directly to a mapped channel segment, then the PDP must show that all downstream channel segments are not susceptible to Hydromodification, consistent with Section 3 of the SMR HMP.

5 RESTORATION AND REHABILITATION

The following subsections discuss the HRU/GLU analyses and the conclusion derived from the analyses.

5.1 Low or Very Low IBI Scores

According to the *SWAMP Report on the Santa Margarita Hydrologic Unit* (SCCWRP, 2007), "biological health varied widely across the watershed. The thresholds for bioassessment samples were based on a benthic macroinvertebrate IBI that was developed specifically for Southern California. The results of the IBI produces a measure of impairment with scores from 0 to 100, where 0 represents the poorest health and 100 the best health. Scores below 40 were considered poor and scores below 20 were considered very poor."

Using aerial photographs and SWAMP Report, multiple locations within the Santa Margarita Hydrologic Unit were found to have low or very low IBI scores but only three were found to be within or immediately downstream of the SMR. All other locations within the Santa Margarita River watershed were outside of Riverside County.

See Table 2 and Figure 2 for the locations with low or very low (poor or very poor) IBI scores that were utilized within this study. However, as described in section 4.3.4 (Bioassessment Data and Analysis) of the SMR FY 2012-13 Monitoring Annual Report: “When considering inter-season (historical) patterns, overall it appears that the trend patterns of BMI communities observed for Lower Murrieta Creek, Lower Temecula Creek, and Adobe Creek appear to be related to prior rainfall and base flow within the creeks. While the overall BMI communities within these lower watershed stations are considered poor, the historical patterns observed within these biological communities suggest that the BMI community health and fluctuations observed are more closely related to rainfall and habitat complexity than water quality.”

Table 2: Low or Very Low IBI Scores

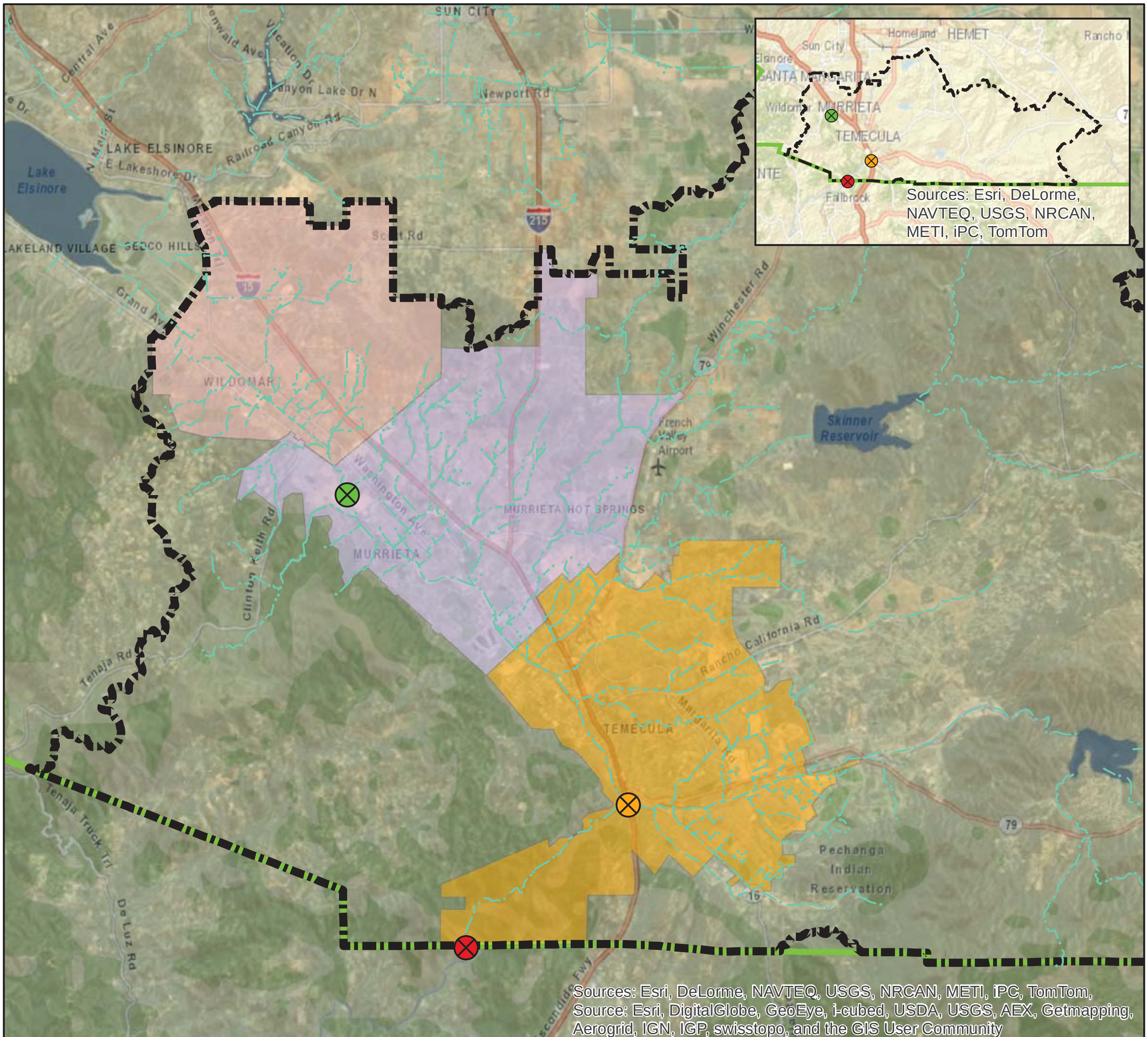
River Name*	Concentration Point	Site Number within SWAMP report	Lowest IBI Score*
Murrieta Creek	Above Warm Springs Creek	2	Very Poor
Temecula Creek	At Interstate 15	11	Very Poor
Santa Margarita River	Willow Glen Drive	10	Poor

*The definition of poor or very poor IBI scores is equivalent to the low or very low IBI scores described within the Permit.

The three channels (Murrieta Creek, Temecula Creek, and Santa Margarita River) exhibit low or very low IBI scores.

5.2 HRU/GLU Analysis

In March 2010, SCCWRP developed *Technical Report 605 – Hydromodification Screening Tools: GIS-based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge* (Technical Report 605). According to Technical Report 605, "although straightforward in intent, Hydromodification Management is difficult in practice. Shifts in the flow of water and bed sediment, and the resulting imbalance in bed sediment load 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 bed sediment, valley shape and slope, presence of in-stream or streamside vegetation, or catchment properties. [Technical Report 605] is the first report of three that outline a process and provide tools aimed at addressing the decision node associated with assessing channel susceptibility. It outlines a process for evaluating potential change to channels resulting from watershed-scale changes in runoff and bed sediment yield."



Legend

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location
- Streams
- SMR
- County Boundary
- City of Murrieta
- City of Temecula
- City of Wildomar

0 1.5 3 6 Miles

N

SMR Copermittees
Hydromodification Susceptibility Mapping: Progress Report for SMR

IBI Score Locations

Figure 2

SCCWRP ran HRU/GLU analyses on 17 locations where the channel segments were "examined from a geomorphic perspective" and the tributary watersheds were both developed and undeveloped. Unlike SCCWRP, this study was only interested in analyzing developed watersheds to determine what potentially caused the channel impacts and which Hydromodification management methods would best suit each individual location. Due to this, only a couple of locations were analyzed.

Two locations, Temecula Creek and Murrieta Creek-Line G, were chosen because they were found to be examples of different types of Hydromodification. Murrieta Creek Line-G is a classic example of Hydromodification from development runoff on naturally high sediment yield areas, while Temecula Creek exhibits why a project-specific approach to Hydromodification is not always appropriate due to the influence of Vail Lake. Both locations exhibit Hydromodification (e.g. degradation, head cutting, separation from existing floodplain). The following subsections discuss the background of the HRU/GLU analysis and the conclusions of the two analyses.

5.2.1 <u>HRU Background</u>

Technical Report 605 states that, "HRUs 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. To simplify the complexity, generally HRU analyses consists of using imperviousness as a surrogate for the relative magnitude of hydrologic impacts due to the availability of classified land cover data and because landcover is the most important landscape-scale driver of downslope physical changes."

According to the *Technical Report 667: Hydromodification Assessment and Management in California* (Technical Report 667) by SCCWRP April 2012, "urbanization of a watershed can drastically increase the frequency, duration, and magnitude of small and moderate flow events by factors of 10 or more. "

5.2.2 <u>GLU Background</u>

According to Technical Report 605, "many of the same physical properties that determine the hydrologic response of the watershed also determine the magnitude of sediment production from those same areas. The three properties that were determined to exert the greatest influence on the variability on sediment-production rates were: geology types, hillslope gradient, and land cover. The GLU analysis consists of grouping each of the datasets into a limited number of categories based on their influence to sediment production and combining the data within GIS to determine the areas with the highest sediment-delivery potential." Each category was provided a rank (low, medium, high or very high) relative to their potential for sediment production. Based on this rank, a number value was provided for the GLU analysis so that the watershed could be broken up into a grid. Each grid cell covers an area of 100-feet by 100-feet and has a GLU value that ranges from 3 to 10, with 3 having the lowest and 10 having the highest potential for sediment production.

Tables 3 through 5 show the categories used for each of the datasets.

Table 3: Geology Types

Geology Classification (Rock Type)	Description	Potential for Sediment Production	GLU Value
gr-m	Granite and metamorphic rocks	Low	1
m	Undivided pre-cenozoic metasedimentary and metavolcanic rocks		
grMz	Mesozoic granite, quartz monzonite, granodiorite, and quartz diorite		
gb	Gabbro and dark dioritic rocks		
J	Shale, sandstone, minor conglomerate, chert, slate, limestone	Medium	2
Q	Aluvium	High	3
QPc	Pliocene and/or Pleistocne sandstone, shale and gravel deposits		

*From National Resource Conservation Service (NRCS), Geologic Map of California, 2000.

Table 4: Land Cover

Land Cover Type	Potential for Sediment Production	GLU Value
Unconsolidated Shore	Low	1
Water		
High Intensity Developed		
Low Intensity Developed		
Medium Intensity Developed		
Cultivated	Medium	2
Pasture/Hay		
Developed Open Space		
Deciduous Forest	High	3
Evergreen Forest		
Mixed Forest		
Palustrine Emergent Wetland		
Palustrine Forested Wetland		
Bare Land	Very High	4
Grassland		
Palustrine Scrub/Shrub Wetland		
Scrub/Shrub		

*From National Land Cover Database, 2006 (NLCD 2006)

Table 5: Hillslope Gradient

Slope	Potential for Sediment Production	GLU Value
Less than 10%	Low	1
10% to 20%	Medium	2
Greater than 20%	High	3

*100-ft x 100-ft grid created from USGS Topography

5.2.3 <u>Temecula Creek</u>

As discussed in Section 5.1, a very low IBI score was found along Temecula Creek near the Interstate 15 bridge and the watershed tributary to the channel was analyzed, see Figure 3 for the site location. This specific location was analyzed because the watershed contains Vail Lake, which has had an impact on the hydrologic and sediment-production characteristics of the watershed.

5.2.3.1 Temecula Creek HRU Analysis

Due to the significant influence of Vail Lake on the downstream hydrologic characteristics of the SMR, land cover by itself would not provide enough information to determine the changes in runoff from natural to existing conditions and the impacts caused by Hydromodification. For this reason, the Phillip Williams & Associates report was used to determine the hydrologic changes that have occurred since "natural" conditions.

According to Phillip Williams & Associates, "Vail [Lake] results in [a] major reduction of peak flows for all events" (See Table 6). When looking at the SMR as a whole, "those channels on which reservoirs are located (including Temecula Creek) show large decreases in existing/future flows compared with natural conditions, while the channel systems without reservoirs show significant flow increases related to the level of development." While the latter portion of the statement is considered more of a "typical" form of Hydromodification, the former shows that with the existence of Vail Lake, the hydrologic characteristics of the Temecula Creek Watershed has permanently changed and it may not be possible restore the channel to "natural" conditions.

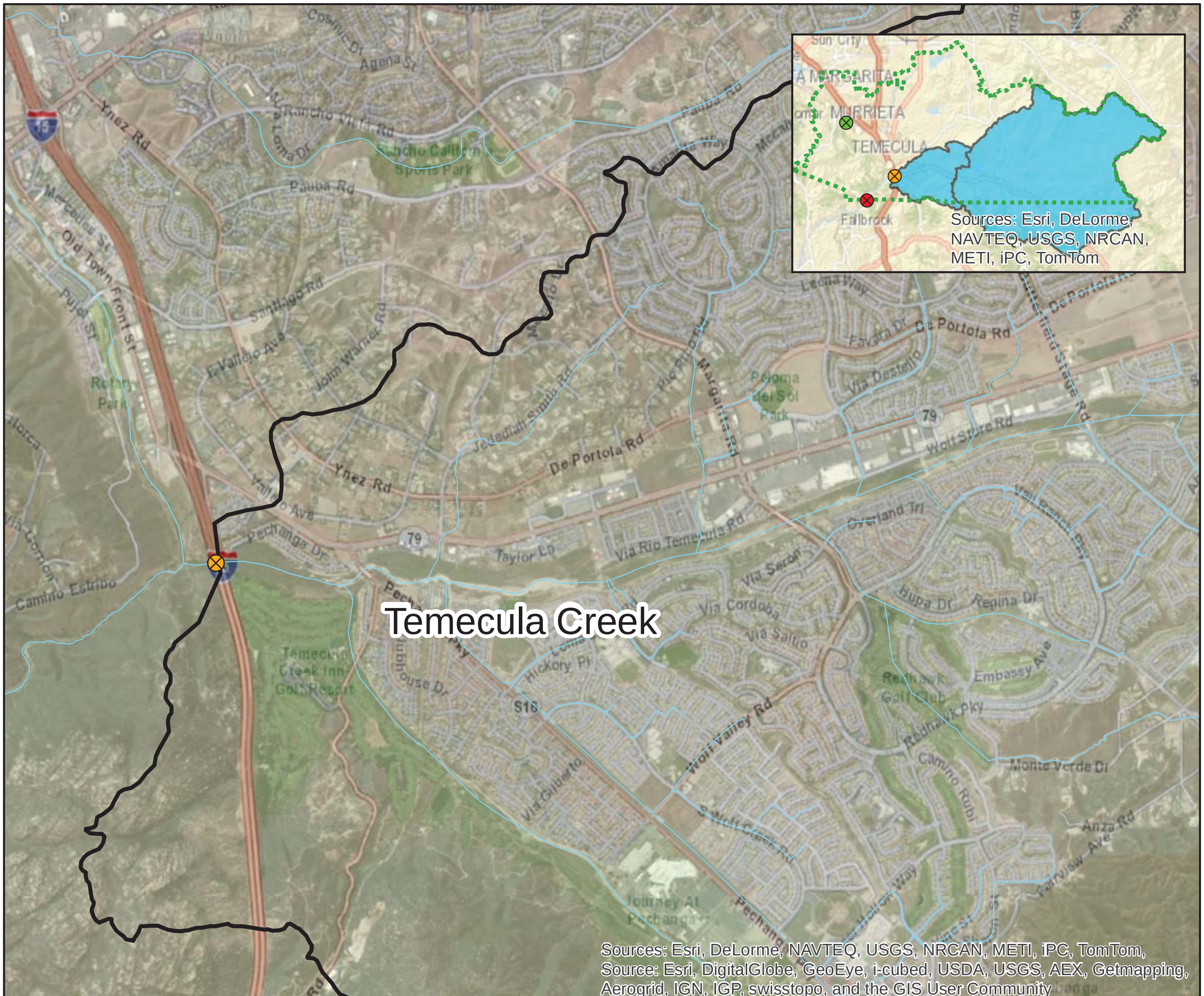
Table 6: Temecula Creek Flow Rates

Condition	2-Year Storm Event (cfs)	10-year Storm Event (cfs)	100-year Storm Event (cfs)
Natural	7,616	22,458	50,979
Existing Conditions	1,023	4,903	44,917

*From the Philip Williams & Associates report

5.2.3.2 Temecula Creek GLU Analysis

The GLU analysis consisted of analyzing the three datasets (geology types, land cover and hillslope gradient) based on the categories shown in Section 5.2.2, see Figures 4 thru 6. From the categories the entire watershed was broken up based on susceptibility to sedimentation (potential for sediment production), see Figure 7. Figure 8 shows the assumed susceptibility



Legend

Poor Index of Biotic Integrity (IBI) Scores

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location
- Temecula Creek Watershed
- Streams
- SMR

N

0 0.2 0.4 0.8 Miles

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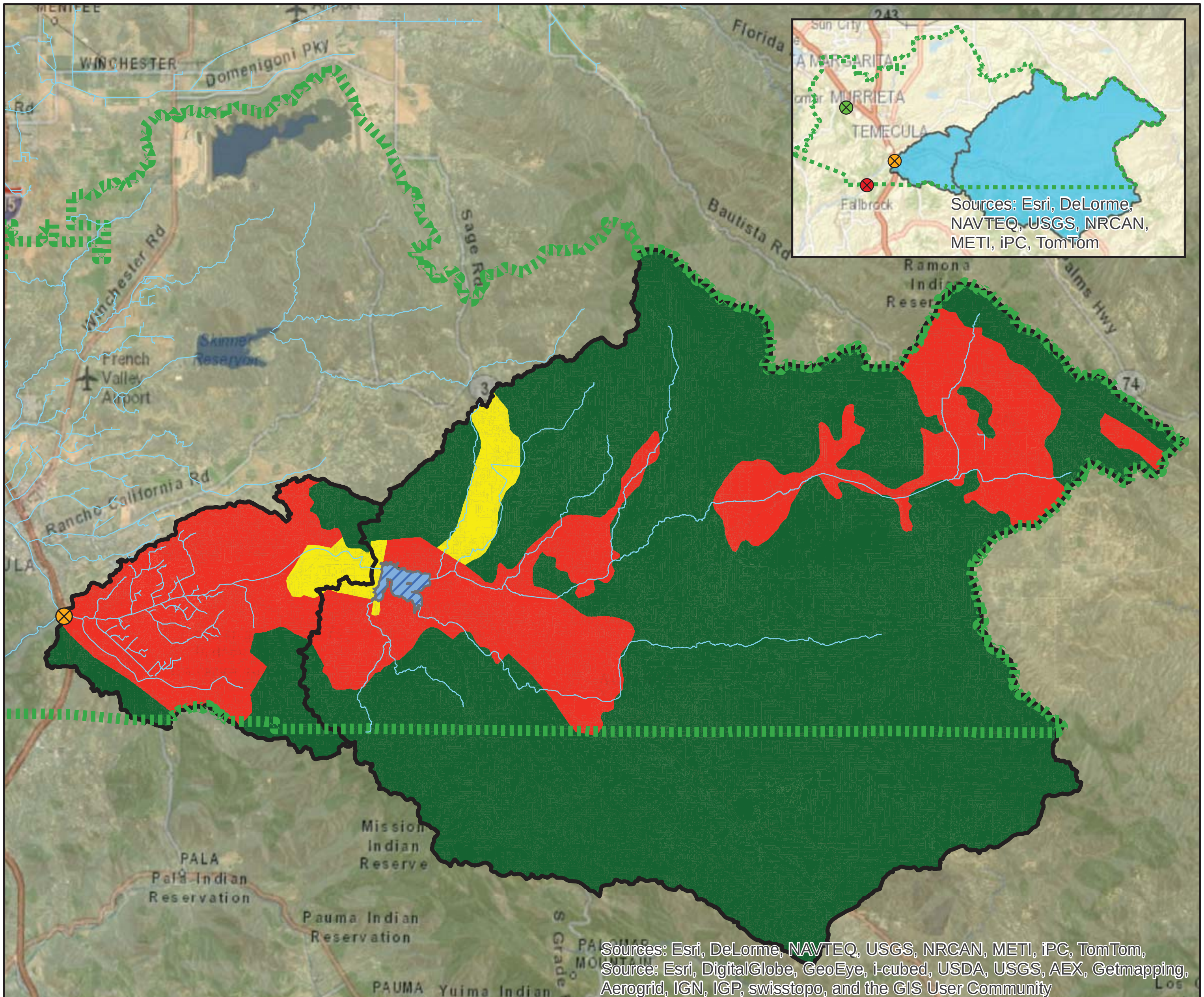
SMR Copermittees
Hydromodification Susceptibility Mapping - Santa Margarita River

Temecula Creek HRU/GLU Analysis - Site Location

Figure 3



Legend

Geology Susceptibility to Sedimentation

- Low
- Medium
- High

Poor Index of Biotic Integrity (IBI) Scores

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location

- Streams
- SMR
- Temecula Creek Watershed
- Vail Lake

N

0 1.5 3 6 Miles

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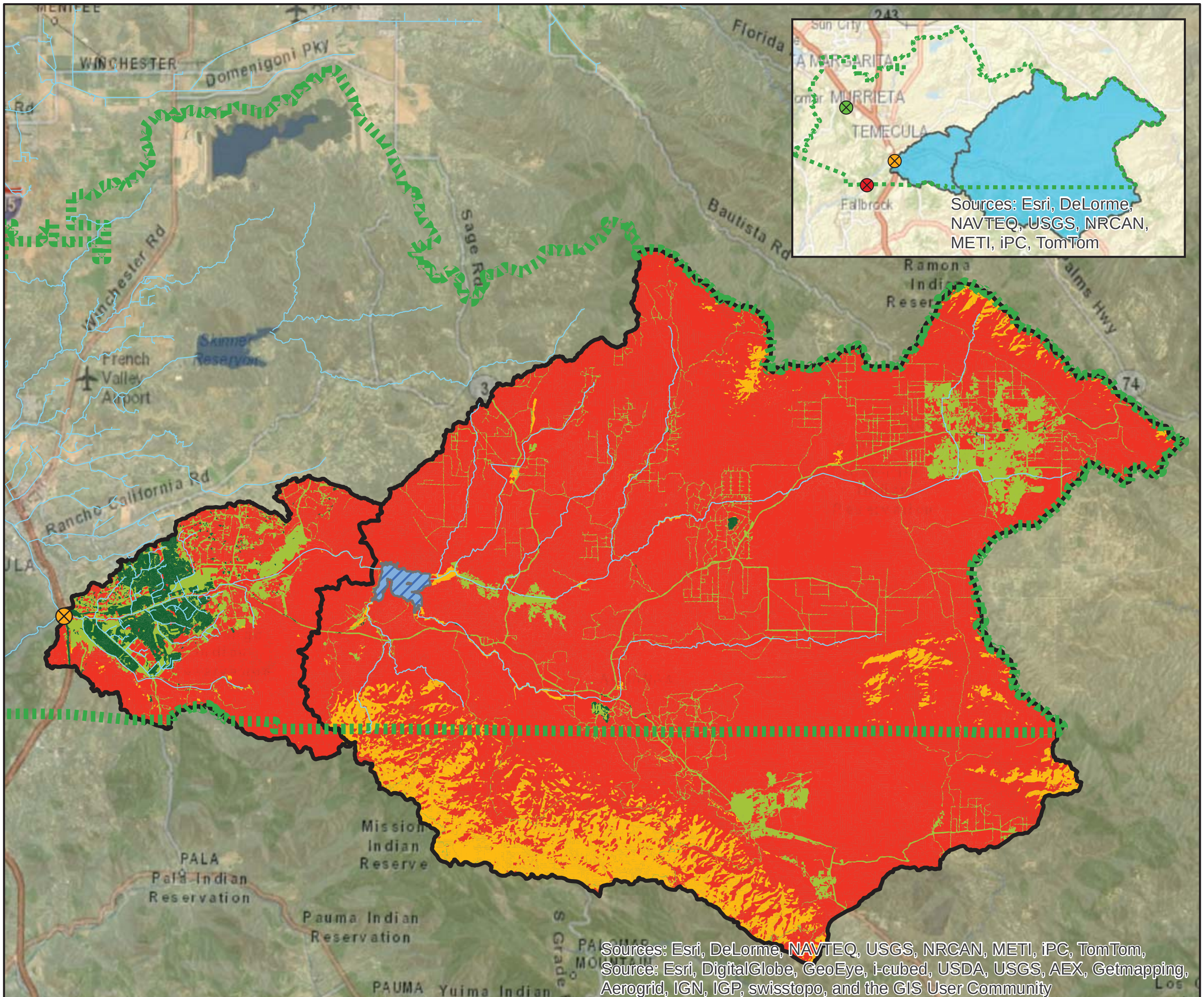
SMR Copermittees
Hydromodification Susceptibility Mapping - Santa Margarita River

Temecula Creek HRU/GLU Analysis - Geology Types

Figure 4



Legend

Land Cover Susceptibility to Sedimentation

- Low
- Medium
- High
- Very High

Poor Index of Biotic Integrity (IBI) Scores

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location

- Streams
- SMR
- Temecula Creek Watershed
- Vail Lake

N

0 1.5 3 6 Miles

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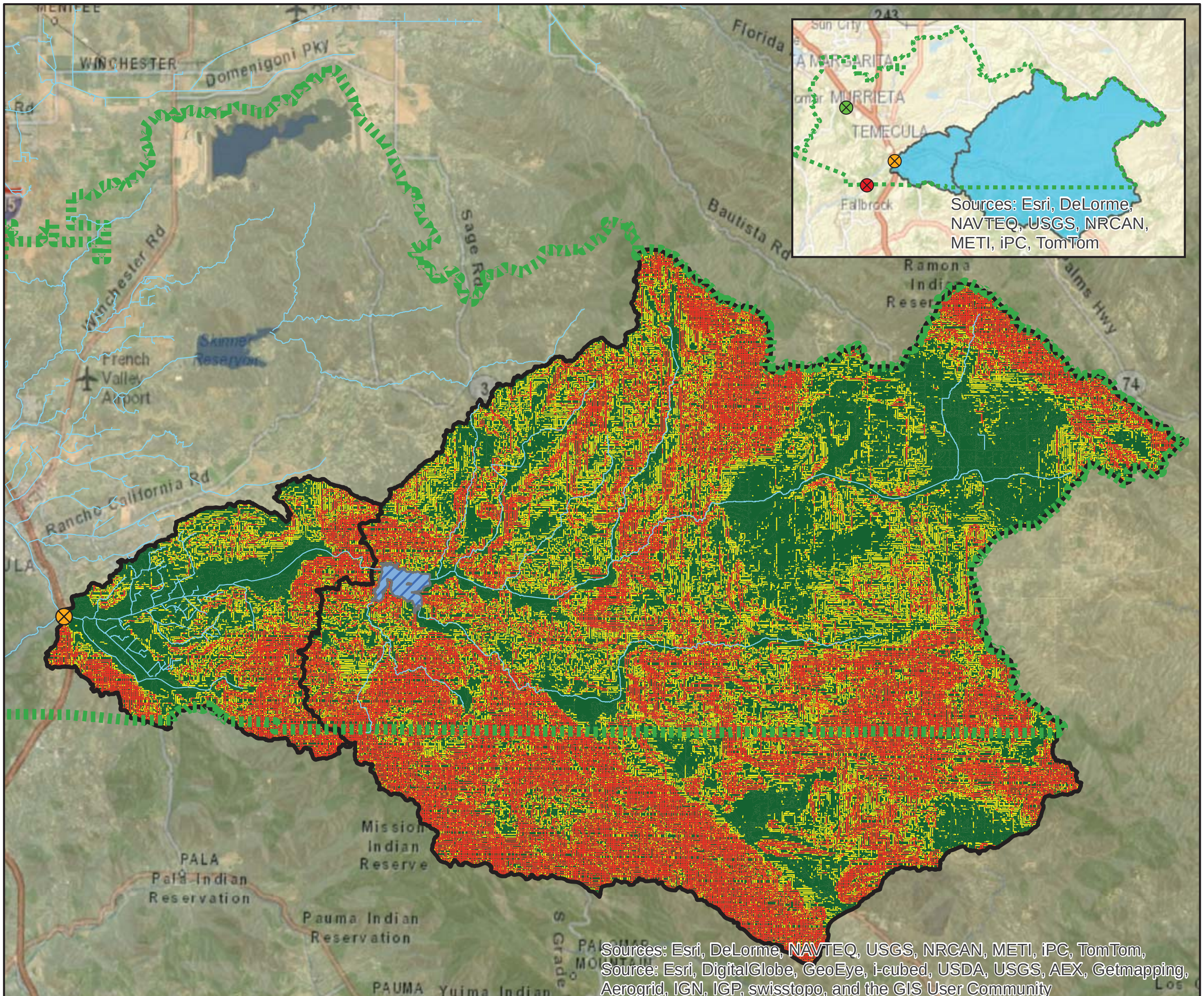
SMR Copermittees
Hydromodification Susceptibility Mapping - Santa Margarita River

Temecula Creek HRU/GLU Analysis - Land Cover

Figure 5



Legend

Slope Susceptibility to Sedimentation

- Low
- Medium
- High

Poor Index of Biotic Integrity (IBI) Scores

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location

- Streams
- SMR
- Temecula Creek Watershed
- Vail Lake

N

0 1.5 3 6 Miles

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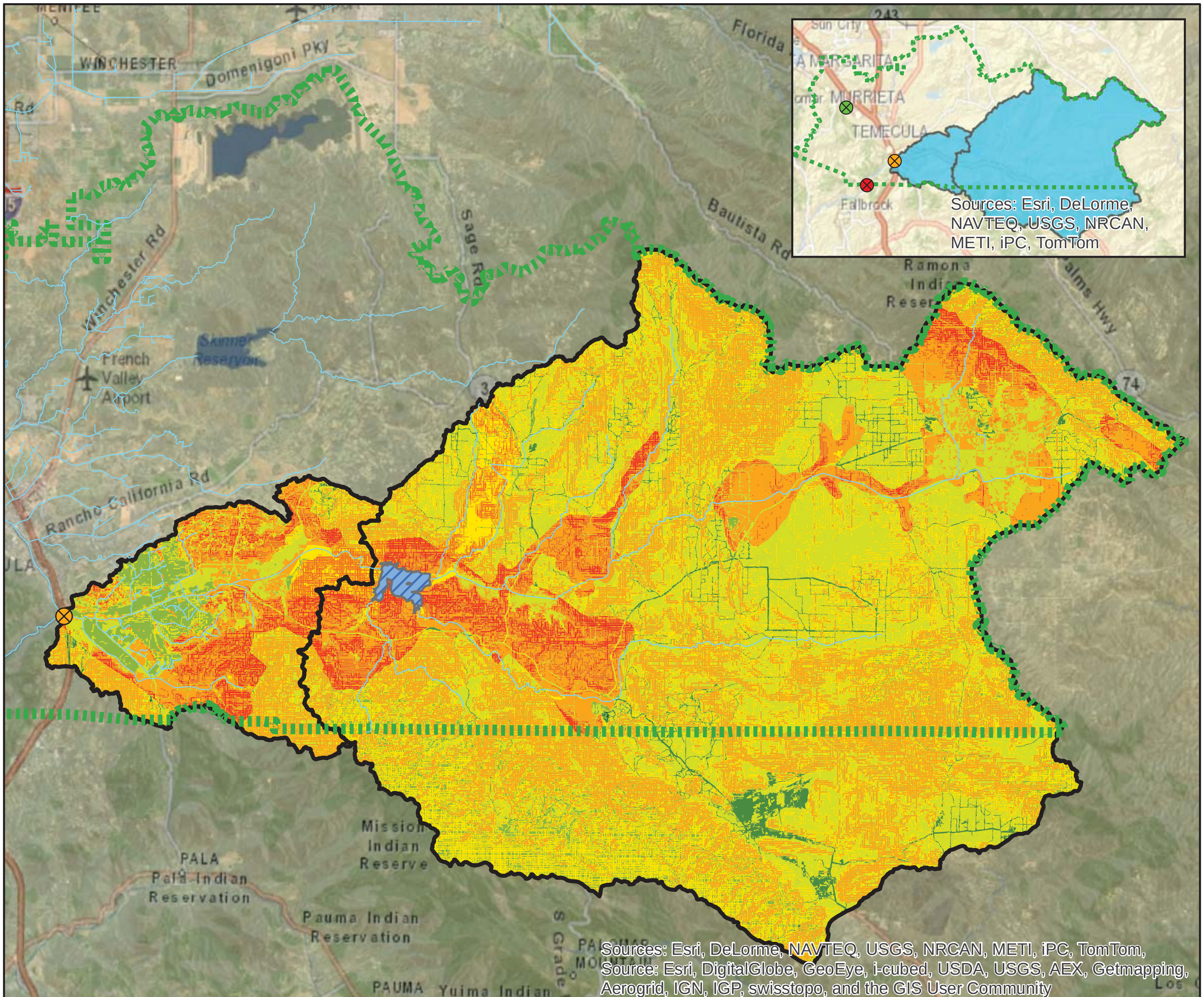
Hydromodification Susceptibility Mapping - Santa Margarita River

Temecula Creek HRU/GLU Analysis - Hillslope Gradient

Figure 6



Legend

GLU Analysis Value

- 3 - Lowest Susceptibility
- 4
- 5
- 6
- 7
- 8
- 9
- 10 - Highest Susceptibility

Poor Index of Biotic Integrity (IBI) Scores

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location
- Streams
- SMR
- Temecula Creek Watershed
- Vail Lake

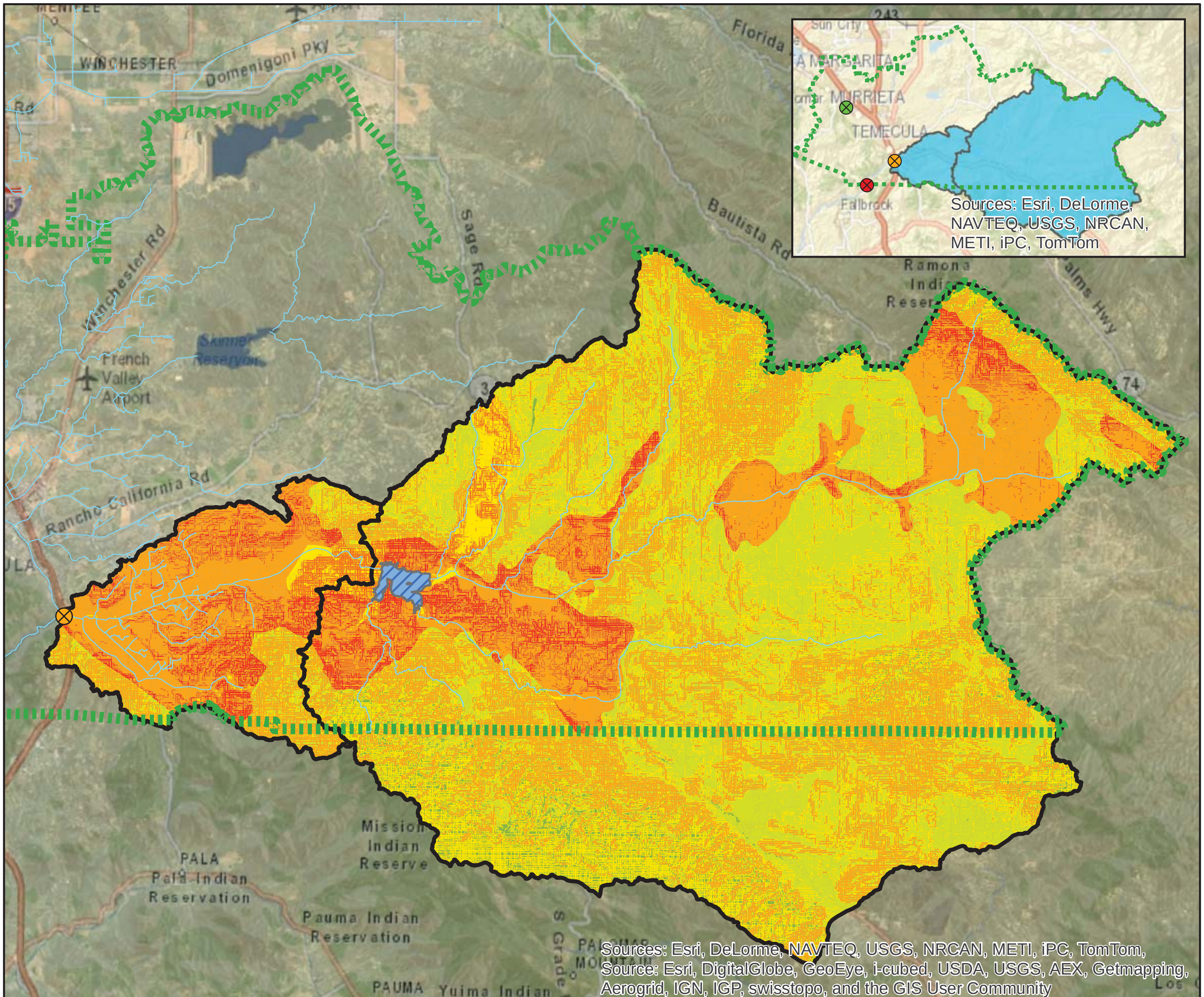
N

0 1.5 3 6 Miles

SMR Copermittees
Hydromodification Susceptibility Mapping - Santa Margarita River

Temecula Creek HRU/GLU Analysis

Figure 7



Legend

GLU Value (Susceptibility to Sedimentation)

- 3 - Lowest Susceptibilty
- 4
- 5
- 6
- 7
- 8
- 9
- 10 - Highest Susceptibilty

Poor Index of Biotic Integrity (IBI) Scores

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location
- Streams
- SMR
- Temecula Creek Watershed
- Vail Lake

N

0 1.5 3 6 Miles

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SMR Copermittees

Hydromodification Susceptibility Mapping - Santa Margarita River

Temecula Creek HRU/GLU Analysis - Natural Conditions

Figure 8

to sedimentation for the "natural" conditions, where all low or medium Land Cover areas were converted to Very High. Very High was picked as the default because most developable/developed land is located within grasslands or shrub areas.

The Geology Types analysis shows most of the potentially erodible land is located adjacent to or downstream of Vail Lake. The upper reaches of the watershed consist of harder rock and has a lower susceptibility of sedimentation.

The Hillslope Gradient analysis shows that the steepest area-averaged slopes are generally on the perimeter of the Temecula Creek watershed, with some flatter area-averaged slopes (0-10%) located at the most eastern and western reaches of the watershed. The western reaches may have been influenced by development.

The Land Cover analysis shows that approximately 22% of the Temecula Creek Watershed is located downstream of Vail Lake that also includes a major portion of the developed land within the SMR. The Watershed is prominently made up of grasslands, shrubs and bare land, especially in the upper reaches.

The GLU analysis shows that the areas of the highest potential sediment production (GLU value 10), are predominately located around Vail Lake. A little over half of that area is directly tributary to Vail Lake and would not continue to the downstream Temecula Creek. The lowest sediment production is located in developed areas or in the upper reaches of the watershed where agricultural land uses are located on gentle slopes to flat lands.

The upper, steeper reaches of Temecula Creek have remained in a natural condition. Generally this is beneficial because the steep slopes and undeveloped land still produce significant sediment to replenish the downstream channel. The presence of Vail Lake has partially reduced the supply of bed sediment load to the downstream channel reaches.

When comparing Figures 7 and 8, it can be seen that existing development is located on areas that historically produced high sediment yields. Additionally, based on slopes and accessibility, most of the future development will occur in existing regions of medium (GLU value 7) to very high (GLU value 10) sediment production. This along, with the influence of Vail Lake, is the cause of the change to sediment supplied to Temecula Creek.

5.2.3.3 Temecula Creek HRU/GLU Analysis Conclusion

Temecula Creek is an example of why a watershed-wide approach is required to determine the causes of Hydromodification and potential management approaches. Instead of restoring the channel to the "natural processes and characteristics of [the] channel," "different management goals are probably appropriate…at varying stages of development and varying degrees of adjustment." Application of onsite Hydromodfication controls for development discharging to Temecula Creek below Vail Lake will not provide any meaningful restorative benefits to Temecula Creek. This is due to the fact that operation of the dam and the lake dominate the hydrology and sedimentation in the downstream reach. Evidence of this is identified above in Table 6 where the range of Hydromodification causing events (2-year and the 10-year) show significant reductions in flow for Temecula Creek in the present condition with the dam as compared to the natural condition.

5.2.4 Murrieta Creek–Line G

As discussed in Section 5.1, a very low IBI score was found along Murrieta Creek, downstream of Warm Springs Channel. Murrieta Creek-Line G is directly tributary to Murrieta Creek and the receiving water station that exhibits a very low IBI score. See Figure 9 for the site location. Murrieta Creek-Line G was analyzed because the tributary sub-watershed has experienced a significant amount of development and this channel segment exhibits vertical degradation, see Figure 9.

Figure 9: Murrieta Creek–Line G Vertical Degradation

5.2.4.1 Murrieta Creek–Line G HRU Analysis

For this location, only the Land Cover analysis was utilized because there was no detailed hydrology for the tributary watershed. The Land Cover analysis shows that a majority of the watershed has been changed from "natural" conditions, with approximately one-third being developed. Since the watershed is not influenced or tributary to a basin/reservoir, it can be assumed that the "stream system [would] show significant flow increases related to the level of development" (Philip Williams & Associates, 1998).

5.2.4.2 Murrieta Creek–Line G GLU Analysis

The GLU analysis consisted of analyzing the three datasets (geology types, land cover and hillslope gradient) based on the categories shown in Section 5.2.2, see Figures 10 thru 12. From the categories the entire Murrieta Creek – Line G watershed was broken up based on susceptibility to sedimentation (potential for sediment production), see Figure 13. Figure 14 shows the assumed susceptibility to sedimentation for the "natural" conditions, where all low or medium Land Cover areas were converted to Very High. Very High was picked as the default because most developable/developed land is located within grasslands or shrub areas.

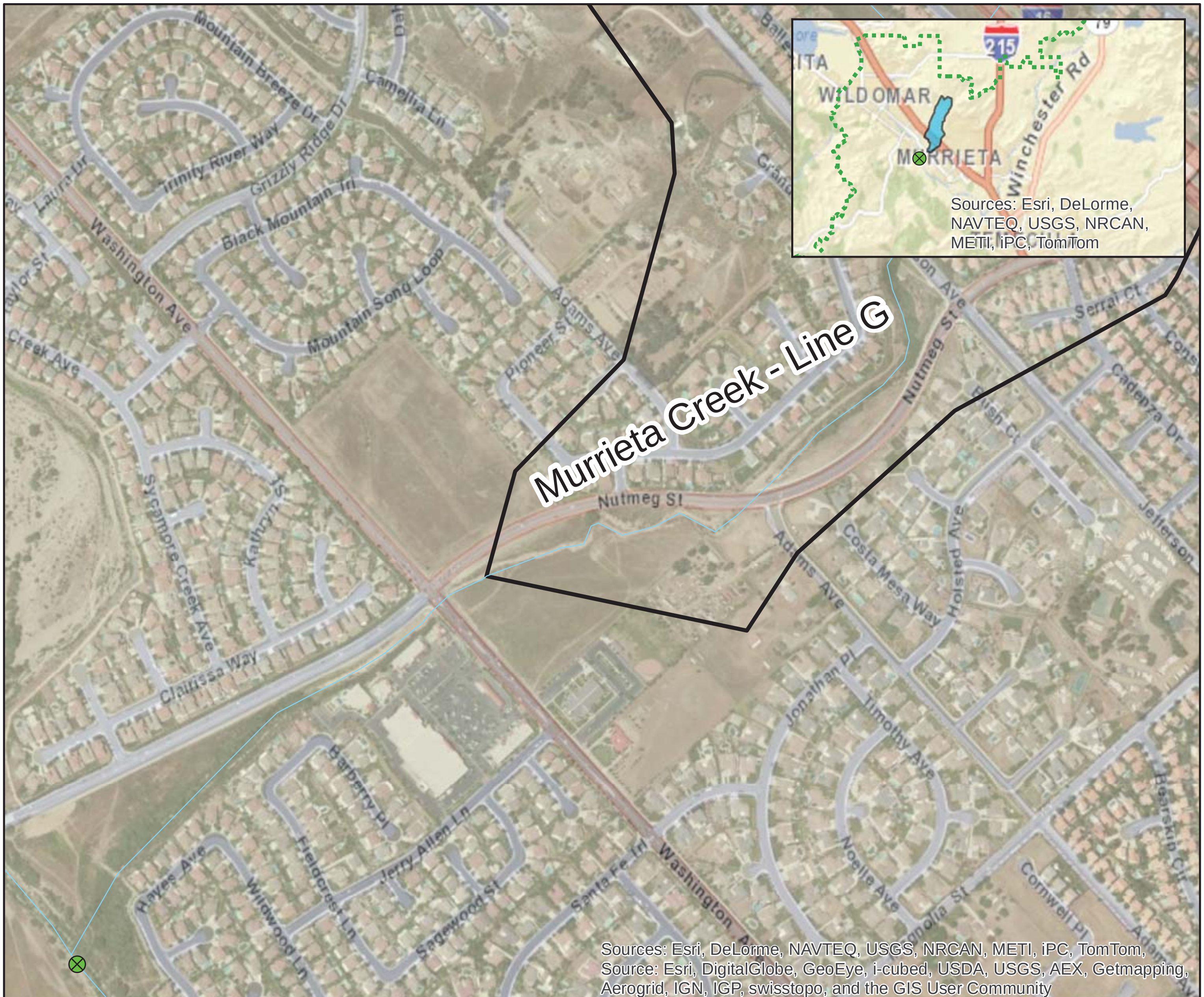
The Geology Types analysis shows that most of the erodible land is located in the lower reaches of the Murrieta Creek – Line G watershed. Only a small portion of the watershed can be considered low susceptibility to sedimentation based geology types and it is located in the upper reaches.

The Hillslope Gradient analysis shows that the steepest slopes are generally located at the upper reaches of the Murrieta Creek – Line G watershed. The watershed is predominately flat, with an area-averaged slope of 0-10%.

The Land Cover analysis shows that the Murrieta Creek – Line G watershed is made up of developed, agriculture and grasslands/shrub land covers. A majority of the watershed has been changed from "natural" conditions, with approximately one-third being developed.

The GLU analysis shows that there are almost no areas with a very high potential for sediment production (GLU value 10). Almost the entire Murrieta Creek – Line G watershed can be considered medium (GLU values 5 thru 8) susceptibility to sedimentation. Additionally, due to the large amount of open or agricultural land, there is still potential for development and a further decrease in sediment production.

When comparing Figures 13 and 14, it can be seen that existing development is located on areas that were historically produced medium to high sediment yields. Based on the analysis and comparison, the watershed tributary to Murrieta Creek–Line G has exhibited a significant decrease in sediment yield.



Legend

Poor Index of Biotic Integrity (IBI) Scores

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location
- Streams
- Murrieta Creek - Line G Drainage Area
- SMR

N

0 250 500 1,000 Feet

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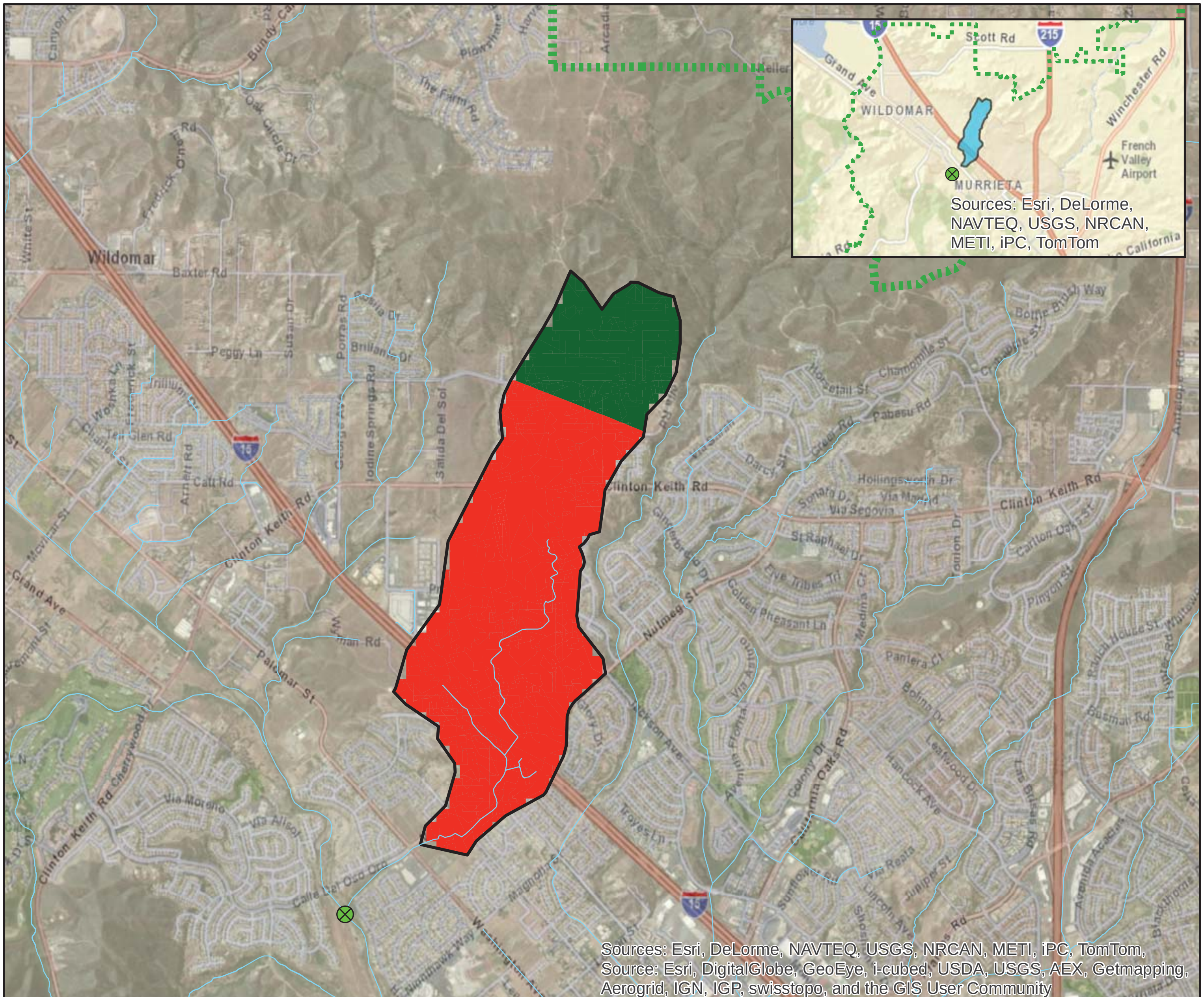
SMR Copermittees
Hydromodification Susceptibility Mapping - Santa Margarita River

Murrieta Line G HRU/GLU Analysis - Site Location

Figure 10



Legend

Geology Susceptibility to Sedimentation

- Low
- Medium
- High

Poor IBI Scores

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location

- Streams
- Murrieta Creek - Line G Drainage Area
- SMR

N

0 0.25 0.5 1 Miles

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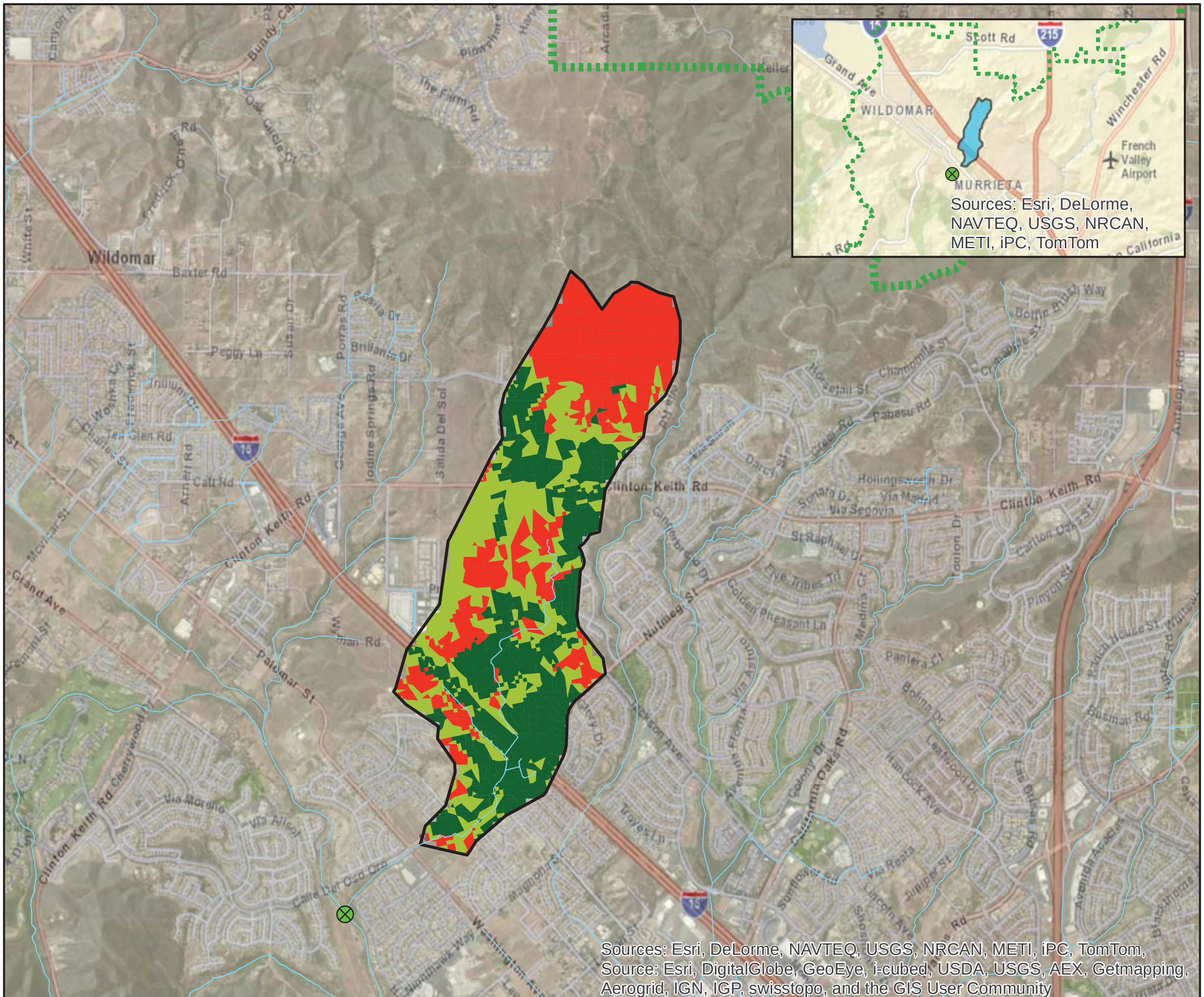
SMR Copermittees
Hydromodification Susceptibility Mapping - Santa Margarita River

Murrieta Line G HRU/GLU Analysis - Geology Types

Figure 11



Legend

Land Cover Susceptibility to Sedimentation

- Low
- Medium
- High
- Very High

Poor IBI Scores

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location

Streams

Murrieta Creek - Line G Drainage Area

SMR

N

0 0.25 0.5 1 Miles

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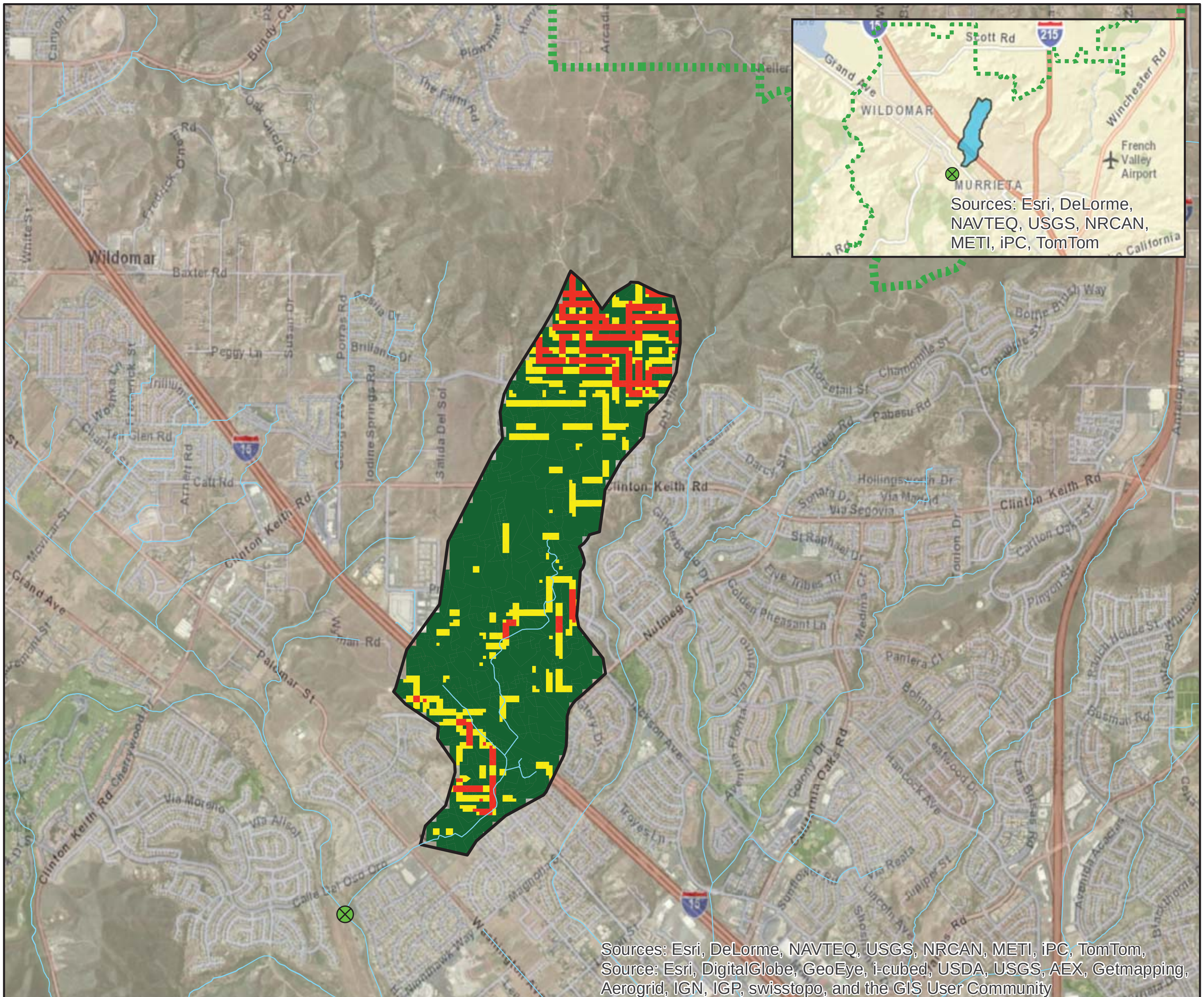
SMR Copermittees

Hydromodification Susceptibility Mapping - Santa Margarita River

Murrieta Line G HRU/GLU Analysis - Land Cover

Figure 12



Legend

Slope Susceptibility to Sedimentation

- Low
- Medium
- High

Poor IBI Scores

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location

- Streams
- Murrieta Creek - Line G Drainage Area
- SMR

N

0 0.25 0.5 1 Miles

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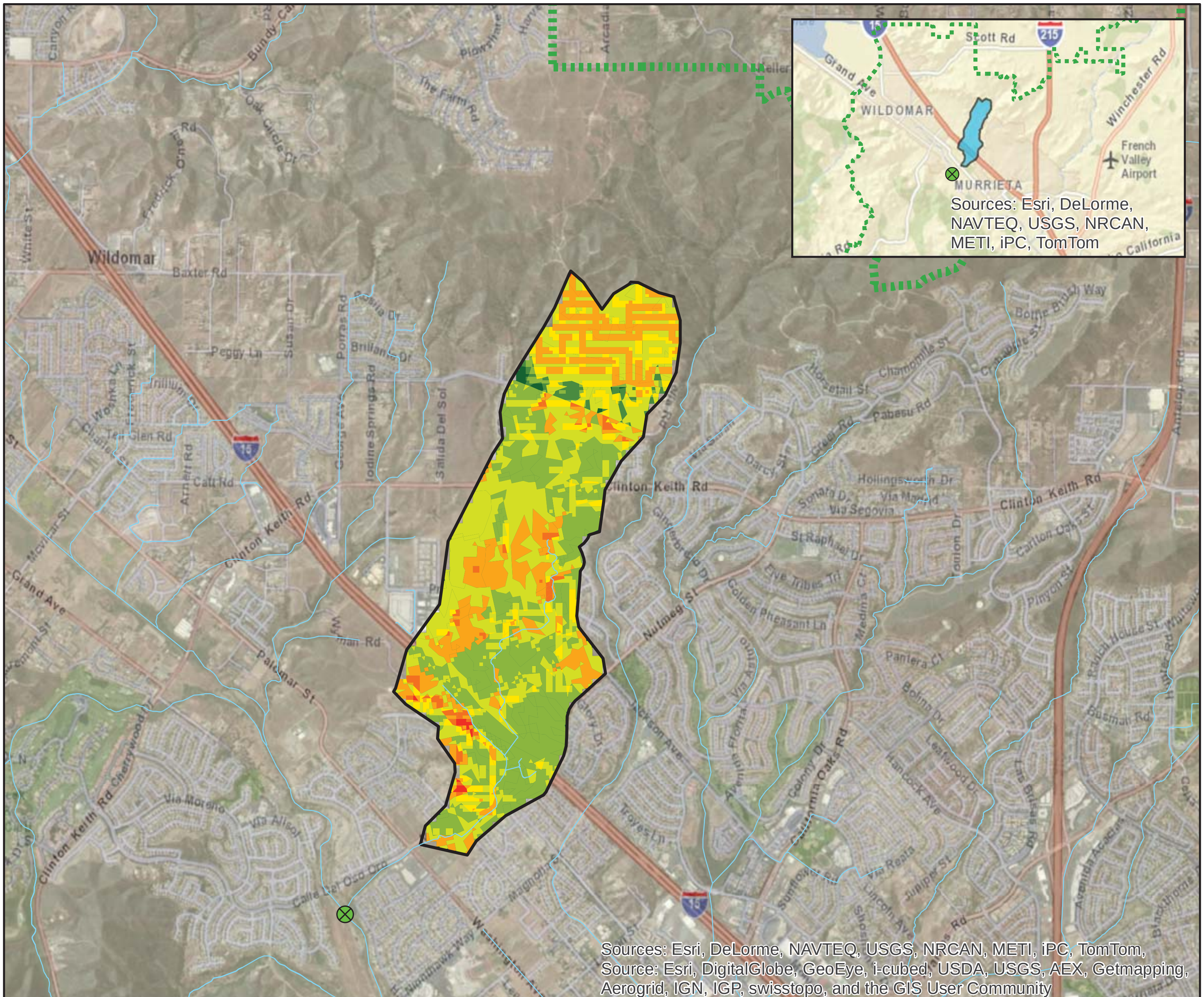
Hydromodification Susceptibility Mapping - Santa Margarita River

Murrieta Line G HRU/GLU Analysis - Hillslope Gradient

Figure 13



Legend

GLU Analysis Value

- 3 - Lowest Susceptibility
- 4
- 5
- 6
- 7
- 8
- 9
- 10 - Highest Susceptibility

Poor IBI Scores

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location
- Streams
- Murrieta Creek - Line G Drainage Area
- SMR

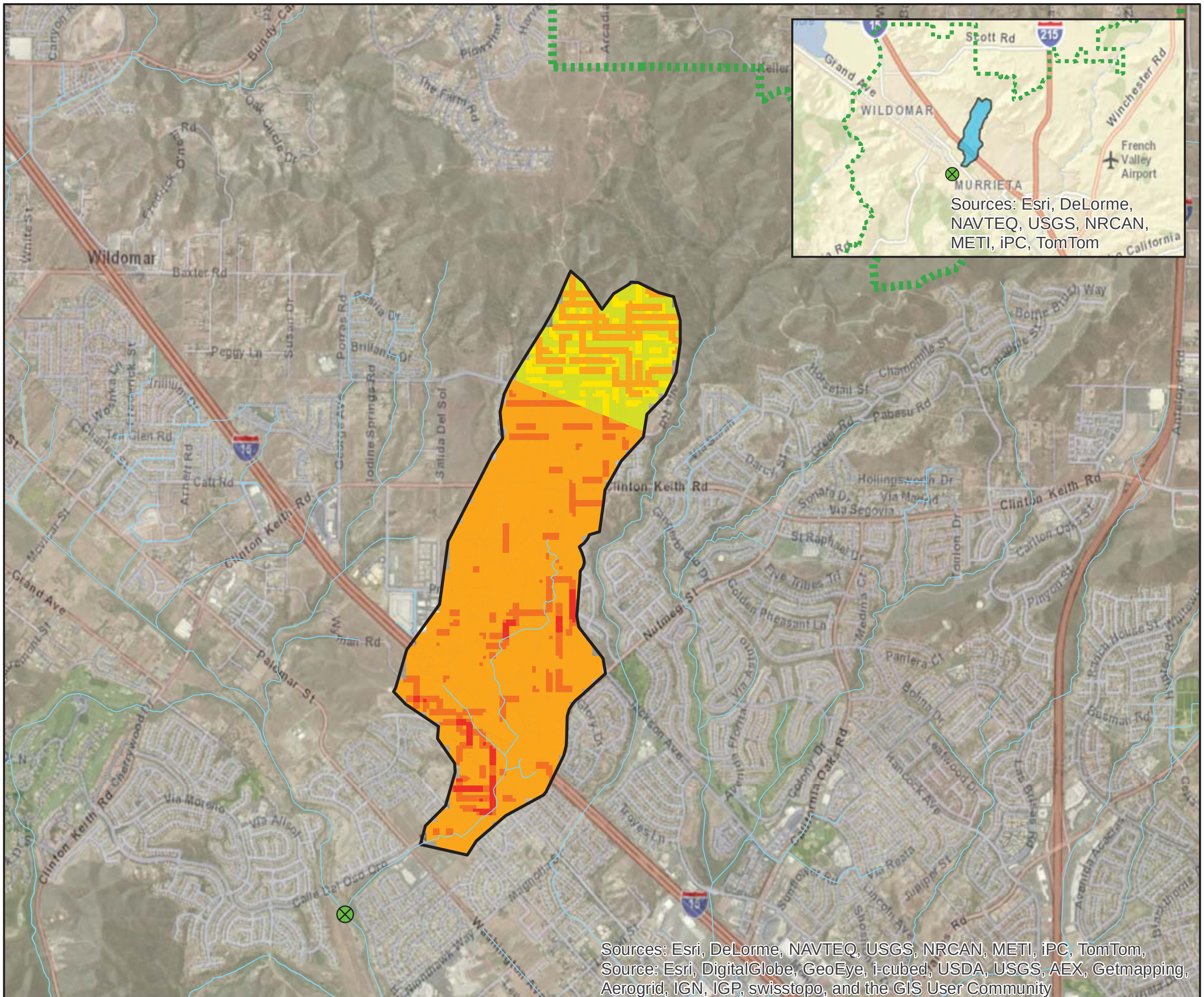
N

0 0.25 0.5 1 Miles

SMR Copermittees
Hydromodification Susceptibility Mapping - Santa Margarita River

Murrieta Line G HRU/GLU Analysis

Figure 14



Legend

GLU Value (Susceptibility to Sedimentation)

- 3 - Lowest Susceptibility
- 4
- 5
- 6
- 7
- 8
- 9
- 10 - Highest Susceptibility

Poor IBI Scores

- Murrieta Creek Very Poor IBI Score Location
- Santa Margarita River Poor IBI Score Location
- Temecula Creek Very Poor IBI Score Location
- Streams
- Murrieta Creek - Line G Drainage Area
- SMR

N

0 0.25 0.5 1 Miles

SMR Copermittees
Hydromodification Susceptibility Mapping - Santa Margarita River

Murrieta Line G HRU/GLU Analysis - Natural Conditions

Figure 15

5.2.4.3 Murrieta Creek–Line G HRU/GLU Analysis Conclusion

Since a large portion of the Murrieta Creek – Line G watershed is already developed and the channel exhibits Hydromodification, the preferred method for Hydromodification Management would be a watershed wide strategy. Technical Report 667 states "management strategies should be tailored to meet the objectives, desired conditions, and constraints of the specific channel reach being addressed. Objectives for specific stream segments may include: protect, restore, or manage as a new channel form". Murrieta Creek – Line G most likely falls under the third management strategy, manage as a new channel form. This could include: onsite rehabilitation, some individual based Hydromodification management, and reconnecting upstream sediment sources, while allowing the stream to reach a new equilibrium.

6 REFERENCES

Federal Emergency Management Agency, August 28, 2008. *Flood Insurance Study: Riverside County, California and Incorporated Areas.*

Philip Williams & Associates, October 26, 1998. *Santa Margarita Watershed Study: Hydrology and Watershed Processes.*

Southern California Coastal Water Research Project (SCCWRP), April 2012. *Technical Report 667: Hydromodification Assesment and Management in California.*

Southern California Coastal Water Research Project (SCCWRP), March 2010. *Technical Report 605: Hydromodification Screening Tools: GIS-Based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge.*

Southern California Coastal Water Research Project (SCCWRP), July 2007. *Surface Water Ambient Monitoring Program (SWAMP) Report on the Santa Margarita Hydrologic Unit.*

MAP 1

MAP 2

APPENDIX A

Sample File Input (Run 42)

APPENDIX B

Sample File Output (Run 42)