May 2014

Santa Margarita Region Hydromodification Management Plan

In compliance with Order No. R9-2010-0016, this HMP has been developed by the Riverside County Copermittees

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS, ABBREVIATIONS AND DEFINITIONS

2010 SMR MS4 Permit	The SMR MS4 Permit requires the Copermittees to develop and implement a stormwater management program to reduce the contamination of stormwater runoff and prohibit illicit discharges
ACCWP	Alameda Countywide Clean Water Program
Adequate Sump	
ALERT	Automated Local Evaluation in Real Time: a local flood warning system for a local agency such as a county or a city
Alternative Compliance Option	
Alternative Performance Standard	
BAHM	Bay Area Hydrology Model
Bed Sediment	Term to define the coarse-grained portion of the sediment load
Bed Sediment Load	The Bed Sediment (material that moves along the bed by sliding or saltating) and part of the suspended sediment load including particle size fractions in the channel Bed Sediments.
BMP	Best Management Practice
CALVEG	A California statewide system for describing vegetation types in mapping their general distributions
CCCWP	Contra Costa Clean Water Program
CEM	Channel Evolution Model
Channel Stability Performance Standard	Requires that geomorphic stability within a channel will not be compromised as a result of receiving runoff from a PDP
Comprehensive Regional BMP	Regional runoff management systems that address water quality, hydrologic, and fluvial geomorphologic requirements for PDPs larger than 100 acres.
Copermittees	County, District, and Cities of Murrieta, Temecula and Wildomar
Critical Shear Stress	Threshold above which motion of bed sediment is initiated.
D_{50}	Median grain size diameter
DAMP	Drainage Area Management Plan
DCV	Design Capture Volume
Ep	stream erosion potential
Erosion	The process by which soil and rock are removed from the Earth's surface by exogenic processes such as wind or water flow, and then transported and deposited in other locations
ESA	Environmentally Sensitive Areas
FSURMP	Fairfield-Suisun Urban Runoff Management Program
GIS	Geographical Information System
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
HMP	Hydromodification Management Plan

HMP Criteria	All PDPs must use continuous simulation to ensure that post-project runoff flow rates and durations for the PDP shall not exceed pre-development, naturally occurring, runoff flow rates and durations by more than 10% over more than 10% the length of the flow duration curve, from 10% of the 2-year runoff event up to the 10-year runoff event.
HMP Management Bank	
HMP Performance Standard	The Hydrologic Performance and Sediment Supply Performance Standards
HR	Hydraulic Radius
HRU/GLU Analysis	Hydrologic Response Units/Geomorphic Landscape Units
HSPF	Hydrologic Simulation Program FORTRAN, distributed by USEPA
Hydrologic Control BMPs	A technique, measure or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff
Hydrologic Performance Standard	Consists of matching or reducing the flow duration curve of post-development conditions to that of pre-existing, naturally occurring conditions, for the range of geomorphically significant flows (10% of the 2-year runoff event up to the 10-year runoff event).
Hydromodification	The change in the natural watershed hydrologic processes and runoff characteristics (i.e., interception, infiltration, overland flow, interflow and groundwater flow) caused by urbanization or other land use changes that result in increased stream flows and sediment transport. In addition, alteration of stream and river channels, such as stream channelization, concrete lining, installation of dams and water impoundments, and excessive streambank and shoreline erosion are also considered Hydromodification, due to their disruption of natural watershed hydrologic processes.
IMP	Integrated Management Practices
K	Soil erosion factor
LEED	Leadership in Energy and Environmental Design
LID	Low Impact Development
LSPC	Loading Simulation Program in C++
Management Bank	A Bank consisting of regional HMP management projects where PDPs can buy HMP management credits if it is determined that implementing onsite Hydrologic Control BMPs is infeasible.
MHHW	Mean Higher High Water
MS4	Municipal Separate Storm Sewer System
MSHCP	Western Riverside County Multi-Species Habitat Conservation Plan
MUSLE	Modified Universal Soil Loss Equation. A mathematical model that describes soil erosion processes
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
PDP	Priority Development Project
Project Specific WQMP	Project Specific Water Quality Management Plan
Q or Qw	Flow
Qcrit - Qc	Critical flow
Qcp	Geomorphically critical flow – 10% of the 2-year flow
District	Riverside County Flood Control and Water Conservation District
Receiving Water	Water of the United States

RGO	Retail Gasoline Outlets: A category 2 PDP less than one acre that uses BMPs to reduce or eliminate pollution
RWQCB	Regional Water Quality Control Board
Saltation	
SCCWRP	Southern California Coastal Water Research Project
SCS	Soil Conservation Service
SCVURPPP	Santa Clara Valley Urban Runoff Pollution Prevention Program
SDRWQCB	San Diego California Regional Water Quality Control Board
SDHM	San Diego Hydromodification Model
Sediment Supply BMP	Site design principles to preserve onsite first-order or higher order streams that have been identified as significant contributors of bed sediment load.
Sediment Supply Performance Standard	Consists of maintaining the pre-project bed sediment supply to the downstream channel reach.
SMCWPPP	San Mateo Countywide Water Pollution Prevention Program
SMR	Santa Margarita Region
SMRHM	Santa Margarita Region Hydrology Model
SOHM	South Orange Hydrology Model
SSMP	Standard Stormwater Mitigation Plan, also known as WQMP (Water Quality Management Plan)
STOPPP	San Mateo County Stormwater Pollution Prevention Program
SUSMP	Standard Urban Stormwater Mitigation Plan
SWM SWMM	Stanford Watershed Model Stormwater Management Model; distributed by USEPA
SWMP	Stormwater Management Plan
SWRCB	State Water Resources Control Board
SWWM	Stormwater Management Model
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
User	The person using this guidance document to prepare analyze a projects and preparea WQMP
USGS	United States Geological Survey
Wash Load	The portion of the total sediment load carried continuously in suspension by the flow, and generally consists of the finest particles.
WQMP	Water Quality Management Plan
WWHM	Western Washington Continuous Simulation Hydrology Model

Note to the User:

The Santa Margarita Region Hydromodification Management Plan (SMR HMP) uses the term "User" to refer to any public or private entities seeking the discretionary approval of new development or significant redevelop projects (Priority Development Projects [PDP]) by the Copermittee with jurisdiction over the project site. The SMR HMP employs the term "User" to identify the person responsible for submitting the Water Quality Management Plan (WQMP) that meets the performance standards set forth in the SMR HMP.

Simplified HMP Roadmap for User

The Copermittees continue to reduce Hydromodification and flood risk through master planning and evaluating specific development projects to manage stormwater runoff. Additionally, the Santa Margarita Region Hydromodification Management Plan (SMR HMP) was developed by the Copermittees in response to Provision F.1.h of the 2010 SMR Municipal Separate Storm Sewer System (MS4) Permit (Order R9-2010-0016) to manage increases in runoff discharge rates and durations from Priority Development Projects (PDPs). The 2010 SMR MS4 Permit contains requirements specifying the methodology to be employed in the development of the HMP, including the development of hydrologic and sediment supply performance standards that will support maintenance of geomorphic stability in channels receiving runoff from PDPs.

The simplified HMP roadmap guides the User through the steps and the sections of the SMR HMP to be followed to:

1. Identify if the development project is subject to the requirements of the HMP; and
2. When required, guide the User in meeting the HMP requirements.

A User, who must meet Low Impact Development (LID) and Hydromodification requirements simultaneously, may refer to the SMR WQMP.

How to identify if my project is subject to the requirements of this HMP?

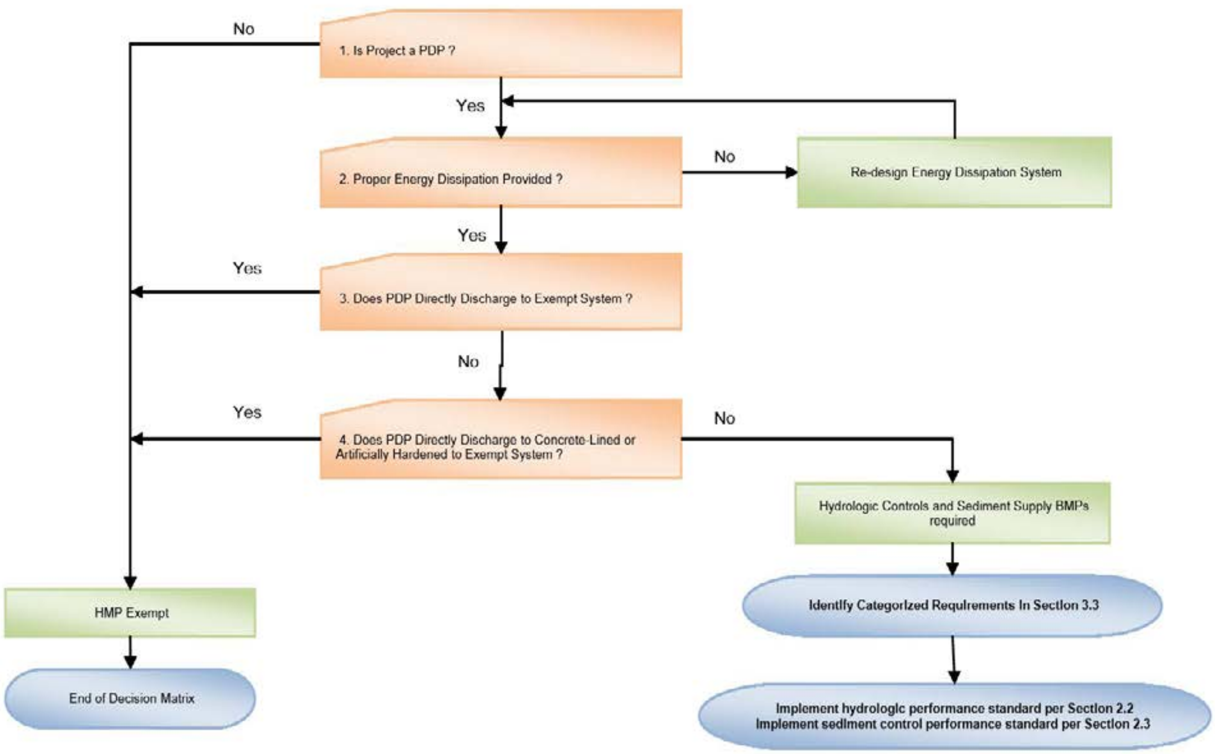
The User may refer to the HMP Decision Matrix presented in **Figure 1** to identify if the PDP is exempt from the requirements of the SMR HMP.

Conditions for exemption of development projects from HMP requirements must be documented by the User and may only be considered by the Copermittee with jurisdiction over the project site if:

- The project is not classified as PDP per Permit Provision F.1.d.;
- The proposed project discharges runoff directly to an exempt channel such as an exempt river reach, or an exempt reservoir. Or, if the proposed project discharges to an concrete-lined or artificially hardened channel, that extends to an exempt river reach or reservoir (See **Section 3.2.i**);
- The project discharges to a large river per the definition provided in Section 3.2.ii;

If the project is not exempt, the User should identify the categorized requirements that apply. For specific categorized requirements, the User may refer to **Section 3.3**. These requirements direct the User to implement, when required, Hydrologic Control BMPs and Sediment Supply BMPs following the approach listed in **Section 2.0**.

Figure 1. HMP Decision Matrix



What are the HMP Performance Standards that PDPs must meet?

Users must demonstrate compliance with the overall HMP Performance Standard, thus demonstrate compliance with the ***Hydrologic Performance Standard*** and the ***Sediment Supply Performance Standard***, respectively.

The Hydrologic Performance Standard consists of matching or reducing the flow duration curve of post-development conditions to that of pre-existing, naturally occurring conditions, for the range of geomorphically significant flows (10% of the 2-year runoff event up to the 10-year runoff event). The Sediment Supply Performance Standard consists of maintaining the pre-project Bed Sediment supply to the channel receiving runoff from the project site.

PDPs are categorized based on their size and type. Specific requirements are associated with each of the two categories. The User should refer to **Section 3.3** to identify the specific categorized requirements.

How to meet the Hydrologic Performance Standard?

This HMP includes a tool to provide continuous simulation of peak flow rates, from 10% of the 2-year runoff event up to the 10-year runoff event for PDPs. The tool is the Santa Margarita Region Hydrology Model (SMRHM), which is a Hydrologic Simulation Program FORTRAN

(HSPF) model based on the South Orange County Hydrology Model. This model allows Users to demonstrate compliance with the HMP Performance Standards through interactive graphic user interface. Details about how to use the model are provided in the 2013 SMRHM Guidance Document (see APPENDIX F).

In some situations, onsite Hydrologic Control BMPs may not be feasible due to identified constraints. In this case the User must investigate the feasibility of alternative options and must implement offsite Hydrologic Control BMPs or in-channel restoration or rehabilitation projects. The User should refer to **Section 2.2** for additional information.

How to meet the Sediment Supply Performance Standard?

The User may follow a three-step process, as identified in **Section 2.3,** to attain maintenance of the pre-project sediment supply to the channel receiving runoff from the project:

1. Determine whether the project site is a significant source of Bed Sediment load to the receiving channel.
2. Avoid significant Bed Sediment supply areas in the site design.
3. Replace significant Bed Sediment supply areas that are eliminated through development of the PDP.

If the three-step process is deemed infeasible, an alternative compliance option allows the User to model the site conditions and the receiving channel and provide additional management in site runoff to compensate for the reduction (or addition) of Bed Sediment Load. Specifics are detailed in **Section 2.3.ii**.

How to initiate compliance with the requirements of this HMP?

The User must integrate Hydrologic Control and Sediment Supply BMPs into the PDP design, and define the design specifics in the preliminary WQMP that should be submitted to the Copermittee with jurisdiction over the project site. The Copermittee with jurisdiction over the project site may approve the proposed design upon identification of compliance with the requirements of this HMP.

The User may refer to the SMR WQMP for complete guidelines on how to develop a WQMP for the PDP.

1.0 Introduction

1.1 SMR HMP Context

The SDRWQCB jurisdiction covers the portion of Riverside County that is located within the Santa Margarita Watershed referred to as the SMR. The Copermittees regulated under the 2010 SMR MS4 Permit are the Cities of Murrieta, Temecula, and Wildomar, as well as the County of Riverside and the Riverside County Flood Control and Water Conservation District (District).

The 2010 SMR MS4 Permit defines Hydromodification as:

> *The change in the natural watershed hydrologic processes and runoff characteristics (i.e., interception, infiltration, overland flow, interflow and groundwater flow) caused by urbanization or other land use changes that result in increased stream flows and sediment transport. In addition, alteration of stream and river channels, such as stream channelization, concrete lining, installation of dams and water impoundments, and excessive streambank and shoreline erosion are also considered Hydromodification, due to their disruption of natural watershed hydrologic processes.*

In addition to urban development activities, anthropogenic activities that may result in Hydromodification may include agriculture, forestry, mining, water withdrawal, climate change, and flow regulation by upstream reservoirs. Hydromodification can result in impacts on receiving channels, such as erosion, sedimentation, and potentially degradation of in-channel habitat. The degree to which a channel will erode or aggrade is a function of the increase or decrease in work (shear stress), the resistance of the channel bed and bank sediments – including vegetation (critical shear stress), the change in sediment delivery, and the geomorphic condition (soil lithology) of the channel.

Not all flows cause significant movement of Bed Sediment—only those which exceed the Critical Shear Stress of the sediments found in the channel bank and bed. Critical Shear Stress is the threshold above which motion of Bed Sediment is initiated. Urban development may increase the discharge rate, amount and timing of runoff, and associated shear stress exerted on the receiving channel by channel flows, may reduce sediment delivered to the channel, and can trigger erosion in the form of incision (channel downcutting), aggradation (deposition of sediment), widening (bank erosion), or both. Flow velocities that generate shear below Critical Shear Stress levels will not result in the channel's degradation and may result in aggradation.

The Copermittees continue to reduce factors that may lead to Hydromodification and reduce flood risk through master planning and evaluating specific development projects to manage stormwater runoff. Additionally, program Provision F.1.h of the Santa Margarita Region (SMR) Municipal Separate Storm Sewer System (MS4) Permit (Order R9-2010-0016) (2010 SMR MS4 Permit) issued by the San Diego California Regional Water Quality Control Board (SDRWQCB) requires that "Each Copermitee shall collaborate with the other Copermittees to develop and implement a Hydromodification Management Plan (HMP) to manage increases in runoff discharge rates and durations from all Priority Development Projects (PDPs)." Where receiving channels are already unstable due to natural or anthropogenic processes, Hydromodification management may be thought of as a method to avoid accelerating or exacerbating existing Hydromodification. Where receiving channels are in a state of dynamic equilibrium, Hydromodification management may prevent the onset of accelerated erosion, sedimentation, lateral bank migration, aggradation, or impacts to in-channel vegetation.

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

The SMR HMP addresses the impacts of Hydromodification on the channels receiving stormwater runoff from a PDP. As identified in **Section 1.2**, other anthropogenic stressors to the channels in the SMR are outside of the jurisdictional purview of the Copermittees.

The SMR HMP will serve as the technical documentation for Hydromodification aspects to support the LID BMP Design Handbook and the SMR WQMP. The LID BMP Design Handbook will be updated with Hydrologic Control and Sediment Supply BMPs. For BMP sizing and site planning purposes, Users and plan checkers may refer directly to the LID BMP Design Handbook and the SMR WQMP. The methodology for meeting LID and Hydromodification requirements, or LID requirements alone, will be identified in these documents.

1.2 SMR History and Historic Hydromodification Impacts

The Southern California Coastal Water Research Project (SCCWRP) characterizes the Santa Margarita River as one of the largest rivers in southern California whose course has remained unobstructed by dams and other artificial infrastructure from its confluence of Temecula Creek and Murrieta Creek to the Pacific Ocean (SCCWRP, 2007). The Santa Margarita River begins at the confluence of Temecula Creek and Murrieta Creek, in Southern Riverside County, and flows southwest successively through Temecula Canyon, a large floodplain in Camp Pendleton Marine Corps Base, and ultimately discharges into the Pacific Ocean. The Santa Margarita River Watershed drains a tributary area of 746-square miles and is physiologically split into a mountainous highland and broad, flat topped sea terrace. The boundary between the upper drainage basin and the coastal drainage basin transitions at the border between Riverside County and San Diego County. The construction of Vail Dam and Skinner Reservoir and historical urbanization within the SMR have progressively and significantly altered the hydrology and sediment transport regimes in the downstream channels. The intent of this section is not to quantify these impacts, but rather to describe the existence of these historic modifications.

1.2.i Water Reservoirs

Runoff from approximately 65% of the SMR has been controlled by the construction of Vail Dam and Skinner Reservoir. In 1974, the 44,200 acre-feet Lake Skinner was formed by construction of a dam on Tucalota Creek. Skinner Lake creates a sump for surface flows and Bed Sediment that has been transported from the upper reaches of Tucalota Creek. Vail Lake is a 49,370 acre-feet reservoir located at the confluence of Temecula Creek, Wilson Creek, and Kolb Creek. The reservoir was built in 1949 by Vail Ranch to develop an irrigation system for expanding their agricultural activities. Since 1978, the reservoir has been operated by the Rancho California Water District to help replenish local groundwater.

Vail Lake and Skinner Lake are operated based on water supply and groundwater recharge considerations, and not for flood control purposes. Virtually all runoff received in these reservoirs is conserved for municipal, industrial, and agricultural use. Nonetheless, the storage capacity of each reservoir induces a management of peak flow rates and durations during storm events. The potential increases in flood flows resulting from urban development in the SMR are offset by the storage effect of the reservoirs (PWA, 2004).

1.2.ii Existing Surface Water and Groundwater Conditions

In 2013 the District conducted field reconnaissance to identify perennial channel segments within the SMR. These investigations identified that 97.3% of the stream segments in the SMR are ephemeral. Sources of dry-weather runoff, if any, were identified as predominantly from urban and agricultural irrigation runoff. The channel segments exhibiting dry weather flow were observed to be short and discontinuous, with the minor flows evaporating and/or infiltrating. There was no continuity of flow from the MS4 to the confluence of Murrieta and Temecula Creeks. Dry weather flows in the Santa Margarita River consist of deliveries of imported water by the Rancho California Water District to Camp Pendleton augmented with minor amounts of rising groundwater that occur in the vicinity of the confluence of Murrieta and Temecula Creeks.

Surface runoff from the SMR does not augment the dry weather flows in the Santa Margarita River. Dry-weather runoff in the SMR evaporates and infiltrates prior to the confluence of Murrieta and Temecula Creeks. The creeks in the urbanized areas of the watershed, located primarily in the valley, are ephemeral and flows are observed only during and immediately after significant storm events. During major storms, after initial wetting, periods of intense rainfall result in rapid increases in channel flow in steep foothill and mountain areas. Runoff in channels in the watershed is derived primarily from rainfall, and as a result, channel flow exhibits monthly and seasonal variations similar to those shown by the precipitation records. There is a rapid decrease in channel flow at the conclusion of the winter precipitation season. Following severe storms, discharge in the larger channels often increases in a few hours from no flow, to a rate of thousands of cubic feet per second. Channel flows vary greatly from month to month and from season to season.

1.2.iii Historical Urbanization in the SMR

The Riverside County Drainage Area Management Plan (2007 DAMP) assumes that 92% of the SMR remained undeveloped as of 2010. Much of the remaining SMR lands will ultimately be incorporated into the Western Riverside County Multi-Species Habitat Conservation Plan (MSHCP), which requires the ongoing conservation of 500,000 acres within the County. For the average annual event, it is estimated that approximately 89% of the volume of runoff in the SMR is due to non-urban land uses not regulated under the federal stormwater program (2007 DAMP).

1.3 SMR HMP Organization

The HMP is organized in two major sections, supported with technical appendices. The first major section identifies the HMP Performance Standards and identifies the applicable tools and measures to meet these standards. The second major section establishes specific categorized requirements for a User, based on a classification of the PDP and the susceptibility to Hydromodification of the channels receiving stormwater runoff from the PDP. The technical appendices reference the HMP development process and reporting requirements per 2010 SMR MS4 Permit Provision F.1.h.(5), provide a literature review of the state of the Hydromodification science per 2010 SMR MS4 Permit Provisions F.1.h.(1)(g) and F.1.h(1)(k), and incorporate the findings of HMP studies performed to classify channel segments per susceptibility category. The HMP also is required to identify areas with historic Hydromodification of Receiving Waters and that are tributary to documented low or very low Index of Biotic Integrity scores for potential opportunities for channel restoration or rehabilitation per Permit provisions F.1.h(1)(a) and F.1.h(1)(h), respectively.

It should be noted that this HMP has in large part been based on the San Diego HMP, which was developed by the San Diego Copermittees and the South Orange County HMP developed by the Copermittees of South Orange County. The San Diego HMP was approved by the SDRWQCB and served as the starting point for development of the SMR HMP.

2.0 SMR HMP Criteria and Performance Standards

The objective of this section is to identify the specific HMP criteria and Performance Standards for Hydromodification to be implemented. PDPs are required to implement Hydrologic Control BMPs so that post-project runoff flow rates and durations are similar to those found in pre-development conditions, i.e. naturally occurring conditions, flow rates and durations where they would result in an increased or decreased potential for erosion or significant impacts to Beneficial Uses (Permit Section F.1.h.). The purpose of this chapter is to identify the HMP criteria, detail the HMP applicability requirements, and provide a framework for alternative compliance.

2.1 HMP Criteria and Performance Standards

The HMP Criteria is designed to manage changes in runoff discharge rates and durations from PDPs:

> All PDPs must use continuous simulation to ensure that post-project runoff flow rates and durations for the PDP must not exceed pre-development, naturally occurring, runoff flow rates and durations by more than 10% over more than 10% the length of the flow duration curve, from 10% of the 2-year runoff event up to the 10-year runoff event.

Section F.1.h.(1)(d) of the 2010 SMR MS4 Permit identifies that PDPs are required to implement Hydrologic Control and Sediment Supply BMPs to meet the following Performance Standards such that that geomorphic stability within a channel will not be compromised as a result of receiving runoff from a PDP:

1. The Hydrologic Performance Standard, which consists of demonstrating flow duration matching for the range of geomorphically-significant flows. This HMP includes a tool to provide continuous simulation of peak flow rates, from 10% of the 2-year runoff event up to the 10-year runoff event for PDPs. The tool is the SMR Hydrology Model (SMRHM), which is a Hydrologic Simulation Program FORTRAN (HSPF) model based on the South Orange County Hydrology Model. This model allows Users to demonstrate compliance with the Hydrologic Performance Standard defined below through interactive graphic user interface. Details about how to use the model are provided in the 2013 SMRHM Guidance Manual (See APPENDIX G).

2. The Sediment Supply Performance Standard, which consists of the approximate maintenance of pre-project Bed Sediment supply. The general approach that a User must follow to demonstrate compliance with the Sediment Supply Performance Standard is described in **Section 2.3.**

Users managing a PDP must demonstrate compliance with the Hydrologic Performance Standard and the Sediment Supply Performance Standard. Compliance with these standards constitutes compliance with the overall HMP criteria.

As demonstrated in APPENDIX C , the lower flow threshold ($0.1Q_2$) satisfies Section F.1.h.(1)(b) in that it corresponds with the critical channel flow that produces the Critical Shear Stress that initiates channel Bed Sediment movement or that erodes the toe of channel banks of a soft-bottomed channel.

In addition, the Copermittees have selected the lower flow threshold ($0.1Q_2$) based on the results from the Flow Control Threshold Analysis performed for the San Diego HMP. The analysis evaluated the geomorphic stability of a channel under 170 scenarios that are representative of the typical watershed sizes, receiving channel dimensions, channel Bed Sediment, and rainfall conditions in San Diego County. As identified in Appendix C, the SMR is located within the Peninsular Ranges geomorphic zone; hence the results from the San Diego HMP Flow Control Threshold Analysis are applicable to the SMR. A copy of the Flow Control Threshold Analysis is available in APPENDIX J .

Alternatively, the User may put forth other low flow thresholds for individual PDPs, but other low flow thresholds will require site-specific justification, at the User's expense, using modeling or field tests to support the unique threshold value. For those PDPs that chose to perform a site-specific analysis, the selected lower flow threshold must also ensure that it meets the requirements of Section F.1.h.(1)(b) of the 2010 SMR MS4 Permit, i.e. the selected lower flow threshold must correspond to the critical channel flow that produces the critical shear stress that initiates channel Bed Sediment movement or that erodes the toe of channel banks. For a channel segment that is lined but not exempt by this HMP, the low flow threshold must be computed based on a comparable natural channel. The User may consult APPENDIX I to identify a site-specific low-flow threshold, as follows:

- A simplified approach, which consists of a critical flow sensitivity assessment, which provides the User with a general indication that a site-specific low flow threshold may be appropriate, but is not sufficient to quantify the threshold. The approach is consistent with the Flow Control Threshold Analysis, also referenced in APPENDIX J .

- Guidelines for performing a full-scale geomorphic assessment of the stability of the channel receiving runoff from a PDP that may be considered by the Copermittee with jurisdiction over the project site.

The HMP Performance Standard is also applicable to those PDPs that are unable to implement flow duration controls onsite or via a regional or sub-regional BMP that accepts discharges from the project, but is located outside of the project boundaries, but seek compliance through offsite Hydrologic Control BMP projects. The offsite Hydrologic Control BMP project must be capable of matching or reducing the equivalent flow duration curves from the PDP.

This HMP offers an alternate Hydrologic Performance Standard to those PDPs that are unable to implement flow duration matching onsite and offsite, only if the infeasibility is demonstrated and documented to the Copermittee with jurisdiction over the project site. The alternative Hydrologic Performance Standard consists of implementing projects to restore or rehabilitate channels with historic Hydromodification that are tributary to documented low or very low

Index of Biotic Integrity scores. The performance equivalency of a restoration or rehabilitation project must be demonstrated to the Copermittee.

PDPs that either fail to meet both the Hydrologic Performance Standard and the Sediment Supply Performance Standard OR that do not qualify for the Alternate Performance Standard are required to redesign the project.

2.2 Meeting the Hydrologic Performance Standard

The User should consider the full suite of Hydrologic Control BMPs to manage runoff from the post-development condition and meet the Hydrologic Performance Standard identified in this section. The intent of the HMP is not to specify the types of Hydrologic Control BMPs that can be used but rather identify the criteria that must be met, allowing flexibility for PDPs to use the full suite of BMPs to meet the Hydrologic Performance Standard. The User may consider the following in identifying the Hydrologic Control BMPs for incorporation in the design of the PDP:

- LID principles as defined in Section 3.2. of the SMR WQMP;
- Structural LID BMPs that may be modified or enlarged, if necessary, beyond the Design Capture Volume (DCV)
- Structural Hydrologic Control BMPs are distinct from the LID BMPs. The LID BMP Design Handbook provides information not only on Hydrologic Control BMP design, but also on BMP design to meet the combined LID and Hydromodification requirements. The handbook specifies the type of BMPs that can be used to meet the Hydrologic Performance Standard.

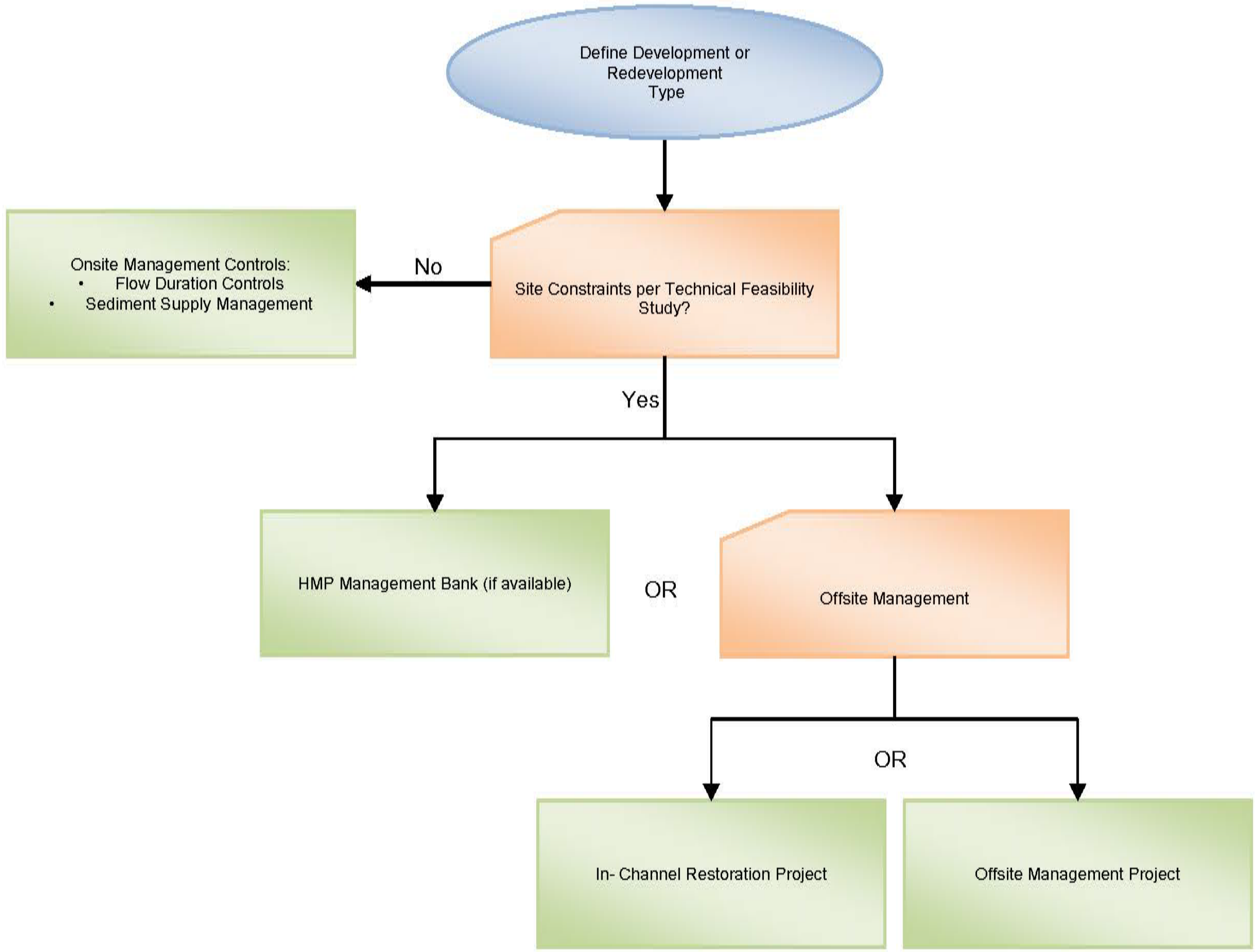
LID principles, structural LID BMPs, and structural Hydrologic Control BMPs can each be modeled in the SMRHM. SMRHM has been developed as the primary tool to assist the User in selecting and sizing Hydrologic Control BMPs. SMRHM can be used by the User not only to meet the Hydrologic Performance Standard, but also to meet the LID requirements. SMRHM incorporates additional BMPs that may be investigated by the User. For example, buffer zones for those PDPs adjacent to channels can be modeled and sized the meet the Hydrologic Performance Standard. The User may refer to the SMRHM User Guidance Manual in APPENDIX G for further details on the BMPs available to meet the Hydrologic Performance Standard.

For some PDPs, implementation of onsite Hydrologic Control BMPs consistent with the HMP may not be feasible due to site constraints. There are two Alternative Compliance Options for PDPs that cannot implement onsite Hydrologic Control BMPs:

- Identify and construct offsite Hydrologic Control BMPs; and
- Pay into an HMP management bank, if an HMP management bank is available to the PDP.

The decision matrix that Users should follow to meet the Hydrologic Performance Standard is summarized in **Figure 2**.

Figure 2. Hydrologic Performance Standard – Decision Matrix



2.2.i Continuous Simulation Modeling

Introduction to the SMR Hydrology Model

Permit Provision F.1.h.(1)(b) identifies that the Hydrologic Performance Standard should be demonstrated based on continuous hydrologic simulation over the entire available rainfall record. As part of the HMP development, an integrated Hydrologic Control BMP sizing tool, SMRHM, has been prepared. The SMRHM has been developed to help Users comply with Hydromodification requirements. This modeling approach is different from the District's calibrated rainfall-runoff procedures and criteria for drainage design, flood control design, and hydrologic management purposes. HMP requirements specified in the 2010 SMR MS4 Permit are separate from the requirements for hydrologic management within the SMR for development effects of runoff per the District's Hydrology Manual. Specific evaluation criteria were developed for the design and analysis of Hydrologic Control BMPs using continuous simulation hydrologic modeling.

Continuous simulation modeling uses an extended time series of recorded precipitation data as input and generates hydrologic output, such as surface runoff, infiltration, and evapotranspiration, for each model time step. Continuous hydrologic models are typically run using either 1-hour or 15-minute time steps. Based on a review of available rainfall records in the SMR, the SMRHM uses 15-minute time series of rainfall data. Continuous models generate model output for each time step. In this case, hydrologic output is generated at each time step (15 minutes) of the continuous model.

Use of the continuous modeling approach allows for the estimation of the frequency and duration by which flows exceed the significant flow range (with a lower flow threshold adopted as 10% of the 2-year flow for this plan, and an upper flow valued adopted as 100% of the 10-year flow for this plan, which is considered the significant flow range). The limitations to increases of the frequency and duration of flows within that geomorphically significant flow range represent the key component to the SMR approach to Hydromodification management.

The SMRHM, along with a SMRHM Guidance Document explaining how to operate the model, is made available to all Users at no cost. The SMRHM is the only software that is approved by the Copermittees. However, the User may opt to develop its own model using publicly-available software, which performs continuous hydrologic simulations over the available period of rainfall record (over 30 years). The use of a different model than the SMRHM is subject to prior approval by the Copermittee with jurisdiction over the project site. The following public domain software models may be used:

- Hydrologic Simulation Program – FORTRAN (HSPF), distributed by the United States Environmental Protection Agency (USEPA)
- Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS), distributed by the USACE Hydrologic Engineering Center
- Stormwater Management Model (SWMM); distributed by USEPA

Peak Flow and Duration Statistics

To assess the effectiveness of Hydrologic Control BMPs to meet the Hydrologic Performance Standard, peak flow frequency statistics are required. Peak flow frequency statistics estimate how often flow rates exceed a given threshold. In this case, the key peak flow frequency values are the lower and upper bounds of the geomorphically significant flow range. Peak flow frequency statistics can be developed using either a partial-duration or peak annual series. Partial-duration series frequency calculations consider multiple storm events in a given year while the peak annual series considers just the peak annual storm event.

Flow duration statistics are also summarized to determine how often a particular flow rate is exceeded. To determine if a Hydrologic Control BMP meets the Hydrologic Performance Standard, peak flow frequency and flow duration curves are generated for the pre-development (naturally occurring) condition and the post-project condition. Both pre-development and post-project simulation runs are extended for the entire length of the rainfall record.

The need for partial-duration statistics is more pronounced for Hydrologic Performance Standards based on more frequent return intervals (such as the 2-year runoff event), since the peak annual series does not perform as well in the estimation of such events due to the bimodal nature of the precipitation in Southern California (few wet years with many events, many dry years with few events). This problem is especially pronounced in the SMRs semi-arid climate. After a review of supporting literature, the use of a partial-duration series is recommended for semi-arid climates similar to the climate in the SMR, where prolonged dry periods can skew peak flow frequency results determined by a peak annual series for more frequent runoff events.

For the statistical analysis of the rainfall record, partial duration series events have been separated into discrete unrelated rainfall events assuming the following criteria.

1. A minimum interval of 24 hours between peaks is applied to capture those peaks generated from back-to-back storms.
2. The Weibull plotting method is used to rank the selected peaks by the partial duration method as this method is the most adequate for statistical analysis of Southern California channels, in which wet-weather and dry-weather years produce two populations of flood events.

Rainfall Data

The SMRHM integrates local rainfall data to design Hydrologic Control BMPs. To provide for clear climatic distinction between the Temecula Valley, the western plateau, the northern valley, and the eastern slopes of the SMR, historical records for a series of three rainfall data stations located within or in close proximity to the SMR were compiled, formatted, modulated, and quality controlled for analysis.

Long-term rainfall records of 15-minute intervals have been prepared and made available by the District for these three rainfall stations. The District operates and maintains several rainfall stations, which feed into the Riverside County Automated Local Evaluation in Real Time (ALERT) telemetry system rain gauges, the California Climatic Data Archive, National Oceanic and Atmospheric Administration (NOAA), the National Climatic Data Center, and the Western Regional Climate Center. For the selected three stations, the length of the overall rainfall station record is a minimum of 37 years.

Gauge selection was further governed by minimum continuous simulation modeling requirements, including the following:

- The selected precipitation gauge data set should exhibit similar meteorological and rainfall trends, especially in terms of intensity and total precipitation depth, to ensure that long-term rainfall records are similar to the anticipated rainfall patterns for the project site. When available, gauges were selected near areas planned for future development and redevelopment.
- Reporting frequency for the gauge data set should be at least hourly, if not at a 15-minute interval. Most of the rainfall stations operated by the District report precipitation in real-time.
- The gauge rainfall data set should extend for the entire length of the record, with a minimum of 37 years.
- Use of the most applicable long-term rainfall gauge data, along with regional scaling of rainfall patterns from a reference station, is required to account for the diverse rainfall patterns across the SMR.

Four meteorological zones were identified and delineated from the rainfall patterns observed from NOAA Atlas 14 precipitation-frequency maps, isohyetal maps from the District's Hydrology Manual (1978), and the professional knowledge of the District's Hydrologic Data Collection Section. Only three precipitation stations were identified as viable for the purpose of continuous simulation because of the available length of precipitation records. Out of the three stations, only one station (Temecula, ID#217) is located within the SMR; the two other stations, Elsinore (ID#067) and San Jacinto (ID#186), are located in close proximity to the SMR. The four meteorological zones are: the Western Plateau covering the Santa Rosa Plateau area, the Temecula Valley, the Wildomar/North Murrieta area, and the Eastern Slopes covering the eastern part of the SMR. For each meteorological zone, a correction factor, which accounts for the variations in depths and intensity observed on the isohyetal maps, is applied independently to the associated precipitation records. The location of the three selected raingage stations and the delineation of the four meteorological zones are shown in **Figure 3**.

Table 1 lists the meteorological zones and the associated rainfall stations. In addition, the period of available record is presented.

Table 1 - SMR Meteorological Zones & Associated Rainfall Stations

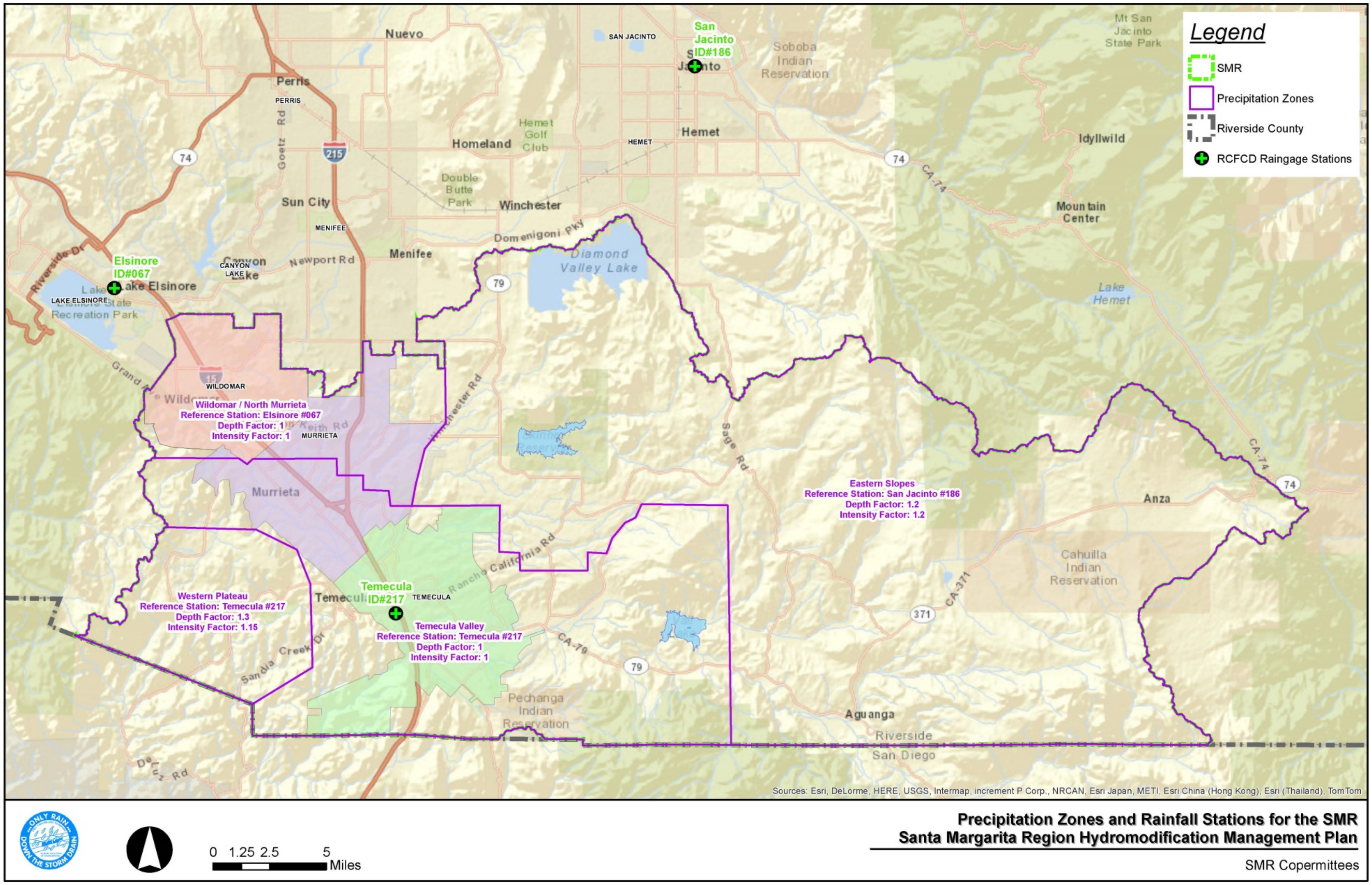
Meteorological Zone	Station	15-minute data span
Western Plateau	Temecula (ID#217)	January 1974 – July 2012
Wildomar/North Murrieta	Elsinore (ID#067)	January 1940 – July 2012
Temecula Valley	Temecula (ID#217)	January 1974 – July 2012
Eastern Slopes	San Jacinto (ID#186)	January 1940 – July 2012

All the presented factors have been considered in the selection of the appropriate rainfall data set before inclusion into the SMRHM. For a given project location, the User should refer to the rainfall station map shown in **Figure** and identify the meteorological zone where the proposed project is located. The meteorological zones are integrated in the SMRHM and the appropriate raingage station will be automatically selected by the model upon pinpointing the location on the model's map.

If desirable, the User is allowed to design a project-specific continuous simulation model and must comply with the factors and precipitation zones presented in this section when selecting the associated raingage station.

A rainfall station map associated with this HMP is presented in **Figure 3** for public use. Where possible, rainfall data sets located in the same meteorological zone as the project should be selected.

Figure 3 - Precipitation Zones and Rainfall Stations for the Santa Margarita Region



Evapotranspiration Parameters

Hydrologic Performance Standards developed as part of this HMP to control runoff peak flows and durations are based on a continuous simulation of rainfall runoff using locally derived parameters for evaporation and evapotranspiration. Known data sources for potential evapotranspiration data in proximity to the SMR are listed below.

Historical potential evapotranspiration at Elsinore station (CA042805) is considered to best represent the evapotranspiration conditions within the SMR.

Other gauging stations that record potential evapotranspiration were not selected because the period of record did not match with that of the precipitation station, or the local meteorological patterns are not representative of those observed in the SMR. The potential evapotranspiration will be coupled with historical records of temperature to determine the actual daily evapotranspiration. **Table 2** summarizes available sources for potential evapotranspiration in the SMR.

Table 2 - Available Evapotranspiration Sources

Station Name ID	Data Type	Data Source	Recording Frequency	Hourly data span
Elsinore (CA042805)	Potential Evapotranspiration	BASIN	Hourly	August 1948 – November 2005

Long-term evaporation / evapotranspiration data sets are being generated to correspond with long-term rainfall records. The final selection of rainfall loss parameters and evaporation data is part of the SMRHM development process.

In summary, the published literature reviewed as part of this study support the methods and approach taken in developing the SMR HMP.

2.2.ii Identification of naturally-occurring conditions

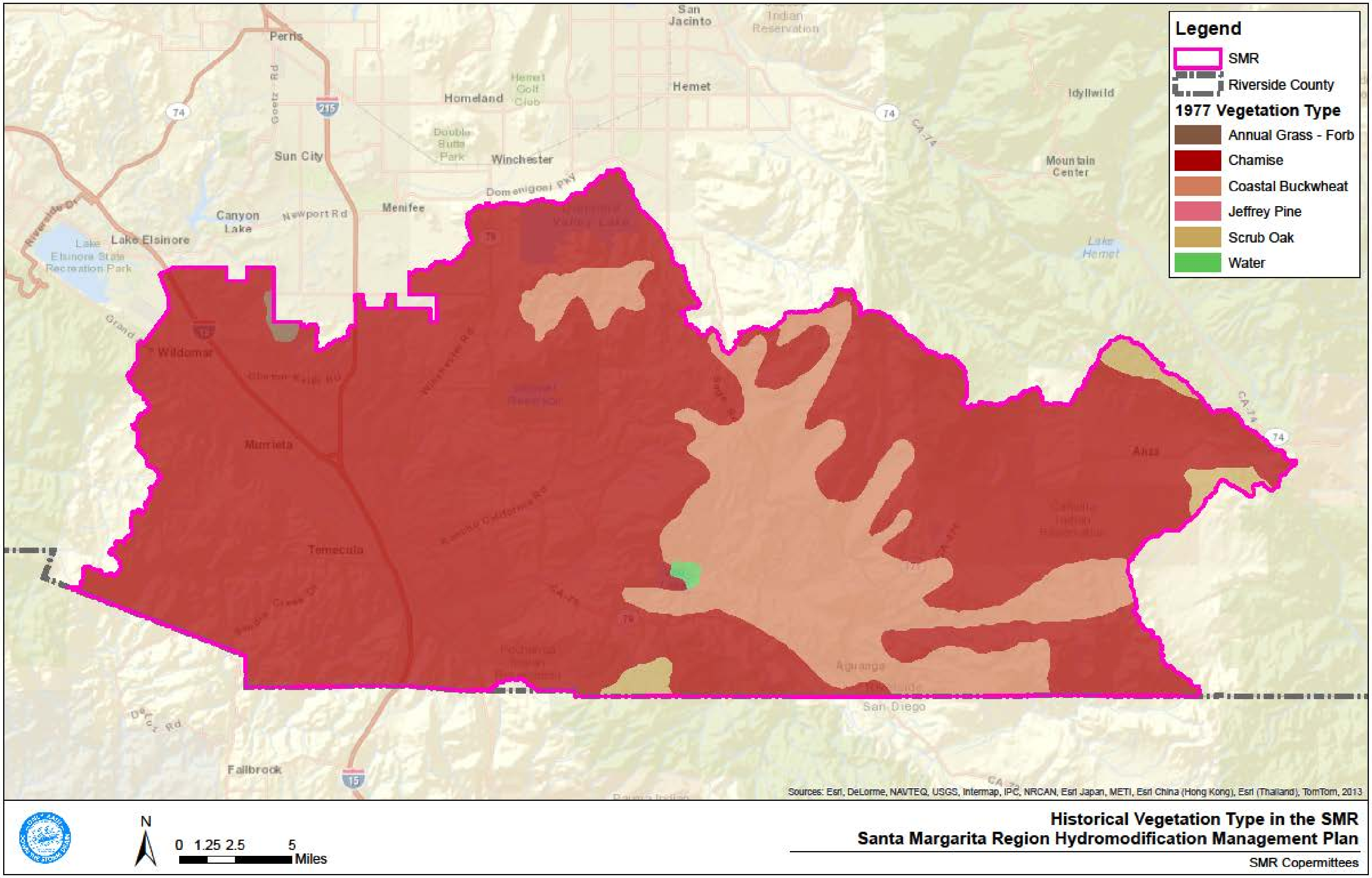
Section F.1.h.(d) of the 2010 SMR MS4 Permit requires that estimated post-project runoff discharge rates and durations shall not exceed pre-development (naturally occurring) discharge rates and durations. Compliance with this Permit requirement should be based on the results of continuous simulation and the use of the SMRHM or an approved equivalent model. As part of developing the supporting hydrology model for a PDP, a User must identify and document, using professional knowledge, pre-development (naturally occurring) conditions in terms of geology, topography, soils, and vegetation.

Several publicly-available information sources may help the User characterize pre-development conditions, including:

- Soil database (#678, #679, and #680) from the Natural Resources Conservation Service (NRCS). Among the parameters of interest, the database identifies the type, the original range of observed topographic slopes, the soil erosion factor K, and, if available, plant community information for the native or pre-development soil. The database is accessible through the Web Soil Survey page (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm).

- Vegetation and ecoregional GIS information listed by the U.S. Forest Services. The USEPA Ecoregion database information locates the SMR in the Southern California Mountains and Valleys Ecoregion and references the climate of humid and temperate Mediterranean type. The USEPA Ecoregion database identifies also the vegetation province of the SMR within the California Coastal Range Open Woodland-Shrub-Coniferous Forest-Meadow province. A historical CALVEG GIS vegetation layer is available for the year 1977 (USFS, 2000). The historical vegetation layer reveals a majority of evergreen chaparral shrub and scrub oak within the watershed. For those areas located within the Urban Land and Agriculture vegetation area, the User may select the shrub vegetation for pre-development, naturally occurring, conditions. **Figure 4.** Historical Vegetation and Ecoregions in the Santa Margarita Region delineates the distribution of historical vegetation types in the SMR. GIS-based layers are available on the USFS website: (http://www.fs.usda.gov/detail/r5/landmanagement/gis/). Consistent with historical aerials, the User should select Shrub as the native vegetation, if the PDP is located in an urban/agricultural area on the 1977 CALVEG GIS layer.
- Other historical USGS topographic maps and aerial photos of Riverside County, specifically of the SMR area, are publicly available from the USGS website.

Figure 4. Historical Vegetation and Ecoregions in the Santa Margarita Region



2.2.iii Hydrologic Control BMPs

As identified in **Section 2.2.i**. PDPs are encouraged to use the full suite of Hydrologic Control BMPs available to meet the Hydrologic Performance Standards. The intent of the HMP is not to specify the types of Hydrologic Control BMPs that can be used but rather identify the criteria that must be met.

Selection and design of Hydrologic Control BMPs is an iterative process that can be facilitated using the SMRHM. The SMRHM has a comprehensive menu of site design LID BMPs and Hydrologic Control BMPs that can be selected for PDPs. The design parameters for these Hydrologic Control BMPs have been incorporated into the model and can be modified to an extent based on site constraints. The User is invited to refer to the SMRHM Guidance Document that is referenced in APPENDIX G for SMRHM specific questions.

Hydrologic Control BMPs must be maintained for optimal operation. PDPs are conditioned to provide verification of inspections and maintenance operations as defined in Section H of the SMR WQMP Template that must be completed in its entirety prior to the issuance of a grading permit. The list of such inspections and maintenance operations must be included in the WQMP for the PDP submitted by the User. Maintenance activities must ensure that the Hydrologic Control BMPs are functioning as designed.

2.2.iv Alternative Compliance Options

The use of Alternative Compliance Options will require coordination with the Copermittee with jurisdiction over the project site and may also require coordination with other Copermittee(s) with jurisdiction over an offsite location where a Hydrologic Control BMP may be proposed. For some PDPs, implementation of onsite Hydrologic Control BMPs consistent with the HMP may not be feasible due to site constraints. These projects require alternatives to onsite Hydrologic Control BMPs. There are two Alternative Compliance Options for PDPs that cannot implement onsite Hydrologic Control BMPs. One option is for the User to identify and construct offsite Hydrologic Control BMPs. The other option is for the PDP to pay into an HMP Management Bank, if an HMP Management Bank option is available.

HMP Alternative Compliance Option 1: Offsite Hydrologic Control Management

A progression through a defined process is required to document eligibility then implementation of alternative HMP compliance. Offsite Hydrologic Control management is based on completing a series of steps to meet compliance that is consistent with Section F.1.h.(3) of the 2010 SMR MS4 Permit. These steps include the following:

1. Technical feasibility study of onsite Hydrologic Control BMPs; and
2. Offsite Hydrologic Control BMP project within the same hydrologic unit as the PDP or in-channel restoration of a channel receiving runoff from the PDP.

Step 1: Conduct a technical feasibility study for onsite Hydrologic Control BMPs

A technical feasibility study is required to identify why onsite Hydrologic Control BMPs cannot be incorporated into the PDP. The technical feasibility study must include the project constraints and provide detailed technical justification as to why the project constraints prevent implementation of onsite Hydrologic Control BMPs. The technical feasibility study will be submitted to the Copermittee with jurisdiction over the project site for review as part of the Preliminary WQMP. The Copermittee must approve the findings of the technical feasibility study before the PDP moves on to Step 2.

The Hydrologic Control BMP technical feasibility study will be incorporated into the SMR WQMP Template and integrated with the LID feasibility analysis; however, it should be noted that the criteria for Hydrologic Control BMP and LID requirements are different. The feasibility analysis for both Hydrologic Control BMPs and LID will be integrated into one feasibility study for the PDP and submitted with the Preliminary WQMP.

The technical feasibility study should:

- Provide a narrative regarding the applicability of LID principles onsite as required by the SMR WQMP;
- Evaluate the feasibility of infiltration to capture partially or in its entirety the DCV based on the presence of either low infiltrating soils or high groundwater level, proximity to a water well or a contaminated plume, or a geotechnical report precluding effective and safe infiltration;
- Evaluate the feasibility of harvest-and-use BMPs based on local water demands;
- Evaluate the feasibility of implementing detention or retention BMPs onsite based on critical geotechnical considerations such as collapsible soil, expansive soil, slopes, liquefaction and other factors identified by a registered Geotechnical Engineer. The feasibility to implement Hydrologic Control BMPs and meet the Hydrologic Performance Standard onsite may be principally dictated by the geotechnical considerations.

Step 2: Implement offsite Hydrologic Control BMP projects within the same channel system as the PDP (2a) or implement in-channel restoration or rehabilitation of the PDP receiving water (2b)

For those PDPs where the Hydrologic Control BMP technical feasibility study for onsite controls has been approved by the Copermittee with jurisdiction over the project site, step 2 is to either (a) implement an offsite Hydrologic Control BMP project within the same channel system as the PDP, or (b) implement an in-channel restoration project for the channel receiving runoff from the PDP. The process for these options under Step 2 is detailed below:

HMP Alternative Compliance Option 1 – Step 2a: Implement Offsite Hydrologic Control Project within the Channel System receiving runoff from the PDP

In choosing this option, the PDP must investigate potential locations for implementation of an offsite Hydrologic Control project within the channel system receiving runoff from the PDP. If the User demonstrates that an offsite Hydrologic Control project is not feasible in the channel system receiving runoff from the PDP, then an offsite Hydrologic Control project in the same hydrologic unit as the PDP may be approved. The offsite Hydrologic Control project must manage the incremental impact from not achieving the pre-development (naturally occurring) runoff flow rates and durations for the project site. Sizing of offsite Hydrologic Control projects may be accomplished using the SMRHM. The User will evaluate and identify potential sites in the channel system receiving runoff from the PDP, and if not feasible, then evaluate projects in the same hydrologic unit for implementation of an offsite Hydrologic Control project that has the capacity to provide the PDPs Hydrologic Performance Standard requirements. If an Adequate Sump is identified in the channel system receiving runoff from the PDP, the User will submit a report detailing:

- That the offsite Hydrologic Control project manages the incremental impact from the pre-development (naturally occurring) runoff flow rates and durations for the project site;
- Conceptual plans for the offsite Hydrologic Control project as part of an amended WQMP for review and approval;
- If the PDP is a redevelopment project, that the post-project runoff flow rates and durations do not exceed pre-project runoff flow rates and durations; and
- If no potential offsite Hydrologic Control project sites are identified in the channel system receiving runoff from the PDP, that there is an offsite Hydrologic Control project in the same hydrologic unit.

If no potential offsite Hydrologic Control project sites are identified in the same hydrologic unit as the PDP, the PDP must implement Option 2(b), a restoration or rehabilitation project in the channel system with historic Hydromodification and receiving runoff from the PDP.

HMP Alternative Compliance Option 1 – Step 2b: Implement In-Channel Restoration or Rehabilitation of the Channel Receiving Runoff from the PDP

In choosing this option, the PDP investigates the potential for implementation of an in-channel restoration or rehabilitation project for the channel receiving runoff from the PDP. It must be determined that the channel receiving runoff from the PDP has experienced historic Hydromodification. The in-channel restoration or rehabilitation project must be located in the channel receiving runoff from the PDP. The PDP must submit a report detailing the historic Hydromodification, as well as conceptual plans for the in-channel restoration or rehabilitation project to the Copermittee with jurisdiction over the project site for review. The Copermittee is responsible for ensuring that the level of restoration or rehabilitation is adequate given the potential Hydromodification impacts of the PDP. Copermittees maintain individual processes consistent with their approval procedures to ensure that the User's obligations under the HMP alternative compliance process are completed prior to approval of the PDP.

Once the project conceptual plans have been approved by the Copermittee with jurisdiction over the project site, the User must submit required permit applications to the appropriate regulatory agencies (e.g., SDRWQCB, California Department of Fish and Wildlife, USACE) for review and approval. If the PDP identifies no opportunities for in-channel restoration or rehabilitation in the channel receiving runoff from the PDP, then the PDP must implement Option 2(a), an offsite Hydrologic Control project within the same hydrologic unit as the PDP.

HMP Alternative Compliance Option 2: HMP Management Bank Alternative Compliance Option

(Note: Option 2 is available only if an HMP management bank has been developed and is available to the PDP.)

The Copermittees have the option to develop an HMP Management Bank or multiple HMP Management Banks. A HMP Management Bank will develop regional HMP management projects where PDPs can buy HMP management credits if it is determined that implementing onsite Hydrologic Control BMPs is infeasible. The development and operation of an HMP Management Bank will include the identification of potential regional Hydrologic Control projects; the planning, design, permitting, construction, and maintenance of regional Hydrologic Control projects; the development of a fee structure for PDPs participating in the HMP Management Bank; and managing the HMP Management Bank fund. Regional Hydrologic Control projects can also serve as projects for an LID waiver program if site conditions allow for implementation of LID-type projects.

If PDPs are unable to meet the Hydrologic Performance Standard by incorporating onsite Hydrologic Control BMPs, and a HMP Management Bank is available, the PDP can apply to participate in the Bank. The application must include a technical feasibility study to identify why onsite Hydrologic Control BMPs cannot be incorporated into the PDP. The technical feasibility study must include the project constraints and detailed technical justification as to why the project constraints prevent implementation of onsite Hydrologic Control BMPs. The technical feasibility study will be submitted to the Copermittee with jurisdiction over the project site for review as part of the Preliminary WQMP. The Copermittee must approve the Hydrologic Control BMP technical feasibility study for the PDP to participate in a HMP Management Bank.

2.3 Meeting the Sediment Supply Performance Standard

Bed Sediment Supply from PDPs plays a role in the stability of alluvial channels. As identified in APPENDIX C , a change in Bed Sediment Load may cause instability in the receiving channel manifested through general scour or aggradation. Lateral bank migration may also result from changes in Bed Sediment Load as the channel slope increases or decreases.

Bed Sediment typically includes coarse sand (1-2 mm) and thicker sediment sizes. The User may refer to the classification table (Table 14 of APPENDIX I) for a full listing of sediment sizes and associated critical shear stresses.

Bed Sediment Supply to a receiving channel during construction may increase as land surface is cleared and the potential for erosion is increased. Once the land surface is urbanized, the potential for Bed Sediment Supply may be reduced as compared to the pre-development condition. The purpose of this portion of the HMP is to maintain the pre-development supply of Bed Sediment to receiving channels following urban development. Total Sediment Load consists of the Bed Sediment Load that includes both material moving along the bed by rolling, sliding or Saltation) and coarse sand (1-2 mm) that is transported in near-suspension by the velocity of flow, and the Wash Load that includes clays, silts and fine sand (under 1 mm). Bed Sediment Load is a primary variable controlling channel morphology. Wash Load is the portion of the total sediment load carried continuously in suspension by the flow. Changes in Wash Load are not likely to significantly affect the channel stability, and reductions in Wash Load are generally assumed to improve habitat function.

The resiliency of channels to forestall changes due to urban development varies with the magnitude of the change and characteristics of the channel (bed and bank sediment, vegetation, channel cross-section and slope). It is difficult to quantitatively predict the response in a channel receiving runoff from urban development to changes in the fundamental variables described by Lane (1955) of discharge, Bed Sediment grain size, channel slope and Bed Sediment Load. Accordingly, the most effective approach to ensuring channel stability may be to avoid changes in the fundamental variables (Lane's interrelationship) during urban development through the implementation of channel management guidelines. In the case of Bed Sediment Load, this will be accomplished by avoiding development in areas that are a Significant Source of Bed Sediment Supply to a channel. The User must identify the areas on the project site that are a Significant Source of Bed Sediment Supply. The determination will be performed following the three-step process, as described in **Section 2.3.i**.

The general approach to ensure maintenance of the pre-project Bed Sediment Supply is a three-step process:

1. Determine whether the portion of the site is a Significant Source of Bed Sediment Load to the channel receiving runoff from the PDP.
2. Avoid areas identified as Significant Sources of Bed Sediment Supply in the PDP design.
3. Site-specific alternative compliance measures.

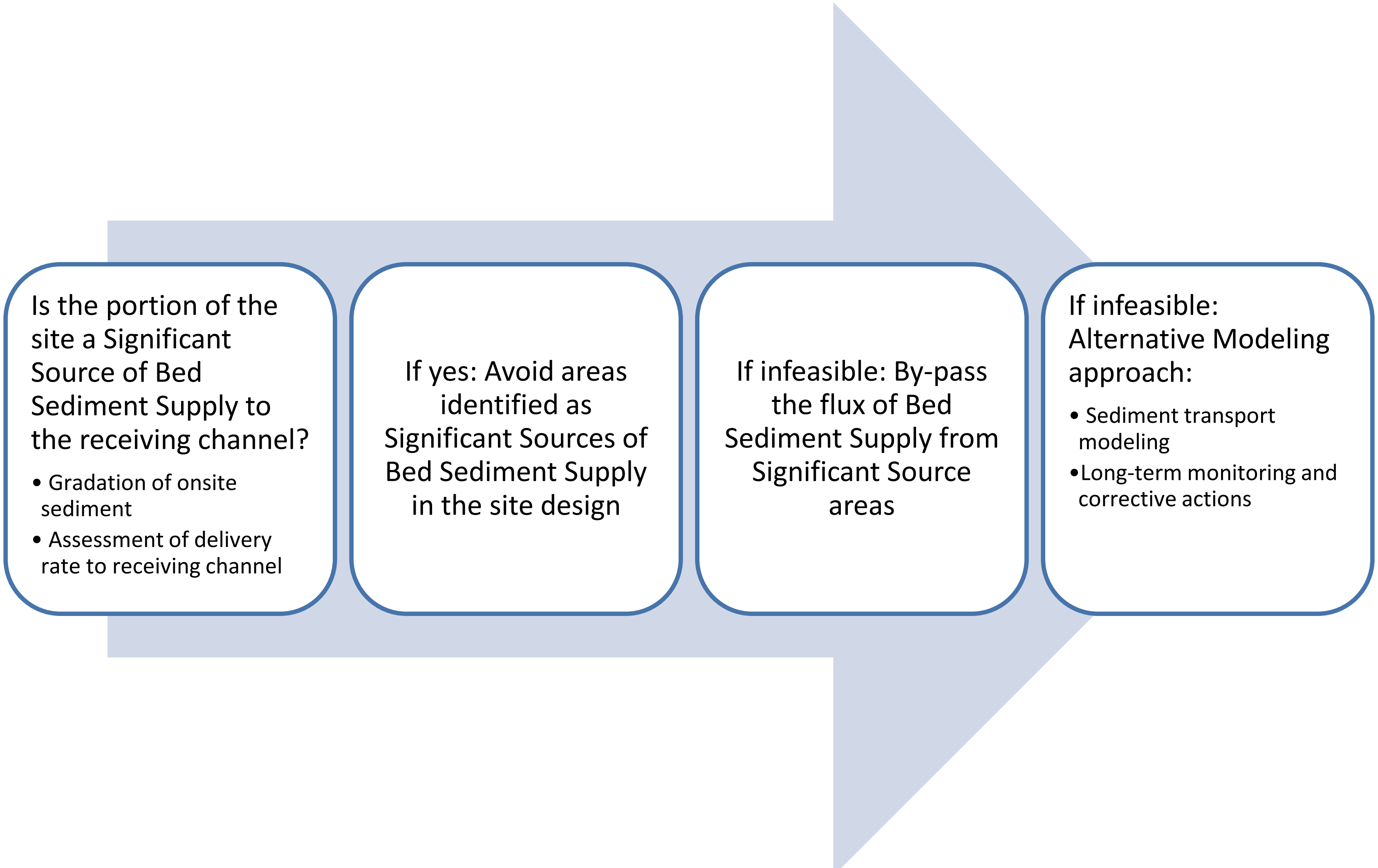
In the event of a projected reduction in Bed Sediment Supply, the User must investigate the feasibility of Sediment Supply BMPs, including bypassing the flux of Bed Sediment Supply from Significant Source areas onsite, otherwise maintaining pre-project Bed Sediment Supply from the site, or providing additional management of site runoff to accommodate the reduced Bed Sediment Supply. Specific guidance on sediment management measures will be provided in the SMR WQMP Template. Specifically, the SMR WQMP Template includes a Section for performing a Bed Sediment Supply assessment, which:

- Identifies the conditions for exemption from the Sediment Supply Performance Standard, if any;
- Summarizes the results of the three-step approach and identifies, for each step, the documentation required for approval of the evaluation by the Copermittee with jurisdiction over the project site. Documentation may include:
    - Results from the geotechnical and sieve analysis, the soil erodibility factor, a description of the topographic relief of the project area, and the lithology of onsite soils;
    - Results from the analyses of the sediment delivery potential to the channel receiving runoff from the project site, including the sediment source, the distance to the receiving channel, the onsite channel density, the PDP watershed area, the slope, length, land use, and rainfall intensity;
    - Quantification of the bank stability investigation, including the degree of incision, a gradation of the Bed Sediment, and identification if the receiving channel is sediment supply-limited.
- Provides a site map that identifies all onsite channels and highlights those that were identified as a Significant Source of Bed Sediment Supply. The site map must demonstrate if feasible, that the site design avoids those project site channels that may be a Significant Source of Bed Sediment Supply. In addition, the User must describe the characteristics of each channel on the project site identified as a Significant Source of Bed Sediment Supply. If the design plan cannot avoid the channels on the project site, the User should provide a rationale for each channel individually.

An Alternative Compliance Option allows the User to model the site conditions and the channel receiving runoff from the project site and provide additional management of site runoff to compensate for the reduction (or addition) of Bed Sediment Load. This option may only be used if the general approach outlined above is deemed infeasible by the Copermittee with jurisdiction over the project site, or if the project site design requires significant alteration of channel(s) on the project site. Step 1 of the three-step approach describes how channels on the project site should be identified and characterized by the User.

The stepwise approach that Users should follow to meet the Sediment Supply Performance Standard is summarized in **Figure 5**.

Figure 5 - Sediment Supply Performance Standard – Stepwise Approach



2.3.i Three-Step Process

The User must determine the location of the alluvial channel receiving runoff from the project site. The first such channel that is unlined (invert, side slopes or both) will serve as the "assessment" or "receiving" channel for the PDP. The following methodology will be used to ensure that the PDP does not adversely impact the delivery of Bed Sediment Supply to the assessment channel.

Step 1: Determine whether the Portion of the Project Site is a Significant Source of Bed Sediment Supply to the Channel Receiving Runoff

A triad approach will be completed to determine whether the project site is a Significant Source of Bed Sediment Supply to the channel receiving runoff and includes the following components:

A. Site soil assessment, including an analysis and comparison of the Bed Sediment in the receiving channel and the onsite channel;

B. Determination of the capability of the channels on the project site to deliver the site Bed Sediment (if present) to the receiving channel; and

C. Present and potential future condition of the receiving channel.

Prior to performing a site-specific triad assessment, the User should refer to the macro-scale findings of the HRU/GLU Analysis performed as part of the SMR Hydromodification Susceptibility Study (APPENDIX D). The HRU/GLU Analysis will provide the designer with critical geomorphic information for the subwatershed where the PDP is located, including the impacts of existing imperviousness on the hydrologic cycle and the potential for sediment production.

A. Site soil assessment, including an analysis and comparison of the Bed Sediment in the channel receiving runoff and the onsite channels

A geotechnical and sieve analysis is the first piece of information to be used in a triad approach to determine if the project site is a Significant Source of Bed Sediment Supply to the assessment channel. An investigation must be completed of the assessment channel to complete a sieve analysis of the Bed Sediment. Two samples will be taken of the assessment channel using the "reach" approach (TS13A, 2007). Samples in each of the two locations should be taken using the surface and subsurface bulk sample technique (TS13A, 2007) for a total of four samples. Pebble counts may be required for some channels.

A similar sampling assessment should be conducted on the project site. First-order and greater channels that may be impacted by the PDP (drainage area changed, stabilized, lined or replaced with underground conduits) will be analyzed in each subwatershed. First-order channels are identified as the unbranched channels that drain from headwater areas and develop in the uppermost topographic depressions, where two or more contour crenulations (notches or indentations) align and point upslope (NEH, 2007). First-order channels may, in fact, be field ditches, gullies, or ephemeral gullies (NEH, 2007). One channel per subwatershed that may be impacted on the project site must be assessed. A subwatershed is defined as tributary to a single discharge point at the project site boundary.

The sieve analysis should report the coarsest 90% (by weight) of the sediment for comparison between the site and the assessment channel. The User should render an opinion if the Bed Sediment found on the site is of similar gradation to the Bed Sediment found in the receiving channel. The opinion will be based on the following information:

- Sieve analysis results
- Soil erodibility (K) factor
- Topographic relief of the project area
- Lithology of the soils on the project site

The User should rate the similarity of onsite Bed Sediment and Bed Sediment collected in the receiving channel as high, medium, or low. The rating should be consistent with Figures 4 through 6 of the Hydromodification Susceptibility Report and Mapping: SMR (See APPENDIX D). This site soil assessment serves as the first piece of information for the triad approach.

B. Determination of the capability of the onsite channels to deliver Bed Sediment Supply (if present) to the channel receiving runoff from the project site.

The second piece of information is to qualitatively assess the sediment delivery potential of the channels on the project site to deliver the Bed Sediment Supply to the channel receiving runoff from the project site, or the Bed Sediment delivery potential or ratio. There are few documented procedures to estimate the Bed Sediment delivery ratio (see: Williams, J. R., 1977: Sediment delivery ratios determined with sediment and runoff models. IAHS Publication (122): 168-179, as an example); it is affected by a number of factors, including the sediment source, proximity to the receiving channel, onsite channel density, project sub-watershed area, slope, length, land use and land cover, and rainfall intensity. The User will qualitatively assess the Bed Sediment delivery potential and rate the potential as high, medium, or low.

C. Present and potential future condition of the channel receiving runoff from the project site.

The final piece of information is the present and potential future condition of the channel receiving runoff from the project site. The User should assess the receiving channel for the following:

- Bank stability - Receiving channels with unstable banks may be more sensitive to changes in Bed Sediment Load.

- Degree of incision - Receiving channels with moderate to high incision may be more sensitive to changes in Bed Sediment Load.
- Bed Sediment gradation - Receiving channels with more coarse Bed Sediment (such as gravel) are better able to buffer change in Bed Sediment Load as compared to beds with finer gradation of Bed Sediment (sand).
- Transport vs. supply limited channels. Receiving channels that are transport limited may be better able to buffer changes in Bed Sediment Load as compared to channels that are supply limited.

The User will qualitatively assess the channel receiving runoff from the project site using the gathered observations and rate the potential for adverse response based on a change in Bed Sediment Load as high, medium, or low.

In addition to the findings of the macro-scale HRU/GLU Analysis, the User should use the triad assessment approach, weighting each of the components based on professional judgment to determine if the project site provides a Significant Source of Bed Sediment Supply to the receiving channel, and the impact the PDP would have on the receiving channel. The final assessment and recommendation must be documented in the HMP portion of the WQMP.

The recommendation may be any of the following:

- Site is a Significant Source of Bed Sediment Supply – all channels on the project site must be preserved or by-passed within the site plan.
- Site is a source of Bed Sediment Supply – some of the channels on the project site must be preserved (with identified channels noted).
- Site is not a Significant Source of Bed Sediment Supply.

The final recommendation will be guided by the triad assessment. Projects with predominantly "high" values for each of the three assessment areas would indicate preservation of channels on the project site. Sites with predominantly "medium" values may warrant preservation of some of the channels on the project site, and sites with generally "low" values would not require site design considerations for Bed Sediment Load.

The User should also assess if the receiving channel has been altered either for alignment, cross section, or longitudinal grade, or has degraded to the extent that an in-channel restoration or rehabilitation project would be required to restore the functions and values of the channel bed. In such cases, the User should discuss options for participating in an in-channel project in lieu of onsite design features to preserve the Bed Sediment Supply.

Step 2: Avoid Areas Identified As Significant Sources of Bed Sediment Supply in the Site Design

If the analysis in Step 1 indicates that some or all of the channels on the project site must be preserved as a source of Bed Sediment Supply to the receiving channel, the site plan should be developed to avoid impacting the identified channels. The User will designate channels on the project site that should be avoided to preserve the discharge of Bed Sediment Supply from the site. The User may consider the factors discussed above when determining whether a specific channel on the project site is a Significant Source of Bed Sediment Supply and should be preserved.

Step 3: Site-Specific Alternative Compliance Measures

If it is infeasible to avoid channels on the project site that are Significant Sources of Bed Sediment Supply in the design of the site plan, the drainage(s) may be by-passed to maintain the Bed Sediment Supply to the receiving channel. The User will need to prepare specific designs to achieve this objective.

2.3.ii Alternative Compliance Option

An Alternative Compliance Option may only be pursued if the replacement of Bed Sediment Supply is deemed infeasible by the Copermittee with jurisdiction over the project site, or if the project site design requires significant alteration of onsite channels. The infeasibility of the different Sediment Supply BMPs stated in the general approach may only be demonstrated and documented by the User. The User may also demonstrate the expected feasibility of the Alternative Compliance Option.

In such an eventuality, Users may propose an Alternative Compliance Option for Bed Sediment management from a PDP based on numerical modeling. This option would generally include a long-term monitoring program, with potential corrective measures to be identified and implemented as needed in response to findings from the monitoring program. The use of an Alternative Compliance Option derives from Lane's interrelationship that conceptualizes the balance between hydrologic and geomorphic processes for alluvial channels.

For example, the User may recommend an annual replenishment of Bed Sediment Load downstream of the project site based on an estimation of the amount of reduction of Bed Sediment Supply from the project site as a result of development.

The general steps to estimate the average annual replacement of Bed Sediment Load are:

1. Identify the sources of Total Sediment Supply based on a geotechnical review of the site. Areas that are not a Significant Source of Bed Sediment Supply may be omitted from the analysis.
2. Estimate the base erosion rate of areas identified as sources of Total Sediment Supply. This estimate should be completed using the Modified Universal Soil Loss Equation (MUSLE) and a 2-year runoff return period.
3. Approximate the sediment delivery ratio of sources. This can be done using published values for the area or estimated values based on best professional judgment.
4. Evaluate the Bed Sediment proportion of sources and calculate the yield rate. The Bed Sediment proportion of the sources should be determined by comparing the sieve

analysis in the channel with that in the identified supply areas on the project site. The yield is computed by multiplying the total yield, by the Bed Sediment proportion and the sediment delivery ratio.

5. Identity sources of Bed Sediment Supply to be eliminated after development. This is performed based on a review of the site plan.

6. Calculate and compare the total pre- and post-development Bed Sediment Supply yield to estimate the average annual amount of Bed Sediment that should be replenished to the channel.

Alternatively, the User may propose adjusting the flow duration curve to maintain pre-project conditions in the receiving channel with the expected change in Bed Sediment Supply discharge from the project site. The erosion potential (total sediment transported in the proposed condition vs. the baseline) should be modeled and used to adjust the flow duration curve to ensure a condition that does not vary more than 10% from the natural condition. Bledsoe (2002) introduced the index of stream erosion potential (Ep), which compares the erosive power of pre- and post-development streamflows. This index allows comparison of sediment-transport relationships to ensure that an erosion potential that is comparable to pre-development conditions is achieved. Changes in Total Sediment Supply after development are accounted for by changing the target Ep from 1.0 (proposed is the same as pre-project) in proportion to the change in Bed Sediment Supply (post-development/pre-development), calculated using the six steps above. This option may not be practical when changes in Bed Sediment Supply are relatively large (greater than 50%). The User should determine, using best professional judgment, if the alternative modeling approach is applicable.

The alternative modeling approach must include the following:

1. Continuous hydrologic simulation for the project baseline condition and proposed condition over the range of flow values up to the pre-project 10-year event;

2. Sediment transport model of the receiving channel for the PDP baseline condition and proposed condition;

3. Analysis of the change in Bed Sediment Supply from the PDP baseline condition to the proposed condition;

4. Explanation of method used to control the discharge from the PDP to account for changes in the delivered Bed Sediment Supply; and

5. Summary report.

Channel systems and fluvial processes react to changes in the watershed as to progressively evolve to a dynamic equilibrium. However, the SMR is geomorphically highly dynamic due to natural conditions including topography, vegetative cover and soils, and may only achieve dynamic equilibrium in geologic time (i.e., many thousands of years). The alternative Hydrologic Performance Standard for this option consists of evaluating the changes in both Bed Sediment Supply and hydrologic changes caused by a PDP. The User must demonstrate through a channel stability impact assessment that the changes to both the amount of Bed Sediment Load being transported and the amount of sediment supplied to the receiving channel will maintain the general trends of aggradation and degradation in the different impacted channel reaches, which are representative of the pre-development geormorphologic state of a channel. Typical channel sediment continuity analysis procedures may be performed using moveable bed fluvial models such as HEC-6t or equivalent.

Receiving channel monitoring may be required for the project site to verify that the PDP does not result in long-term changes to the receiving channel. The User should make a recommendation if long-term monitoring is required, for concurrence by the Copermittee with jurisdiction over the project site. Some of the considerations in assessing the need for a long-term monitoring program are:

1. Total area of the watershed at the PDP discharge point vs. the PDP area;
2. Condition and type of receiving channel;
3. Magnitude of change in Bed Sediment Supply to the receiving channel;
4. Relief of the land on the project site;
5. Number of channels (density) potentially delivering Bed Sediment Supply to the receiving channel, and the delivery ratio; and
6. Soil characteristics on the project site.

Site-specific modeling is discussed further in APPENDIX H .

2.4 Mechanisms to Assess and Address Cumulative Impacts

The Copermittees have developed the SMR HMP Evaluation Program, which defines both a Hydromodification monitoring approach and a performance protocol as required by provisions F.1.h. (1)(e) and F.1.h. (1)(m) of the 2010 SMR MS4 Permit. Section F.1.h.(1)(e) requires the definition of a protocol to evaluate the potential hydrograph change impacts to downstream channels from PDPs to meet the range of runoff flows identified under section F.1.h.(1)(b).

The HMP Evaluation Program includes a description of inspections and maintenance of Hydrologic Control and Sediment Supply BMPs, as well as a protocol to address cumulative impacts of PDPs within a watershed on channel morphology. The protocol includes the evaluation of changes to physical features of the receiving channels and biological conditions of the receiving channels downstream of the areas where PDPs are developed. The Evaluation Program will assess the cumulative impacts of PDPs through the performance protocol.

A mechanism has been defined in the Evaluation Program to identify the causes of further geomorphologic changes to the channels and address the cumulative impacts of PDPs, if any. The findings of the initial monitoring efforts may trigger refinements improving the Hydrologic and Sediment Supply Performance Standards, to manage the impacts of PDPs on the geomorphology and the biological integrity of receiving channels.

3.0 HMP Requirements for Projects

Per 2010 SMR MS4 Permit Provision F.1.h(1)(d), this chapter identifies where in the SMR and under what circumstances do the HMP Performance Standards apply to PDPs. The HMP identifies the coverage areas that are exempted from Hydromodification requirements based on Permit Provisions, the state of the Hydromodification science, the practicality of implementation of Hydrologic Control BMPs, environmental benefits of the implementation of Hydrologic Control BMPs, and approved Hydromodification exemptions for other jurisdictions in California.

Users may refer to the HMP Decision Matrix presented in **Section 3.1** to determine if Hydrologic Control and/or Sediment Supply BMPs are required. When required, the HMP Decision Matrix will direct the User to the adequate sections of this HMP describing the Hydrologic Control and Sediment Supply BMPs to be implemented based on the project type and size.

3.1 HMP Applicability Requirements

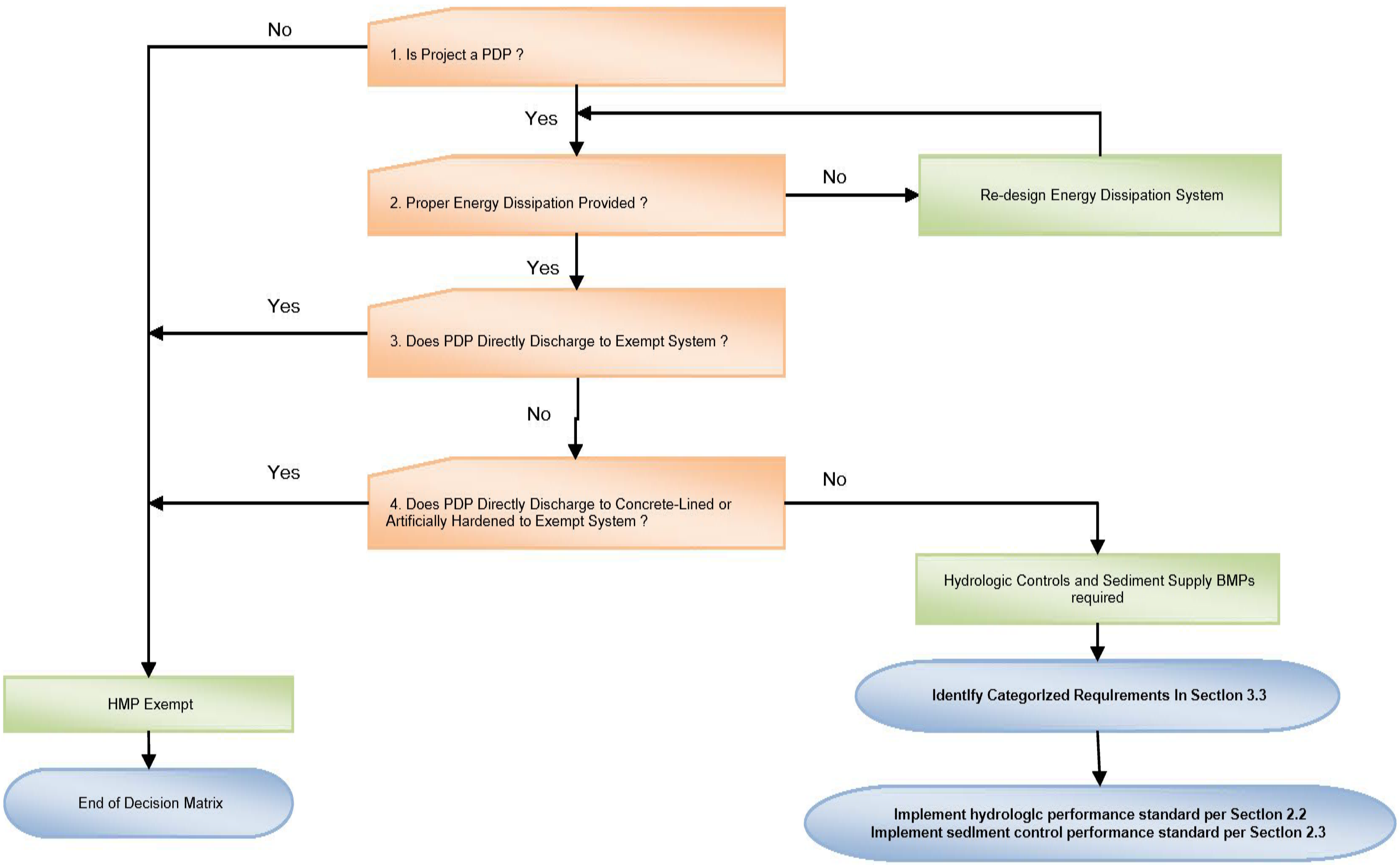
3.1.i HMP Decision Matrix

To determine if a proposed project must implement Hydrologic Control BMPs, refer to the HMP Decision Matrix in **Figure 6.**

The HMP Decision Matrix can be used for all projects. PDP categories are based on the size and type. Their associated requirements are defined in **Section 3.3**.

It should be noted that all PDPs are subject to the 2010 SMR MS4 Permit's LID and water quality treatment requirements even if Hydrologic Control BMPs are not required.

Figure 6 - SMR HMP Decision Matrix



- **Figure 6**, Node 1 – Hydrologic Control BMPs are only required if the proposed project is a PDP, as defined per 2010 SMR MS4 Permit Section F.1.d.
- **Figure 6**, Node 2 – Properly designed energy dissipation systems are required for all PDP outfalls to unlined channels. Such systems should be designed in accordance with the District Standard Drawings and the 1982 Los Angeles County Flood Control District Hydraulic Design Manual or approved alternative to ensure downstream channel protection from concentrated outfalls (identified in **Section 3.1.ii)**.
- **Figure 6**, Node 3 – Exemptions may be granted for PDPs discharging runoff directly to an exempt receiving water, such as Vail Lake or Skinner Lake, or to an exempt channel discharging directly into a large river channel (identified in **Table 3**).
- **Figure 6**, Node 4 – For PDPs discharging runoff directly to a concrete-lined or artificially hardened MS4 facility that has the capacity to convey the 10-year ultimate condition discharge that extends to exempt receiving waters detailed in Node 3, exemptions from HMP Performance Standards may be granted. Such concrete-lined or artificially hardened MS4 facilities that have the capacity to convey the 10-year ultimate condition discharge, include storm drain and channel reaches that have been identified as not-susceptible to Hydromodification (see SMR Hydromodification Susceptibility Study in **Appendix C**).
- **Figure** provides an overview of the SMR, and identifies potentially exempt areas per the requirements of the 2010 SMR MS4 Permit and non-exempt areas.
- **Figure 8** and **Figure 9** zoom geographically into the Temecula area and the Temecula Creek area downstream of Vail Lake, respectively.

3.1.ii Requirement for Proper Energy Dissipation System(s)

As identified in the HMP Decision Matrix in **Figure 6**, properly designed energy dissipation systems are required for all PDP outfalls to unlined channels. The provision is consistent with the District's Standard Design Manual and the 1982 Los Angeles County Flood Control District Hydraulic Design Manual or approved alternative to ensure downstream channel protection from concentrated outfalls.

For reference purposes, the 1982 Los Angeles County Flood Control District Hydraulic Design Manual identifies that (page B-12):

"When a storm drain outlets into a natural channel, an outlet structure shall be provided, which prevents erosion and property damage. Velocity of the flow at the outlet should agree as closely as possible with the existing channel velocity. Fencing and a protection barrier shall be provided…

(1) … When the discharge velocity is high, or supercritical, the designer shall, in addition, consider bank protection in the vicinity of the outlet and an energy dissipation structure."

In order to encroach upon a Copermittee MS4 facility and construct an energy dissipation system, an Encroachment Permit must be obtained during the design phase. The User may contact the District's Operations and Maintenance Division or the Copermittee's Public Works Department, as appropriate, for up-to-date criteria as to location and type of location to be used prior to initiating any design of outlet structure. For a majority of projects seeking encroachment to a MS4 facility, the initial location and type of outlet structures and energy dissipation systems will typically be assessed during the planning phase, specifically during the Environmental Review and Document phase.

Figure 7 - SMR Channel Susceptibility and Exemption Coverage

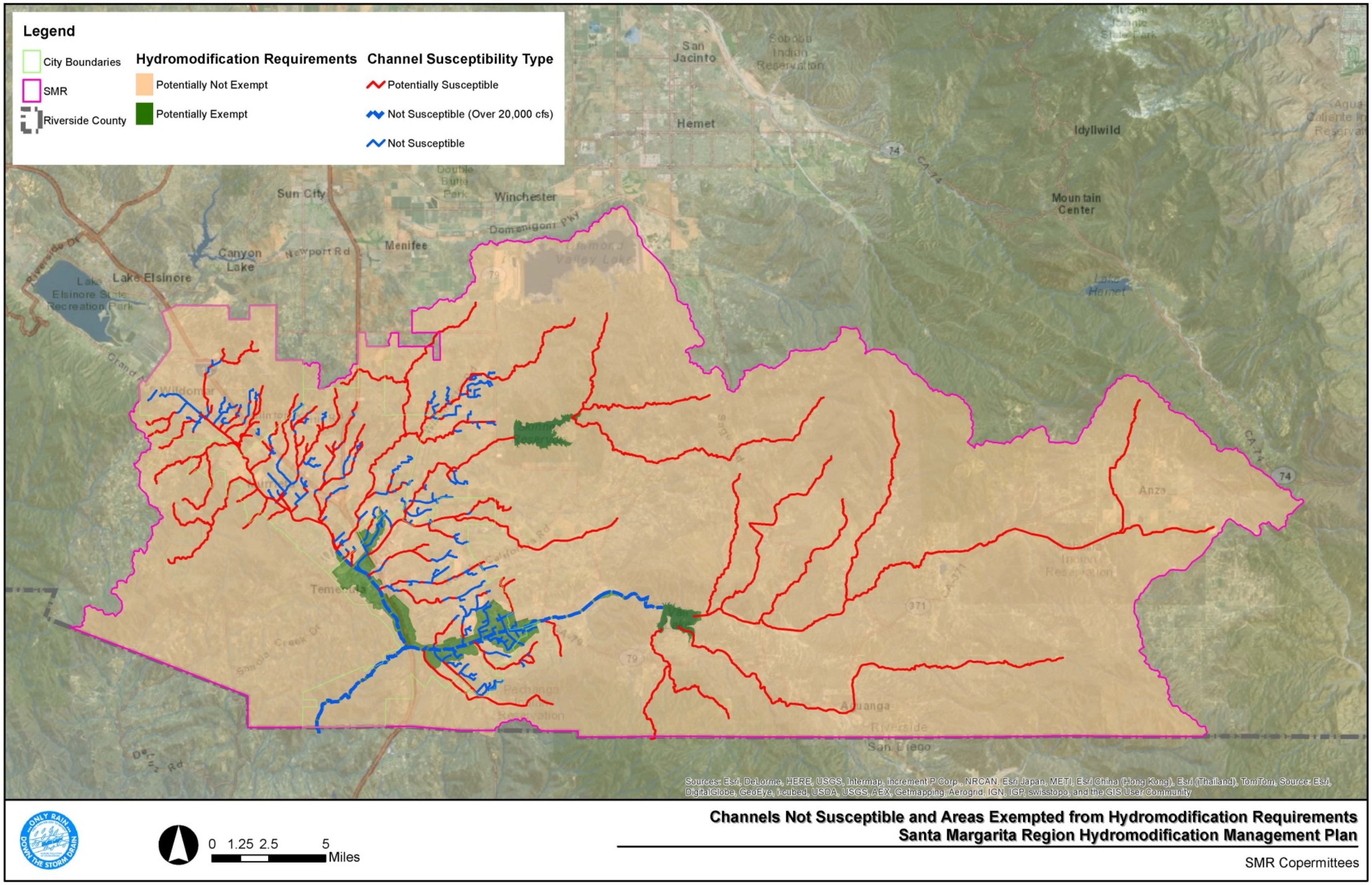


Figure 8 - SMR Channel Susceptibility and Exemption Coverage – Temecula Area

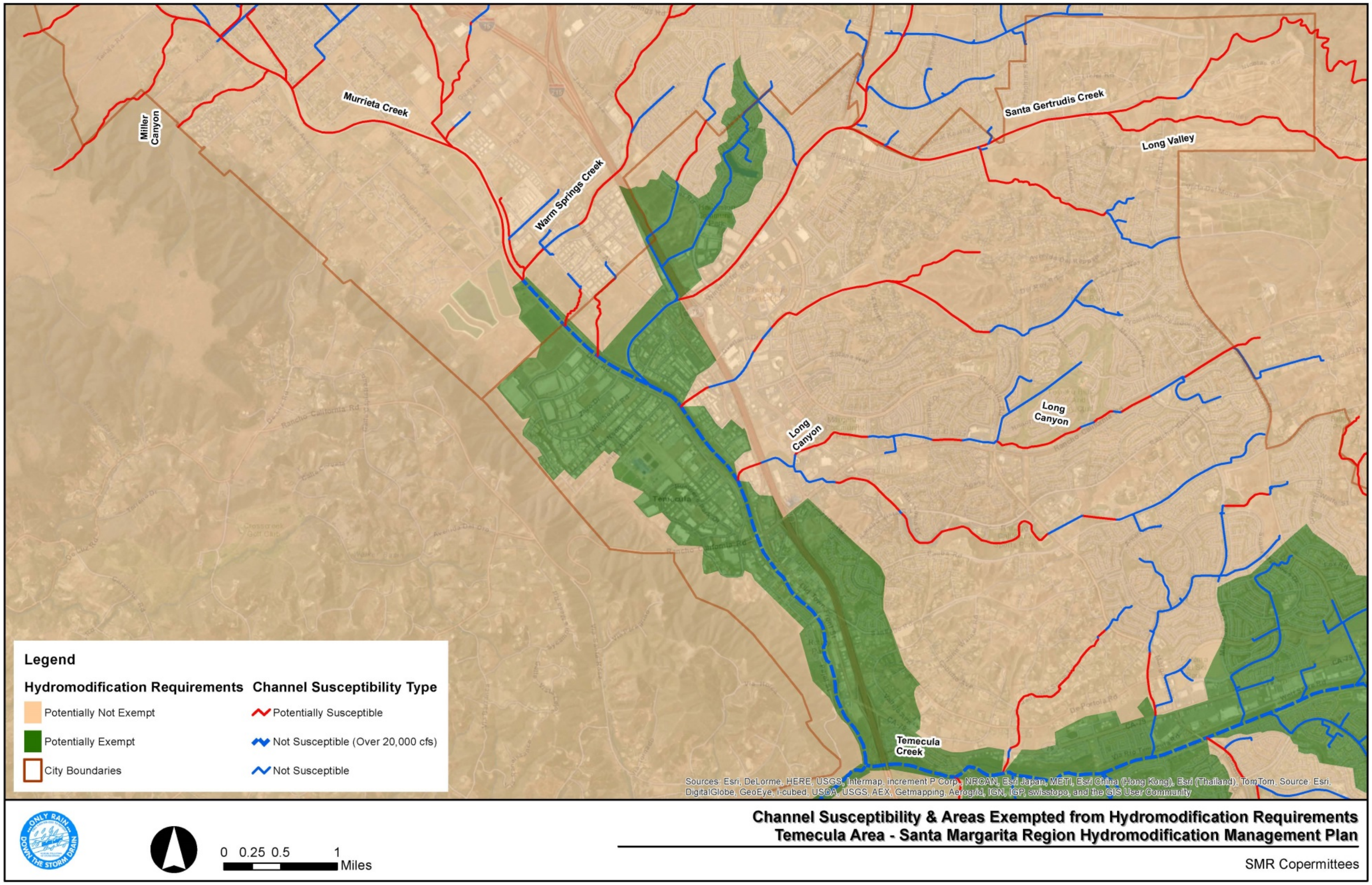
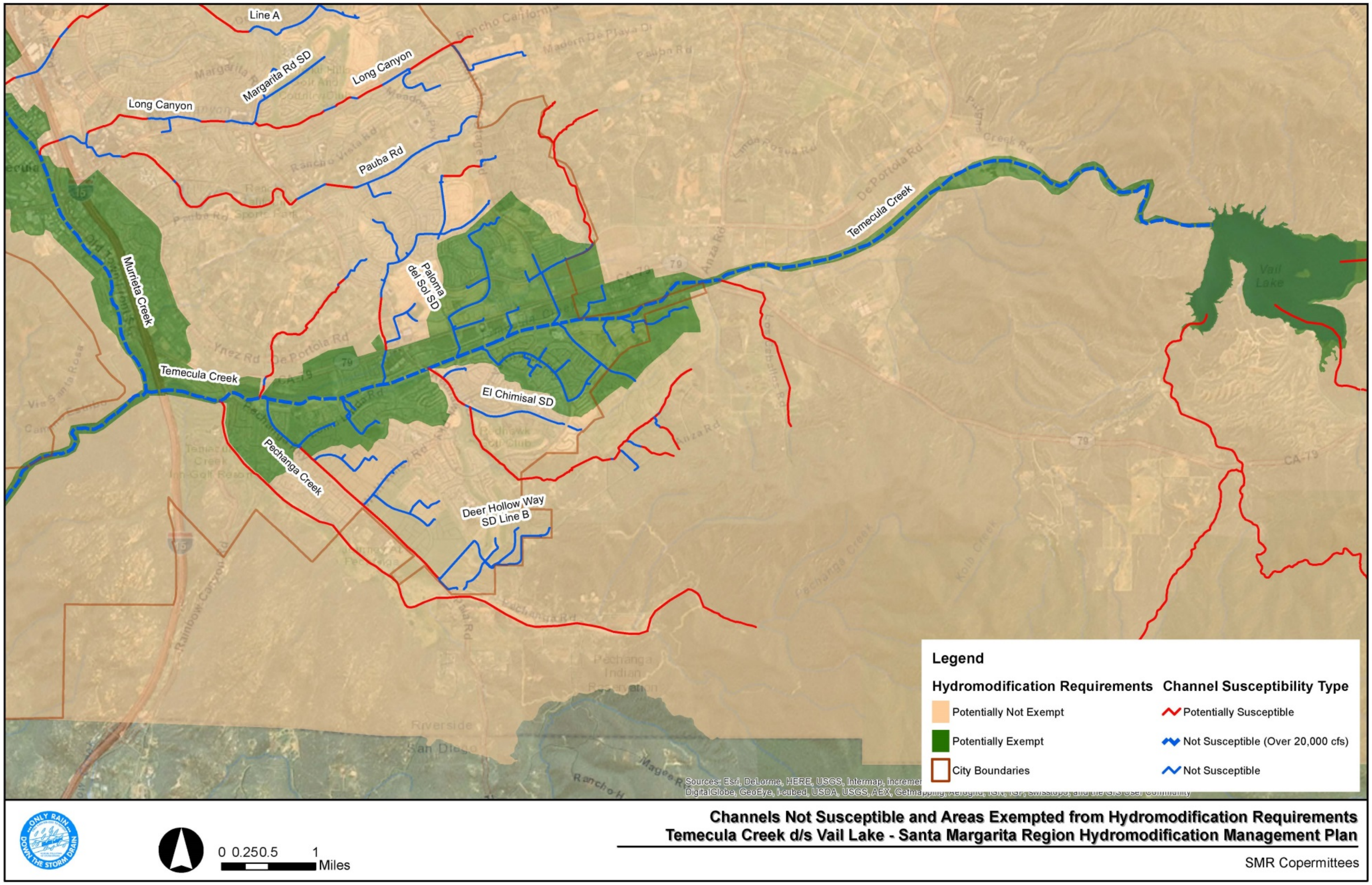


Figure 9 - SMR Channel Susceptibility and Exemption Coverage – Temecula Creek Area



3.2 HMP Exemptions

PDPs may be exempt from HMP Performance Standards based on specific channel or watershed conditions or already approved design guidelines.

3.2.i Concrete-Lined & Artificially Hardened Channel Exempt Areas

The channel exempt areas include those areas that discharge to concrete-lined or artificially hardened channels sections. This includes, as identified in Section F.1.h.(4) of the Permit:

- PDPs that discharge runoff into underground storm drains discharging directly to water storage reservoirs and lakes; or
- PDPs that discharge runoff into MS4 facilities whose bed and bank are concrete lined all the way from the point of discharge to water reservoirs and lakes; or
- PDPs that discharge runoff into other areas identified in the HMP as acceptable to not need to meet the requirements of Section F.1.h by the San Diego Water Board Executive Officer.

Concrete-lined or artificially hardened MS4 facilities that are identified as Engineered, Fully Hardened and Maintained (EFHM) in the SMR Hydromodification Susceptibility Study (see APPENDIX D) are exempt from the HMP Performance Standards. The exemption does not apply to PDPs that discharge to Engineered, Partially Hardened and Maintained (EPHM) and Engineered, Earthen and Maintained (EEM) channels. To confirm the exemption, the succession of existing concrete-lined or artificially hardened MS4 facilities must be continuous from the discharge point to an exempt receiving water, such as a reservoir or a large river. PDPs may evaluate local drainage systems that were not included in the SMR Hydromodification Susceptibility Report for exemption applicability. The User must ensure that the MS4 facilities have been designed to convey the 10-year ultimate condition peak discharge.

The 10-year flow should be calculated based upon the 10-year high confidence synthetic rainfall hydrograph, as detailed in the 1978 RCFCWCD Hydrology Manual. As an alternative, the 10-year ultimate peak discharge may also be determined based on continuous simulation and the results of the SMRHM.

Pursuant to 2010 SMR MS4 Permit Provision F.1.h(1)(a), the SMR was screened to identify and classify susceptible and non-susceptible channels. The screening analysis consisted of verifying the type of material and susceptibility of the GIS-delineated District drainage facilities using as-built plans and aerial photography. For questionable segments, the analysis was complemented by a field visit. Findings are summarized in the Hydromodification Susceptibility Documentation Report and Mapping (see APPENDIX D).

Major MS4 facilities that are exempt from HMP Performance Standards are presented in **Table 3** for reference only. The PDP may use the exemption maps, including Figures 6 through 11 of this HMP and Map 2: HCOC Applicability Map from the Hydromodification Susceptibility Documentation Report and Mapping: SMR (see APPENDIX D), for planning purposes and must determine if the PDP would discharge runoff into a continuous succession of existing concrete-lined or artificially hardenedMS4 facilities that have the capacity to convey the 10-year ultimate condition discharge all the way to an exempt reservoir or other exempt waterbody. The table contains the name of the channel, as well as the associated downstream and upstream limits. The upstream limit being reported corresponds to the nearest cross street. The resulting map from this effort is presented in **Figure** . The map shows drainage areas that are potentially exempt from HMP Performance Standards.

Table 3 - Channels Exempt from Hydromodification Performance Standards

Channel	Downstream Limit	Upstream Limit
Murrieta Creek	Confluence with Warm Spring Creek	600 feet downstream of Elm Street
Storm Drain RCFC5429	Santa Gertrudis Creek Lateral A,B	Lock Haven Center
Santa Gertrudis Creek Line I	Santa Gertrudis Creek Lateral A,B	End of Line I
Santa Gertrudis Creek Lateral A,B	Murrieta Creek Channel	Confluence with Storm Drain RCFC4057
Wolf Valley Creek Channel	Temecula Creek	Loma Linda Road
Wolf Valley – Loma Linda Road Storm Drain	Wolf Valley Creek Channel	None – all tributaries are exempt
Via Del Coronado Storm Drain	Temecula Creek	None – all tributaries are exempt
Line V / VV of Temecula Creek	Temecula Creek	Upstream of tunneling structure under CA-79
Apis Road Storm Drain	Temecula Creek	None – all tributaries are exempt
Wolf Valley Loop / Margarita Road Storm Drain	Temecula Creek	None – all tributaries are exempt
Mahlon Vail Circle Storm Drain	Temecula Creek	None – all tributaries are exempt
DePortola Road Storm Drain	Temecula Creek	Butterfield Stage Park
Butterfield Stage Road / Macho Road Storm Drain	Temecula Creek	None – all tributaries are exempt
Temecula Creek Road Storm Drain	Temecula Creek	Highway 79
Chaote Street Storm Drain	Temecula Creek	None – all tributaries are exempt
Nighthawk Pass Storm Drain	Temecula Creek	None – all tributaries are exempt
Temecula Creek	Confluence with Santa Margarita River	Outflow of Vail Lake

Table 4 provides a summary of the two exempt reservoirs in the SMR, as identified in the Hydromodification Susceptibility Study. Discharges from PDPs to large reservoirs or lakes can be exempt from HMP Performance Standards since stormwater inflow velocities are naturally managed by the significant tailwater condition in the reservoir. HMP Performance Standard exemptions would only be granted for PDPs discharging runoff directly to the exempt reservoirs or into concrete-lined or artificially hardened MS4 facilities designed convey the 10-year ultimate condition discharging into a lake or reservoir. To qualify for the exemption, the outlet elevation of the MS4 facility must be within (or below) the normal operating water surface elevations of the reservoir and properly designed energy dissipation must be provided.

Table 4 - Reservoirs in the Santa Margarita Region

Reservoir	Watershed
Vail Lake	Temecula Creek

Skinner Lake	Tucalota Creek
Diamond Valley Reservoir	

Figure 10 below displays areas that are potentially exempt for the entire SMR based on the criteria outlined above, where the areas in green are potentially exempt as they discharge to engineered MS4 facilities all the way to exempt receiving waters (large river, water storage reservoirs). **Figure 11** provides the User with an exemption map of higher definition in the Temecula area. **Figure 12** provides the User with an exemption map of higher definition for Temecula Creek downstream of Vail Lake.

Figure 10 - SMR Exemption Area

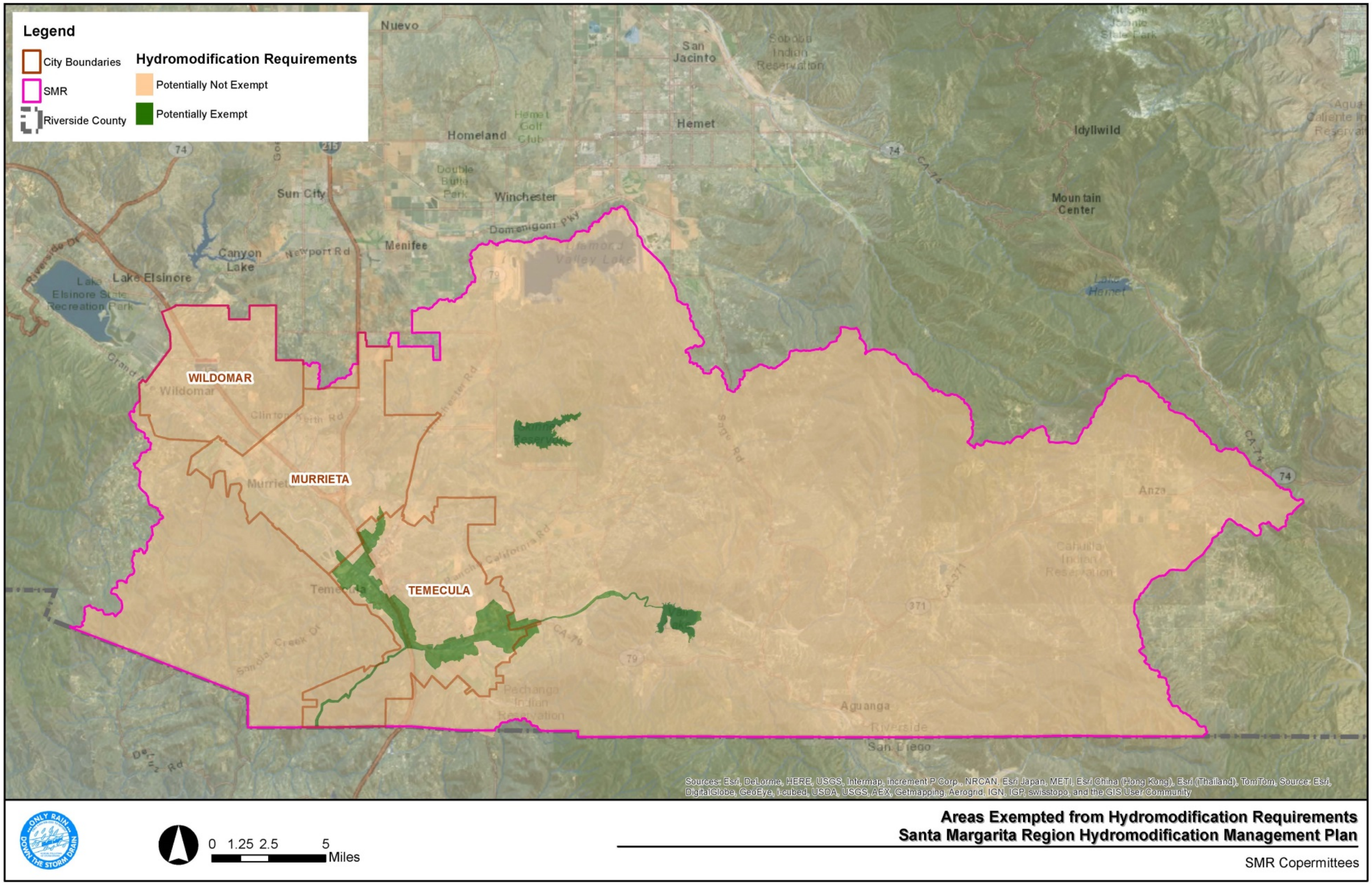


Figure 11 - SMR Exemption Area – Temecula Area

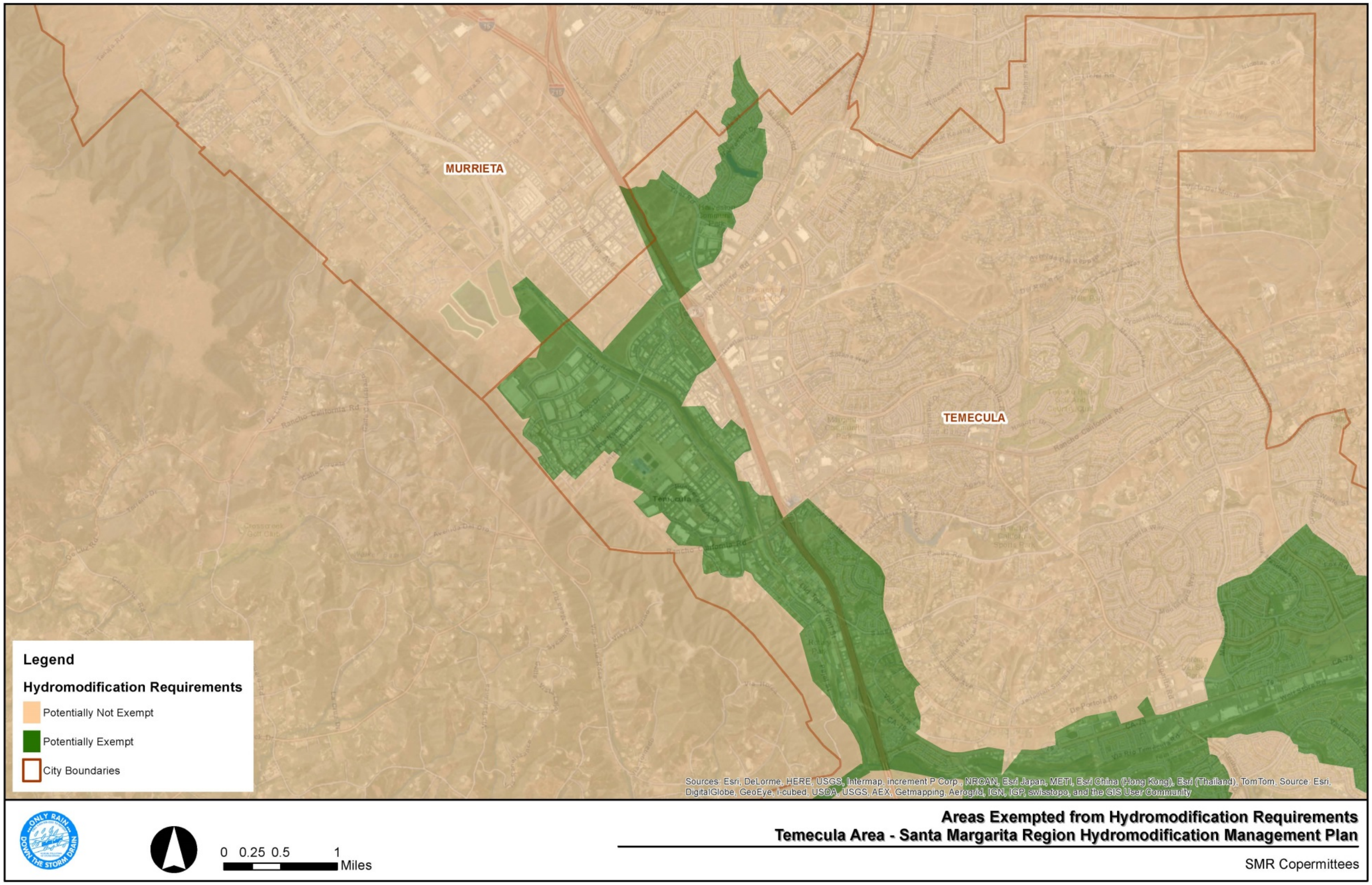
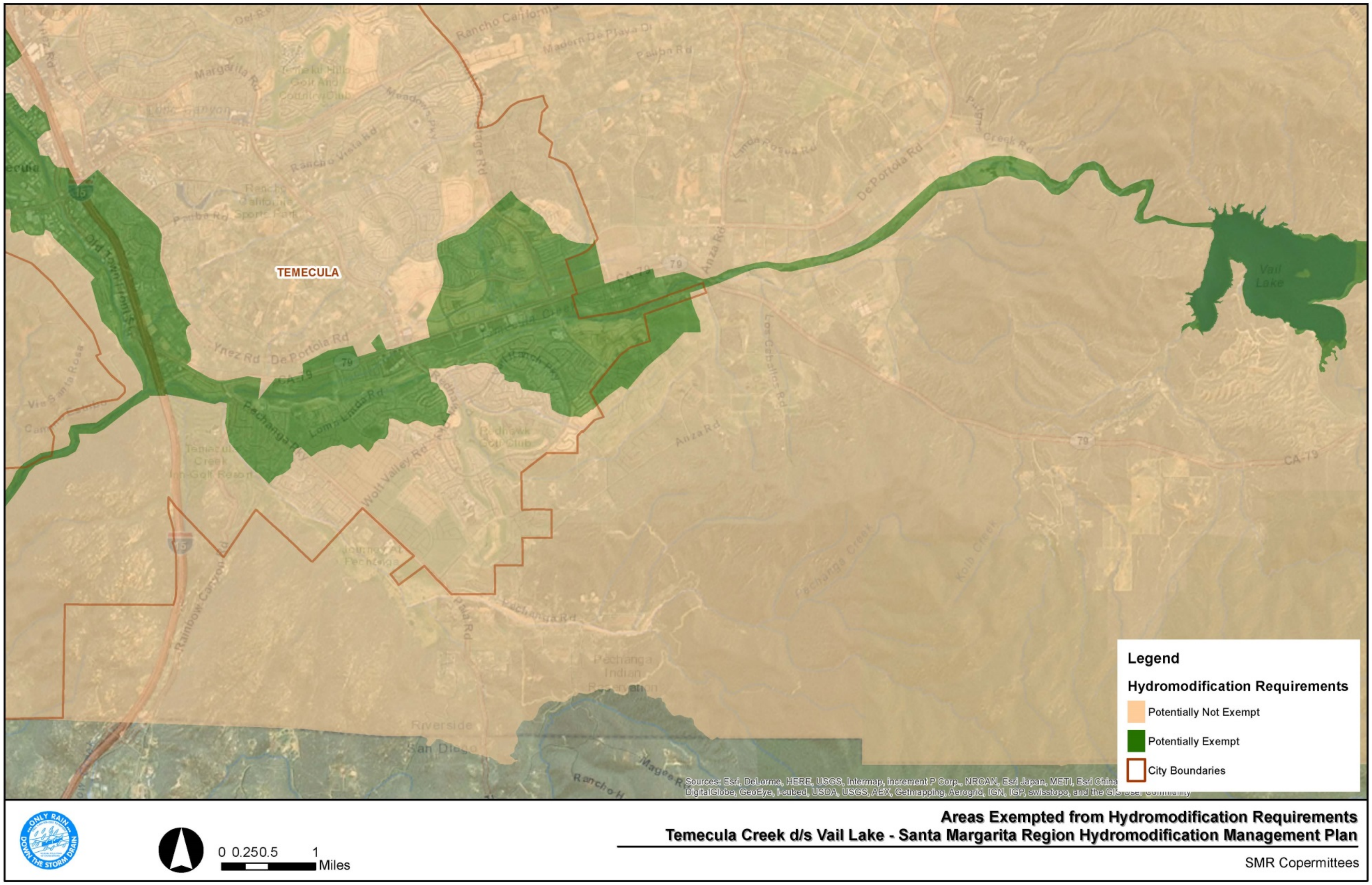


Figure 12 - SMR Exemption Area – Temecula Creek downstream of Vail Lake



3.2.ii Exemption for Large River Reaches

Effects of cumulative watershed impacts are minimal in channel reaches of large depositional rivers. These large rivers typically have very wide floodplain areas when in the natural condition or are stabilized when in the engineered condition, and are of low gradient.

The results of a flow duration curve analysis that was performed for the San Diego River are presented in the San Diego County HMP. This analysis demonstrated that the effects of cumulative watershed impacts are minimal in those reaches for which the contributing drainage area exceeds 100 square miles and with a 100-year design flow in excess of 20,000 cfs. Development and redevelopment projects that discharge either directly or via an engineered and regularly maintained MS4 facility designed to convey the 10-year ultimate condition into such large river channels are hence exempt from the SMR HMP requirements, provided that properly sized energy dissipation is implemented at the outfall location. As identified in the SMR Hydromodification Susceptibility Study (See APPENDIX D), all exempt river reaches, which are presented in **Table 5** have a drainage area larger than 100 square miles and a 100-year design flow higher than 20,000 cfs. **Table 5** also provides the corresponding upstream and downstream limits to define the exempted reach.

Table 5 - Exempt Channel Reaches in the Santa Margarita Region

River	Downstream Limit	Upstream Limit
Murrieta Creek	Confluence with Santa Margarita River	Above Warm Springs Creek
Temecula Creek	Confluence with Santa Margarita River	Outlet of Vail Lake
Santa Margarita River	Pacific Ocean	At Origin

3.3 PDP Requirements

A proposed PDP that is not located in an exemption zone (see **Figure** , **Figure** , or **Figure**) must meet the HMP Performance Standards defined in **Section 2.1**, following the guidelines described in this section. The User may refer to **Figure** , **Figure** , and **Figure** to identify a potential exemption from Hydromodification requirements. To confirm the eligibility to an exemption from Hydromodification requirements, if any, the User must identify in the Preliminary WQMP:

- The list of successive MS4 facilities and Receiving Waters that the project site is tributary to, from the point of discharge of the project site to an exempt Receiving Water. Exempt Receiving Waters are identified in **Section 3.2**.
- For each listed MS4 facility or Receiving Water, if bed and banks are artificially hardened or concrete-lined.

The exemption from Hydromodification requirements will be considered by the Copermittee having jurisdiction over the project site, if all MS4 facilities and Receiving Waters to an exempt Receiving Water, are concrete-lined and/or artificially hardened.

The User may associate the size and type of the PDP to one of the following Categories and meet all the HMP Performance Standards outlined for that category:

- Category 1 – New Development Projects exceeding one acre or Redevelopment Projects over one acre
- Category 2 – Small-sized projects less than one acre yet defined as a PDP and Copermittee roadway projects

Proposed PDPs face different levels of spatial, environmental, financial, technical, and permitting constraints based on their size and type. As such, the 2010 SMR MS4 Permit was translated into HMP Performance Standards that are specific and adapted to each Category. The definition of each Category was principally derived from the elements of the 2010 SMR MS4 Permit, as well as from a review of the other HMPs (Santa Clara, Alameda, Sacramento, San Diego, and South Orange County). Most individual single-family residential projects will be exempt from the HMP Performance Standards.

The following subsections describe the HMP Performance Standards specific to each Category.

3.3.i Category 1 – PDPs over One Acre

Category 1 PDPs will be subject to a number of spatial, environmental, financial, technical, and permitting constraints.

Hydrologic Control and Sediment Supply BMPs to ensure compliance with the HMP Performance Standards are described in **Section 2.1**. Using this approach, management of both flow and duration is achieved through onsite Hydrologic Control BMPs or implementation of hydrologic controls through a regional or sub-regional BMP that accepts discharges from the project, but is located outside of the project boundaries, and sediment loss is addressed through Sediment Supply BMPs.

If allowed by the Copermittee with jurisdiction over the project site, a PDP that is greater than 100 acres or a PDP in a common development plan that exceeds 100 acres may implement Comprehensive Regional BMPs. Comprehensive Regional BMPs must address the incremental impacts of the PDP on the receiving channels from a regional perspective. The User must delineate the subwatersheds that include entirely the project site to demonstrate compliance with the water quality, hydrologic, and fluvial geomorphologic objectives from a regional perspective. The following objectives must be addressed in implementing Comprehensive Regional BMPs:

- Water Quality Objectives, LID site principles, LID BMPs to capture or biotreat the Design Capture Volume (DCV), and HMP Performance Standards in consistency with the requirements set forth in the SMR WQMP;
- Copermittee and regional hydrologic objectives to manage increases in runoff peak discharges and increases in runoff volumes for the 10-year and 100-year frequency storm events, in consistency with the drainage requirements set forth by the Copermittee having jurisdiction over the project;

- Fluvial geomorphologic objectives to manage the adverse impacts of the PDPs over the existing aggradation/degradation of the receiving channel, and the existing stability and erosion of the receiving channels for the 10-year and 100-year frequency storm events, in consistency with the drainage requirements set forth by the Copermittee having jurisdiction over the project.

A PDP may benefit from the implementation of Comprehensive Regional BMPs instead of separate Hydrologic Control BMPs to address NPDES and Local Drainage requirements through the reduction of the overall footprint of Hydrologic Control BMPs, the simplification of the required MS4 facilities, the streamlined maintenance of facilities for optimal operability, and the potential to create multi-use facilities.

Comprehensive Regional BMPs may be onsite or offsite Hydrologic Control BMPs implemented to address regional water quality, hydrologic, and fluvial geomorphologic objectives consistent with the framework of a regional technical study. Comprehensive Regional BMPs will typically be larger detention facilities with a water quality component that manages the DCV, a Hydromodification component including the design of additional storage and adequate outlet structure to manage the range of geomorphically significant flows (10% of Q2 to Q10, or consistent with the guidelines provided in APPENDIX I), and a drainage mitigation component including the design of additional storage and adequate outlet structure to manage increases in runoff peak discharges, runoff volumes, receiving channel aggradation/degradation, channel erosion & channel stability.

The User must develop a regional technical study to demonstrate that the HMP Performance Standards are met for the sub-watersheds that include entirely the project site, through the implementation of Comprehensive Regional BMPs. The regional technical study must be submitted along with the Project-Specific WQMP. The User may consider the following approaches:

- For the Hydrologic Performance Standard, the User may follow Step 1 in **Section 2.2.iv**. If a HMP Management Bank is available, the PDP can pursue this option. The PDP can also pursue the in-channel restoration or rehabilitation option (Option 1 – Step 2b) identified in **Section 2.2.iv**.
- For the Sediment Control Performance Standard, the User may perform the three-step approach as described in **Section 2.3.i**. The alternative compliance will consist of modifying the hydrologic regime of onsite runoff to compensate for sediment loss, while meeting the established Hydrologic Performance Standard.

The Alternative Compliance Options to meet both the Hydrologic Control and Sediment Control Performance Standards are intrinsically related. A flow chart indicating which HMP Performance Standards should be pursued and implemented for a Category 1 project is shown in **Figure 13**

Figure 13 - Hydromodification Performance Standards for PDPs Over One Acre

3.3.ii Category 2 –PDPs less than one acre & Copermittee Roadway Projects

Category 2 PDPs are those projects disturbing an area less than one acre but defined as a PDP. Category 2 PDPs may include the following projects, as characterized by 2010 SMR MS4 Permit Provision F.1.d.(1) and Provision F.1.d.(2):

- New Development Projects that are smaller than one acre that create 10,000 square feet or more of impervious surfaces (collectively over the entire project site) including commercial, industrial, residential, mixed-use, and public projects. This category includes New Development Projects on public or private land which fall under the planning and building authority of the Copermittees.
- Projects to construct automotive repair shops, defined as a facility that is categorized in any one of the following Standard Industrial Classification (SIC) codes: 5013, 5014, 5541, 7532-7534, or 7536-7539.
- Projects to construct restaurants defined as a facility that sells prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption (SIC code 5812), where the land area for development is greater than 5,000 square feet. Restaurant projects where land development is less than 5,000 square feet must meet all WQMP requirements except for Structural Treatment BMP and numeric sizing criteria requirement F.1.d.(6) and Hydromodification requirement F.1.h.
- All hillside development projects greater than 5,000 square feet but less than one acre. This category is defined as any development which creates 5,000 square feet of impervious surface which is located in an area with known erosive soil conditions, where the development will grade on any natural slope that is 25% or greater.
- All development projects less than one acre that are located within or directly adjacent to or discharging directly to an ESA (where discharges from the development or redevelopment will enter receiving waters within the ESA), which either creates 2,500 square feet of impervious surface on a proposed project site or increases the area of imperviousness of a proposed project site to 10% or more of its naturally occurring condition. "Directly adjacent" means situated within 200 feet of the ESA. "Discharging directly to" means outflow from a drainage channel that is composed entirely of flows from the subject development or redevelopment site, and not commingled with flows from adjacent lands.
- Impervious parking lots 5,000 square feet or more and potentially exposed to runoff. Only parking lots that are less than one acre are included into Tier 3. Parking lots are defined as a land area or facility for the temporary parking or storage of motor vehicles used personally, for business, or for commerce.
- Retail Gasoline Outlets (RGOs) - This category includes RGOs that meet the following criteria: (a) 5,000 square feet or more or (b) a projected Average Daily Traffic of 100 or more vehicles per day. RGO projects that are less than one acre are included into Tier 3.

- Those Redevelopment projects less than one acre that create, add, or replace at least 5,000 square feet of impervious surfaces on an already developed site and the existing development and/or the redevelopment project falls under the project categories or locations listed in 2010 SMR MS4 Permit Provision F.1.d.(2). Where redevelopment results in an increase of less than 50% of the impervious surfaces of a previously existing development, and the existing development was not subject to WQMP requirements, the numeric sizing criteria discussed in 2010 SMR MS4 Permit Provision F.1.d.(6) applies only to the addition or replacement, and not to the entire development. Where redevelopment results in an increase of more than 50% of the impervious surfaces of a previously existing development, the numeric sizing criteria applies to the entire development.

In addition, Copermittee Roadway Projects are included in Category 2. Copermittee Roadway Projects are linear New Development or Redevelopment projects to be completed within a limited right-of-way. Category 2 includes also the following roadway projects, as defined per Permit Provisions F.1.d.(1) and F.1.d.(2):

- Streets, roads, highways, and freeways. This category includes any paved surface that is 5,000 square feet or greater used for the transportation of automobiles, trucks, motorcycles, and other vehicles. To the extent that the Copermittees develop revised standard roadway design and post-construction BMP guidance that comply with the provisions of Section F.1 of the Order, then public works projects that implement the revised standard roadway sections do not have to develop a WQMP.
- Roadway Redevelopment Projects that create, add, or replace at least 5,000 square feet of impervious surfaces. Where a roadway Redevelopment Project results in an increase of less than 50% of the impervious surface within the limits of the project, and the existing development was not subject to WQMP requirements, the numeric sizing criteria discussed in Permit Provision F.1.d.(6) applies only to the addition or replacement, and not to the entire development. Where the roadway Redevelopment Project results in an increase of more than 50% of the impervious surface within the limits of the project, the numeric sizing criteria applies to the entire project.

Attachment C of the 2010 SMR MS4 Permit identifies that:

> "Redevelopment does not include trenching and resurfacing associated with utility work; resurfacing existing roadways; new sidewalk construction, pedestrian ramps, or bike lane on existing roads; and routine replacement of damaged pavement, such as pothole repair."

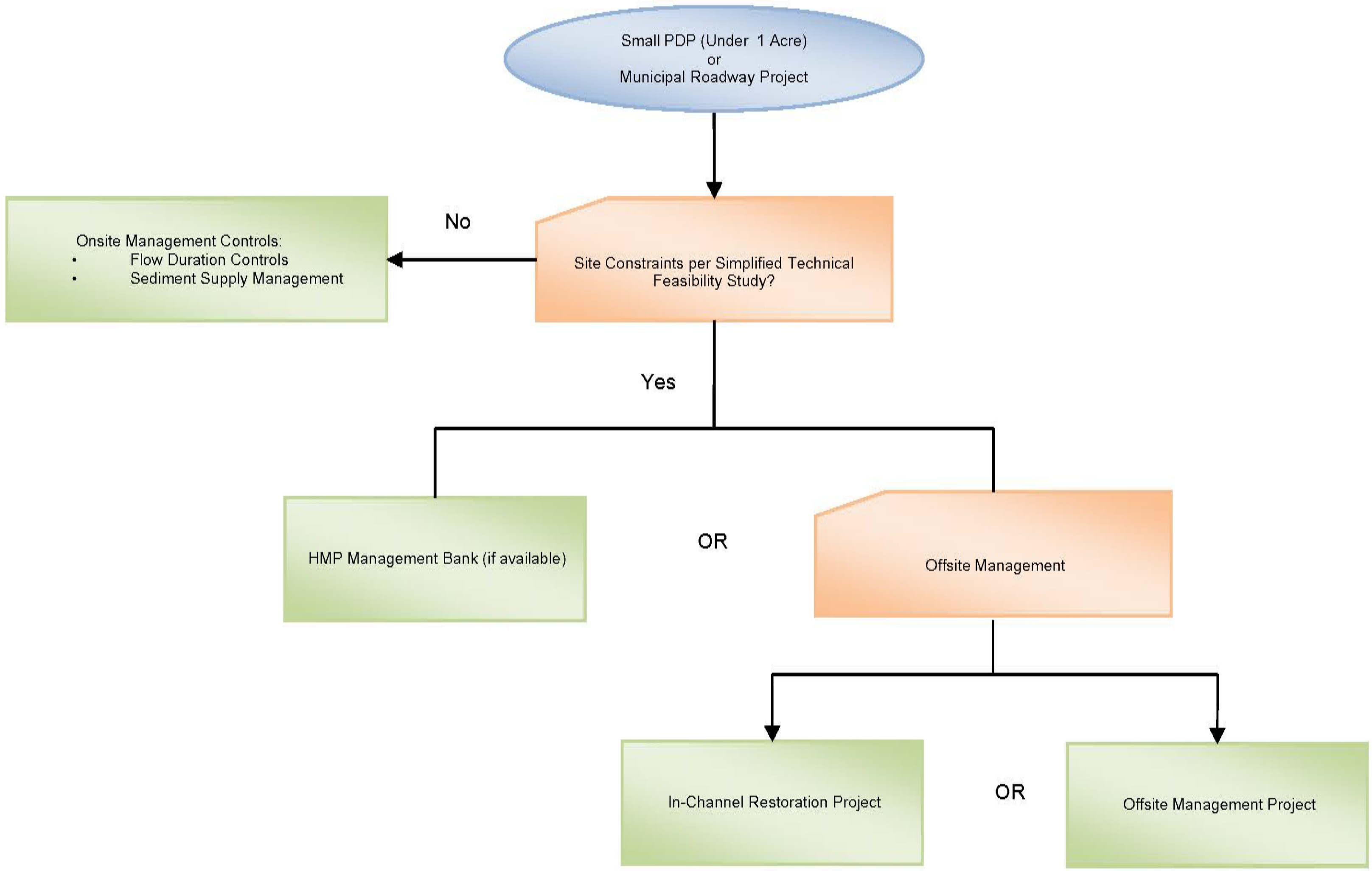
The majority of Category 2 projects are completed within a limited amount of space, making it unlikely the User will be able to implement onsite Hydrologic Control and Sediment Supply BMPs. The following approaches are available:

- Implementing Hydrologic Control BMPs either within the project boundaries or through a regional or sub-regional BMP that accepts discharges from the project, but is located outside of the project boundaries and Sediment Supply BMPs to ensure compliance with the HMP Performance Standards identified in **Section 2.1**. Using this approach, management of both flow and duration is achieved through Hydrologic Control BMPs.

- If onsite Hydrologic Control BMPs are not technically feasible due to site constraints, a simplified technical feasibility study must be developed to explain why the HMP Performance Standards cannot be met onsite. The simplified technical feasibility study must include:
  - the soil conditions of the PDP site;
  - a demonstration of the lack of available space for onsite Hydrologic Control BMPs;
  - an explanation of prohibitive costs to implement onsite Hydrologic Control BMPs; and
  - a written opinion from a California Registered Geotechnical Engineer, who will identify the infeasibility due to geotechnical concerns.
- Once the simplified technical feasibility study is accepted by the Copermittee with jurisdiction over the project site, the User may pursue payment into the HMP Management Bank, if one exists and is available to the PDP. If not, the User must pursue either an offsite Hydrologic Control BMP project or an in-channel restoration or rehabilitation project detailed in Option 1 – Step 2b in **Section 2.2.iv**. The offsite management project or in-channel restoration will meet the hydrologic performance standard.

A flow chart indicating which HMP performance standard should be considered for a Category 2 PDP is shown in **Figure 14**.

Figure 14 - Hydromodification Performance Standards for Small Size PDPs



4.0 HMP and Model WQMP Integration

Within the SMR WQMP, the HMP Performance Standards are incorporated into Section 3.6 – Meet Hydromodification Requirements. The section also identifies HMP Performance Standards for Category 1 and 2 PDPs, as well as the methodology and steps that Users must follow to achieve compliance with these Performance Standards. The alternatives for compliance with HMP Performance Standards – Off-Site Management and 3.6.3.b) – HMP Management Bank, and Section 3.6.4 – Meet the Sediment Supply Performance Standard, respectively will also be integrated into Sections 3.6.3.a) of the WQMP.

Guidance regarding the Hydrologic Control BMP technical feasibility study has also been integrated with the LID feasibility analysis as part of Section D of the SMR WQMP Template. Section D of the SMR WQMP Template addresses evaluation of onsite conditions that may require implementation of offsite Hydrologic Control BMPs. The Copermittees will use the SMR WQMP, WQMP Template, and LID BMP Design Handbook to incorporate the HMP Performance Standards into their development approval processes via their WQMPs and ordinances.

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APPENDIX A - User Quick Start Sheet

The quick start summary lists the following steps that a User should follow for their PDP to meet the HMP Performance Standards:

1. The first step consists of verifying if the project is exempt from HMP Performance Standards. Exemption occurs:

    - If the project is not classified as a PDP per the 2010 SMR MS4 Permit Provision F.1.d.;
    - If the proposed project discharges runoff directly to an exempt Receiving Water such as an exempt river reach, or an exempt reservoir. Or, if the proposed project discharges to an engineered MS4 facility with the capacity to convey the 10-year ultimate condition that extends to the an exempt river reach or reservoir (See **Section 3.2.i**);
    - If the project discharges to a large river per the definition provided in **Section 3.2.iii;** or
    - If the project discharges to stable Receiving Waters per the results of a channel stability analysis (See **Section** Error! Reference source not found.).

2. If not exempt from HMP Performance Standards, the User should identify the Performance Standards that apply to the PDP Category of the proposed project. For specific Category Performance Standards, the User may refer to the HMP Decision Matrix referenced in **Section 3.1**and requirements listed in **Section 3.3**. These direct the User to implement, when required, Hydrologic Control and Sediment Supply BMPs following the approach listed in **Section 2.0**:

    a. Hydrologic Control BMPs

Figure 13 summarizes the options that a User may pursue to achieve Hydrologic Control Performance Standards. Prioritization of Hydrologic Control BMPs, as well as the applicability of each type of Hydrologic Control BMPs, is defined in **Figure 13**. Onsite Hydrologic Control BMPs are to be designed based on the SMRHM. Alternatively, the User may develop their own numerical criteria but should support the findings with continuous simulation models. Technical infeasibility of a type of Hydrologic Control BMP should be documented. Specifics are provided in **Section 2.2**.

Figure 13 - SMR HMP Options for Hydrologic Control BMPs

Type of Hydrologic Control BMP	Onsite	Regional	Offsite (management or in-channel restoration)	Management Bank (if available)	Green Street Project or equivalent
Large (>100 ac)	Yes	Yes	n/a	n/a	n/a
Medium (1 ac ≤A≤100 ac)	Yes - #1	n/a	Yes - #2a	Yes - #2b	n/a
Small (<1 ac)	Yes - #1	n/a	Yes - #2a	Yes - #2b	n/a
Public roadway	n/a	n/a	Yes	n/a	Yes

b. Sediment Supply BMPs

The User may follow a three-step process to ensure maintenance of the pre-project sediment supply to the channel:

1. Determine whether the site is a significant source of Bed Sediment Load to the receiving channel.
2. Avoid areas of significant Bed Sediment Load supply in the site design.
3. Replace areas of significant Bed Sediment Load supply that are eliminated through urban development.

If the three-step process is deemed infeasible, an alternative compliance option allows the User to model the site conditions and the receiving channel and provide additional management in site runoff to compensate for the reduction (or addition) of Bed Sediment Load. Specifics are detailed in **Section 2.3.ii**.

1. The User should integrate Hydrologic Control and Sediment Supply BMPs into the project site design, and define the design specifics in the preliminary project-specific WQMP that should be submitted to the Copermittee with jurisdiction over the project site. The Copermittee may approve the proposed design upon identification of compliance with the HMP Performance Standards.

APPENDIX B - Copermittee HMP Development Process

The District was the lead in the Copermittee development of the HMP. The Copermittees participated financially and through participation in HMP workshops. The workshops were scheduled over the course of the project at times corresponded with key decision points in the development of the HMP. Participants in the HMP workshops provided valuable input on the development of the HMP.

The Copermittees will continue to meet to discuss and resolve issues that may arise during HMP implementation. Participants in the HMP development process will also assist in refining and reinforcing methodologies, criteria, and standards established in the HMP.

The group of participants in the SMR HMP development process has met four times since October 2012. **Table 6** shows meeting dates, locations, and agenda items. In addition to the formal meetings, the Copermittees coordinated via email to review and discuss technical documents, deliberate on specific HMP related topics, and concur on issues.

Table 6 - SMR HMP Copermittee Meetings

Date	Location	Agenda
October 29, 2012	District, Riverside	SMR HMP Outline and Approach Presentation of the San Diego Hydrology Model Tool
December 2012	City Hall, Murrieta	Presentation and discussion of the first Draft SMR HMP Presentation and discussion of the HMP Evaluation Program Schematic
March 2013	City Hall, Temecula	Presentation and discussion of the second Draft SMR HMP Presentation and discussion of the Draft HMP Evaluation Program
April 2013	District, Riverside	SMRHM Training Workshop
May 2013	City Hall, Temecula	Presentation and discussion of the Final SMR HMP Presentation of the Final HMP Evaluation Program
June 2014	District, Riverside	Compliance document training

A Draft SMR HMP was submitted to the SDRWQCB in June 2013 and a proposed final HMP that addressed the SDRWQCBs comments was submitted on March 10, 2014. The final HMP was submitted on July 11, 2014 to address the additional SDRWQCBs comments received on April 8, 2014 and incorporate the Final SMR HMP requirements into the SMR WQMP. In addition, the Copermittees used the revised SMR WQMP to incorporate the HMP requirements into their development approval processes through their WQMPs and municipal ordinances.

As required by Permit Provision F.1.h(5)(a), the draft document was posted on the District's website in January 2013 (http://rcflood.org/NPDES/SantaMargaritaWS.aspx) for public review and comment. The Final Draft SMR HMP was also posted on the District's website for a second round of public review and comment.

APPENDIX C - State of the Hydromodification Science: A Literature Review

Pursuant to 2010 SMR MS4 Permit Provision F.1.h(1)(g), this appendix provides the results of a literature review conducted as a basis for the development of the HMP.

Hydromodification in the context of this HMP refers to changes in the magnitude and frequency of channel flows due to urbanization and the resulting impacts on the receiving channels in terms of erosion, sedimentation, and degradation of in-channel habitat. The processes involved in aggradation and degradation are complex, but may be affected by an alteration of the hydrologic regime of a watershed due to increases in impervious surfaces, more efficient MS4 facilities, and a change in historic sediment supply sources, among other factors. The study of Hydromodification is an evolving field, and regulations to manage the impacts of Hydromodification must be grounded in the latest science available.

HMPs seek ways to manage Hydromodificaton that may result from urban development by establishing requirements for controlling runoff from New Development and Redevelopment projects. In order to establish appropriate requirements for New Development and Redevelopment, it is important to understand 1) how land use changes alter stormwater runoff; and 2) how these changes can impact receiving channels. These and other issues central to HMPs adopted in California have been addressed in numerous journal articles, books, and reports. This literature review builds upon previous literature reviews developed for the South Orange County HMP and the San Diego County HMP, including recent studies or information relevant to Southern California.

C.1. Hydromodification Management Concepts

There are many different approaches to managing Hydromodification impacts from urban development, and most HMPs provide multiple options for achieving and documenting compliance with National Pollutant Discharge Elimination System (NPDES) MS4 permit requirements. In general, hydrograph management approaches focus on managing runoff from a developed area to not increase instability in a channel, and in-channel solutions focus on managing the receiving channel to accept an altered flow regime without becoming unstable. This section briefly summarizes various approaches for HMP compliance.

C.1.1. Stability of Alluvial Channels

Southern California channels typically combine steep slopes and erodible materials with a predominance of sand and gravel substrates, which may be assimilated to alluvial channels (SCCWRP, 2011). An exchange of material between the inflowing sediment load and the bed and banks of the channel is established, thus creating a constant adjustment of the channel's width, depth, slope, and planform in response to changes in water or sediment discharge (NEH, 2007). A channel planform is defined as the horizontal alignment of a channel as observed from a point perpendicular to the Earth's surface (USDA, 2007). Natural alluvial channels constantly form their geometry by moving boundary material to react to changes in precipitation and the rate of tectonic uplift. Lane's interrelationship (1955) conceptualizes this balance between hydrologic and geomorphic processes for alluvial channels:

$$Q_s \times D_{50} \propto Q_w \times S$$

Where:

Q_s = Sediment discharge

D_{50} = Median sediment size

Q_w = Flow

S = Channel Slope

As seen by Lane's interrelationship, if any of the four variables is altered, one or more of the remaining variables must change.

Due to natural and/or man-made conditions, such as construction of Vail Lake and Skinner Reservoir, a majority of channels within the SMR are dynamically adjusting to a new geomorphic equilibrium corresponding to the altered hydrology and sediment transport regimes. The tributary areas to both Vail Lake and Skinner Reservoir consist primarily of mountainous highlands, with narrow, deeply incised drainages whose rate of incision is naturally dependent on precipitation and the rate of tectonic uplift. In addition, the construction of Vail Dam and Skinner Reservoir and historical urbanization within the SMR have progressively altered the hydrology and sediment transport regimes in the downstream channels. Approximately two-thirds of the Upper Santa Margarita River Watershed is controlled by these dams, which conserve virtually all of the runoff for municipal, industrial and agricultural use. Recent observations of the downstream channels show that the latter are still geomorphically adjusting to the altered hydrology and sediment transport regimes. Downstream of the constructed dams, the reduction in frequency and magnitude of discharges into Temecula Creek and Tulacota Creek has resulted in a significant reduction of the cumulative work performed in those downstream channels (See Section C.2.1.), which may result into increased aggradation of Temecula Creek, Tulacota Creek, and their respective downstream reaches. In essence, the SMR is a dynamic system that is still converging towards a geomorphic equilibrium.

In addition to Vail Lake and Skinner Reservoir, the Permittees have constructed a significant storm drain infrastructure to control storm water discharges from urbanized areas and provide an adequate level of protection against flooding hazards in urbanized communities. Currently, two-thirds of the SMR are controlled by controlled-release points, or flood control basins that effectively reduce the magnitude and frequency of incoming storm water discharges. In areas tributary to those controlled-release points, increases in runoff discharge, magnitude, and frequency associated with future urbanization are managed to ensure the long-term stability of downstream channels, thus resulting in aggradation in those downstream channels.

For those channels that are not influenced by dams and controlled-release points, urban development in the upstream reaches will usually result in increased runoff, causing an incremental reduction in channel slope (S) through downcutting or increased channel meander to the existing dynamic adjustment due to the construction of Vail Dam and Skinner Reservoir. Urban development may also result in incremental change in sediment discharge (Qs). Bed sediment load is derived from the channel bed and banks. If channels are altered by urban development in such a way as to reduce or increase sediment discharge, instability may occur.

Only a portion of the total sediment load in a channel is important for channel stability. Total channel sediment load may be classified by size or transport mechanism. The wash load commonly refers to the portion of the total sediment load that remains continuously in suspension (based on particle size). The wash load has a nominal impact on channel stability. Bed sediment load refers to the material that moves along the channel bed via Saltation, and is continuously in contact or exchange with the channel bed. Bed sediment load is the critical portion of total sediment discharge for channel stability.

C.1.2.Hydrologic Management Measures

Facilities that detain or infiltrate runoff to manage development impacts are the focus of most HMP implementation guidance. They work by either reducing the volume of runoff (infiltration facilities) or holding water and releasing it below the critical flow (Qc) (detention facilities). These facilities, also referred to as Hydrologic Control BMPs, can range from regional detention basins designed solely for flow control, to bioretention facilities that serve a number of functions. A number of Hydrologic Control BMPs, including swales, bioretention, flow-through planters, and extended detention basins have been developed to manage stormwater quality, and several resources describe the design of stormwater quality BMPs (CASQA 2003; Richman et al. 2004). In many cases, these facilities can be designed to also meet Hydrologic Performance Standards.

Many HMPs also provide guidance for applying LID approaches to site design and land use planning to preserve the hydrologic cycle of a watershed and manage Hydromodification impacts. These plans typically include decentralized stormwater management systems and protection of natural drainage features, such as wetlands and channel corridors. Runoff is typically directed toward infiltration-based stormwater BMPs that slow and treat runoff. Hydrologic Control BMPs differ from those used to meet Water Quality Objectives in that they focus more on generating a flow duration curve that matches or reduces the undeveloped flow duration curve than on removing potential Pollutants, although these two functions can be combined into one facility. Various methods exist for sizing Hydrologic Control BMPs.

- **Hydrograph Matching** uses an outflow hydrograph for a particular site that matches closely with the pre-project hydrograph for a design storm. This method is most traditionally used to design flood-detention facilities to manage for a particular storm recurrence interval (e.g., the 100-year storm). Although hydrograph matching can be employed for multiple storm recurrence intervals, this method generally does not take into account the smaller, more frequent storms that are identified by the actual state of the science as performing a majority of the erosive work on channels and is therefore not widely accepted for HMP compliance nor recommended for use as a part of this HMP.

- **Volume Control** matches the pre-project and post-construction runoff volume for a project site. Any increase in runoff volume is either infiltrated onsite, or discharged to another location where channels will not be impacted. The magnitude of peak flows and Time of Concentration is not controlled, so while this method ensures there is no increase in total volume of runoff, it can result in higher erosive forces during storms.

- **Flow Duration Control** matches or reduces both the duration and magnitude of a specified range of storms. The entire hydrologic record is taken into account, and pre-project and post-construction runoff magnitudes and volumes are matched as closely as possible. Excess runoff is either infiltrated onsite or discharged below Qcp (Geomorphically critical flow – 10% of the 2-year flow).

The Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVUPPP) HMP reviewed each of these methods and concluded that a Flow Duration Control approach was the most effective in controlling erosive flows. Two examples were evaluated using this approach, one on the Thompson Creek subwatershed in Santa Clara Valley and one on the Gobernadora Creek watershed in Orange County. The evaluation approach used continuous simulation modeling to generate flow duration curves, and then designed a test Hydrologic Control BMP to match pre-project durations and flows.

In addition to the SCVURPP HMP, the flow duration control approach has been applied by the Alameda Countywide Clean Water Program, San Mateo County Water Pollution Prevention Plan, the Fairfield-Suisun Urban Runoff Management Program, Contra Costa Clean Water Program, San Diego County, and South Orange County. Among these agencies, different approaches have emerged on how to demonstrate that proposed Hydrologic Control BMPs meet flow duration control guidelines. Both methods employ continuous simulation to match or reduce flow durations, but differences exist in how continuous simulation is used (site-specific simulation vs. unit area simulation). Differences also exist in the focus of the two approaches (regional detention facilities vs. onsite LID facilities). Both approaches were evaluated by the different RWQCBs and deemed valid (Butcher 2007).

Other existing HMPs have defined an approach to design and implement hydrologic control BMPs, including Counties of the Bay Area and Contra Costa County.

BAHM Approach

The Bay Area Hydrology Model (BAHM) is a continuous simulation rainfall runoff hydrology model developed for ACCWP, SMCWPPP, and SCVURPP. It was developed from the Western Washington Hydrology Model, which focuses primarily on meeting Hydromodification Management Performance Standards using stormwater detention ponds alone or combined with LID facilities (Butcher 2007). The Western Washington Hydrology Model is based on the Hydrologic Simulation Program – FORTRAN (HSPF) modeling platform, developed by the USEPA, and uses HSPF parameters in modeling watersheds.

Users who want to size a Hydrologic Control BMP select the location of their project site from a map of the Bay Area and BAHM correlates the project location to the nearest rainfall gauge and applies an adjustment factor to the hourly rainfall for the nearest gauge, to produce a weighted hourly rainfall at the project site. The User then enters parameters for the proposed project site describing soil types, slope, and land uses. BAHM then runs the continuous rainfall-runoff simulation for both the pre-project and the post-construction conditions of the project site. Output is provided in the form of flow duration curves that compare the magnitude and timing of storms between the pre-project and the post-construction modeling runs.

If an increase in flow durations is predicted, the User can select and size Hydrologic Control BMPs from a list of modeling elements. An automatic sizing subroutine is available for sizing detention basins and outlet orifices that matches the flow duration curves between the pre-project scenario and a post-construction management scenario. Manual sizing is necessary for other Hydrologic Control BMPs included in the program, such as storage vaults, bioretention areas, and infiltration trenches. The program is designed so that, once a Hydrologic Control BMP is selected and sized, the modeling run can be transferred to the Copermittee with jurisdiction over the project site for approval. The Copermittee model reviewer can launch the program and verify modeling parameters and sizing techniques.

A HMP tool was also developed to support Users with the San Diego County HMP. The San Diego Hydrology Model (SDHM) derives from the BAHM, and integrates parameters that are specific to San Diego County. Similarly, the South Orange Hydrology Model (SOHM) was developed for the purposes of the South Orange County NPDES Permit.

A similar approach will be used for the SMR HMP. The Western Washington Continuous Simulation Hydrology Model (WWHM) has been modified to include local rainfall and loss rate information, in addition to preferred local BMP selection to provide Users a user-friendly tool to develop a Hydromodification management strategy. The SMRHM allows the user to match or reduce the flow duration curve for the selected range of flows using locally preferred BMPs.

Contra Costa Clean Water Program (CCCWP) Approach

The CCCWP developed a protocol for selecting and sizing Hydrologic Control BMPs, which are referred to as Integrated Management Practices (IMPs) in their guidebook. Instead of a User running a site-specific continuous simulation to size Hydrologic Control BMPs, the CCCWP provides sizing factors for designing site level IMPs. Sizing factors are based on the soil type of the project site and are adjusted for Mean Annual Precipitation. Sizing factors are provided for bioretention facilities, flow-through planters, dry wells and a combination cistern and bioretention facility.

Sizing factors were developed through continuous simulation HSPF modeling runs for a variety of development scenarios. Flow durations were developed for a range of soil types, vegetation and land use types, and rainfall patterns for development areas in Contra Costa County. Then, based on a unit area (one acre) of impervious surface, flow durations were modeled using several IMP designs. These IMPs were then sized to achieve flow control for the range of storms required, (from 10% of the 2-year storm up to the 10-year storm). These sizing factors were then transferred to a spreadsheet form for use by Users.

The primary difference between the CCCWP approach and the BAHM approach is the level of modeling required. The CCCWP approach is simplified for the User in that both Hydromodification and water quality management is incorporated into the IMP sizing factors. The BAHM allows for more flexibility in that regional BMPs may be used to meet Hydromodification Performance Standards, and if desired, water quality, in addition to site level approaches. The 2010 SMR MS4 Permit allows for offsite management of Hydromodification, if the onsite infeasibility of Hydrologic Control BMPs has been demonstrated. Therefore, an approach that uses continuous simulation to assess regional or neighborhood level BMP implementation is preferred for this HMP.

C.1.3. Sediment Management Measures

Urban development can reduce the mass of Bed Sediment transported through the elimination of alluvial channel sections. This occurs in site development when first-order and particularly larger channels are lined or placed into underground conduits. First-order channels are identified as the unbranched channels that drain from headwater areas and develop in the uppermost topographic depressions, where two or more contour crenulations (notches or indentations) align and point upslope (NEH, 2007). First-order channels may, in fact, be field ditches, gullies, or ephemeral gullies (NEH, 2007).

There are two general approaches for managing the Bed Sediment Load relative to urbanization and channel stability. The first approach attempts to correct for the change in Bed Sediment Load material load by increasing or decreasing the discharge rate as appropriate to generally maintain the balance between hydrologic and geomorphic processes as conceptualized in Lane's interrelationship. While theoretically a sound approach, this option requires a significant amount of detailed information that is difficult to obtain and requires good calibration of sediment models.

Sediment transport models are non-linear and relatively sensitive to the rate of sediment supply and particle size distribution. This HMP does not recommend any specific sediment transport equation or model as the selection of such a model should be based on channel and watershed specific information, and the amount and quality of available data. Examples of sediment transport equations the designer may consider include: Duboys Formula, Meyer-Peter Formula, Einstein Bed Load Function, Modified Einstein Procedure, Colby's Method, Engelund and Hansen Method, Ackers and White Method. There are several models that use these transport formulas to predict long-term sediment transport. General guidance for site-specific analysis is provided in APPENDIX H

The second approach to maintaining sediment supply is physically based, relying on a field assessment of site locations that may supply Bed Sediment Load to the receiving channel, and protecting those sources during the site planning and development process. With this approach, the User will only provide engineered solutions for flow management. Protection of site Bed Sediment Load sources is the preferred approach since it is physically based and potentially less prone to error. Guidelines for field assessment of Bed Sediment Load sources are provided with the sediment control management approach, which is described in **Section 2.3**.

C.1.4. In-Channel Stabilization Solutions

In-Channel solutions focus on managing the channel corridor to provide stability, modifying the channel to accept an altered flow regime. In cases where development is proposed in a watershed with an impacted channel it may be beneficial to focus on rehabilitating the channel to match the new independent variables of channel cross section, sediment discharge, flow discharge and channel slope rather than retrofitting the watershed or only controlling a percentage of the runoff with onsite controls. This type of approach can restore channel functions, beneficial uses, and values at a much more rapid pace, especially in locations that cannot physically be returned to their natural state due to changes in channel alignment and restrictions on the channel cross section due to adjacent development. In addition, in some cases where a master planned watershed development plan is being implemented it may be more feasible to design a new channel to be stable under the proposed watershed land use rather than to construct distributed onsite facilities.

In-channel stabilization and restoration solutions are available as alternative compliance as a part of the SMR HMP. In-channel restoration projects are available if onsite Hydrologic Control BMPs are not feasible and it has been determined that the receiving water that the project discharges to has impacts due to Hydromodification. Tiered benefits (benthic communities, morphology) of such in-channel restoration projects must offset the hydrologic and sediment changes induced by the associated PDP(s).

A number of methods exist for managing channels to accept altered flow regimes and higher shear forces. These have been covered in detail in a number of sources available to watershed groups and public agencies. A few helpful sources include Riley 1998, Watson and Annable 2003, and FISRWG 1998.

C.1.5. Channel Susceptibility – Domain of Analysis

Southern California Coastal Water Research Project (SCCWRP) has developed a series of screening tools that evaluate the susceptibility of a channel to Hydromodification impacts (SCCWRP, 2010). These screening tools allow a User to rate the susceptibility of the evaluated channel to erosion for a variety of geomorphic scenarios including alluvial fans, broad valley bottoms, incised headwaters, etc.

The development of HMPs in most Southern California counties is correlated to the ultimate findings of SCCWRP studies on Hydromodification (SCCWRP, 2008 through 2011). It is generally acknowledged that SCCWRPs formulation of regional standards for Hydromodification management may serve as a baseline for development of HMP Performance Standards for specific regions in Southern California.

When evaluating the channel susceptibility though the SCCWRP screening tools, a domain of analysis is defined. This domain of analysis corresponds to the reach lengths upstream and downstream from a project from which Hydromodification assessment is required. The domain of analysis determination includes an assessment of the incremental flow accumulations downstream of the site, identification of grade control points in the downstream channel, and quantification of downstream tributary influences. The SMR program elected not to perform the extensive susceptibility mapping required to correlate channel reaches with variable low flow discharge thresholds, since the return on investment for this type of analysis appears to be very low.

The effects of Hydromodification may propagate for significant distances downstream (and sometimes upstream) from a point of impact such as a MS4 outfall. Accordingly, the domain of analysis serves as a representative buffer domain across which the susceptibility of a channel should be evaluated. This representative domain spans multiple channel types/settings, and is defined as follows in this HMP (SCCWRP, 2010):

Proceed downstream until reaching the closest of the following:

- at least one reach downstream of the first grade-control point (but preferably the second downstream grade-control location)
- tidal backwater/lentic waterbody
- equal order tributary (Strahler 1952)
- a two-fold increase in drainage area

OR demonstrate sufficient flow attenuation through existing hydrologic modeling.

Proceed upstream to extend the domain for a distance equal to 20 channel widths or to grade control in good condition – whichever comes first. Within that reach, identify hard points that could check headward migration, evidence that head cutting is active or could propagate unchecked upstream

Within the analysis domain there may be several reaches that should be assessed independently based on either length or change in physical characteristics. In more urban settings, segments may be logically divided by road crossings (Chin and Gregory, 2005), which may offer grade control, cause discontinuities in the conveyance of water or sediment, etc.

The domain of analysis is discussed here since it may be relevant for use in site-specific analysis as discussed in APPENDIX H . It is not used in this HMP as a discriminator for HMP applicability to a specific project.

C.2. Flow Duration Control Approach

C.2.1. Effects of Urban Development and Critical Flow

The effects of urban developments on channel response have been the focus of many studies (see Paul and Meyer, 2001 for a review), and the widely accepted consensus is that increases in impervious surfaces associated with urbanizing land uses can cause channel degradation. Urban development generally leads to a change in the amount and timing of runoff in a watershed, which may increase erosive forces on channel bank and bed material and can cause large-scale channel enlargement, general scour, channel bank failure, loss of aquatic habitat, and degradation of water quality.

Channel erosion is a complex process subject to a variety of influences. Channel erosion is non-linear (Philips 2003), meaning the response of channels is not directly proportional to changes in land use and flow regimes. Small changes or temporary disturbances in a watershed may lead to unrecoverable channel instability (Kirkby 1995). These disturbances may give rise to feedback systems whereby small instabilities can be propagated into larger and larger instabilities (Thomas 2001).

A number of studies have sought to correlate the amount of urban development in a watershed and channel instability (Bledsoe 2001; Booth 1990, 1991; Both and Jackson 1997; MacRae 1992; 1993; 1996; Coleman et al. 2005). Evidence from these studies suggests that below a certain threshold of watershed imperviousness, channels maintain stability. This threshold or imperviousness transition zone appears to be around seven to 10% watershed urbanization for perennial channels (Schueler 1998 and Booth 1997), but may begin at a lower level for intermittent channels such as those found in Southern California. Studies done in Santa Fe, New Mexico (Leopold and Dunne 1978) suggest that changes occur at 4% impervious area of the watershed.

Initial studies by Coleman et al. (2005) suggest that a response in the channel may begin to occur at two to 3% watershed imperviousness for intermittent channels in Southern California. It is important to understand that use of impermeable cover alone is a poor predictor of channel erosion due to differences in stormwater detention and infiltration within regions.

In highly urbanized watersheds returning a channel to a natural condition is infeasible due to existing development in the watershed. In these scenarios the focus should be on in-channel restoration to restore the beneficial uses of the Receiving Water.

Though it is well established that watershed urbanization causes channel degradation, a detailed understanding of how development alters runoff and how this altered runoff in turn causes erosion is still being developed.

The ability to transport sediment is proportional to the amount of flow in the channel: as flow increases, the amount of sediment moved within a channel also increases. The ability of a channel to transport sediment is termed stream power, which integrated over time is work. Leopold (1964) introduced the concept of effective work, whereby the flow-frequency relationship of a channel is multiplied by sediment transport rate. This gives a mass-frequency relationship for erosion rates in a channel. Flows on the lower end of the relationship (e.g., two-year flows) may transport less material, but occur more frequently than higher flows, thereby having a greater overall effect on the work within the channel. Conversely, higher magnitude events, while transporting more material, occur infrequently causing less effective work. Leopold found that the maximum point on the effective work curve occurred around the 1-to 2-year frequency range. This maximum point is commonly referred to as the dominant discharge. It corresponds roughly to a bankfull event (a flow that fills the active portion of the channel up to a well-defined break in the bank slope).

The constructions of Vail Lake, Skinner Reservoir, and Diamond Valley Reservoir have effectively created man-made sumps capturing the majority of incoming storm water flows from Temecula Creek, Wilson Creek, Kolb Creek, and Tucalota Creek. At these reservoirs, stormwater may only overtop the spillway(s) and be discharged into the downstream channels during higher magnitude events (10-year and higher magnitude events). Since the completion of the dams, the reduction in frequency and magnitude of discharges into Temecula Creek and Tulacota Creek has resulted in a significant reduction of the cumulative work performed in those downstream channels.

Urban development tends to have the greatest relative impact on flows that are frequent and small, and which tend to generate less-than-bankfull flows. Change is greatest in these events because prior to urban development, infiltration would have absorbed much or all of the potential runoff, but following urban development, a high percent of the rainfall runs off. Thus, events that might have generated little or no flow in a non-urbanized watershed can contribute flow in urban settings. These smaller less-than-bankfull events have been found to cause a significant proportion of the work in urban channels (MacRae 1993) due to their high frequency, and can lead to channel instability. Less frequent, larger magnitude flows (e.g., flows greater than Q10) are less strongly affected by urban development because during such infrequent storm events, the ground rapidly becomes saturated, and acts (for purposes of runoff generation) in a similar manner as impervious surfaces.

Due to the increase in impervious surfaces and fewer opportunities for infiltration of stormwater, urban development creates a higher runoff rate and more runoff volume than an un-urbanized watershed. Opportunities for infiltration of excess stormwater exist in urbanized areas, but many times are infeasible due to cost, technical barriers or land use constraints. Therefore, some of the excess stormwater must be discharged to a receiving channel. In order to achieve a comparable Ep to a pre-developed condition, this excess runoff volume must be discharged at a rate at which insignificant effective channel work is done.

The Bed Sediment Load moves through transmission of shear stress from the flow of water on the channel bed. An increase in the hydraulic radius (measure of channel flow efficiency through a ratio of the channel's cross sectional area of the flow to its wetted perimeter) corresponds to an increase in shear stress. In order to initiate movement of Bed Sediment Load, however, a shear stress threshold must be exceeded. This is commonly referred to as Critical Shear Stress, and is dependent on sediment and channel characteristics. For a given point on a channel where the bed composition and cross-section is known, the Critical Shear Stress can be related to a flow. The flow that corresponds to the Critical Shear Stress is known as the critical flow, or Qc. For a given cross-section, flows that are below the value for Qc do not initiate Bed Sediment Load movement, while flows above this value do initiate Bed Sediment Load movement.

C.2.2. Geomorphically-Significant Flows in Existing HMPs

SCVURPPP expressed Qc as a percentage of the two-year flow in order to develop a common metric across watersheds of different size, and allow for easy application of HMP performance standards. For the two watersheds studied in detail in the SCVURPPP study, a similar relationship was found where Qc corresponded to 10% of the two-year flow. Several methodologies were used to determine both the two-year flows and the ten-year flows across the evaluated watersheds. The two-year flow was computed based on either the rational method, as described in the Santa Clara Valley Hydrology Procedures, or the Cunnane ranking schema applied to "all event frequency" curves. The ten-year flow was computed based on the Log Pearson type III distribution applied to annual flow frequency curves. This became the basis for the lower range of geomorphically significant flows under the SCVURPPP HMP and is referred to as Qcp to indicate that it is a percentage of flow. That program also adopted the 10-year flow as the upper end of the range of flows to control with the justification that increases in channel work above the 10-year flow were small for urbanized areas.

A similar study was conducted for the Fairfield-Suisun Urban Runoff Management Program (FSURMP) on two watersheds in Fairfield, California following a geomorphic assessment. That study found Qcp to be 20%t of the pre-development two-year flow. The differences in the two values may be attributable to differences in watershed characteristics in Santa Clara County and Fairfield, the number of channels studied, the methodology used to compute the two-year flow, and the precision of the modeling tools. Channels in Fairfield were found to have a more densely vegetated riparian corridor and may have a higher resistance to increases in shear stresses (FSURMP). Values for Qcp appear to be similar among neighboring watersheds, but there appears to be a range of appropriate Qcp values. The characteristics of individual biomes (climatically and geographically defined areas of ecologically similar climatic conditions, such as communities of plants, animals, and soil organisms, often referred to as ecosystems) should be taken into account when developing a Qcp. For example, Western Washington State, which has more densely vegetated riparian zones than either Fairfield or Santa Clara County, has adopted a Qcp of 50% of the 2-year flow.

The Santa Clara HMP focused on using detention basins for Hydromodification management and emphasized the lower flow control limit for site runoff. Extended detention Hydrologic Control BMP basins can be constructed with multi-stage outlets to manage both the duration and magnitude of flows within a prescribed range. To avoid the erosive effects of extended low flows, the maximum rate (depth) at which runoff is discharged is set below the erosive threshold. Per the Santa Clara HMP, the lower flow control limit was defined as the flow rate that generates critical shear stress on the channel bed and banks. Both Santa Clara and Alameda Counties correlated the lower flow control limit to a value equal to 10% of the 2-year runoff event.

The Contra Costa HMP emphasized the importance of using LID methods to meet Hydromodification Performance Standards. LID approaches to Hydrologic Performance Standards rely on site design and distributed LID BMPs to control the frequency and duration of flows, and to manage hydrograph modification impacts. By minimizing directly connected impervious areas and promoting infiltration, LID approaches mimic natural hydrologic conditions to counteract the hydrologic impacts of development. LID systems are sized to achieve flow control for the range of storms required (from 10% of the 2-year storm up to the 10-year storm).

The San Diego County HMP defined an adaptive lower flow threshold based on the channel susceptibility rating (high, medium, or low). Receiving channels in San Diego County were individually classified by their susceptibility to channel erosion impacts using a critical flow calculator and a channel screening tool developed by SCCWRP. This classification produced three lower flow thresholds which are 0.1Q2, 0.3Q2, and 0.5Q2. The upper range of the management flow was considered the pre-project 10-year storm event.

To date, seven approved HMPs have been published. These include HMPs for SCVURPPP (2005), the CCCWP (2005), the FSURMP (2005), the Alameda Countywide Clean Water Program (ACCCMP 2005), the San Mateo Countywide Stormwater Pollution Prevention Program (SMCWPPP [formerly STOPPP] 2005), the San Diego County HMP (2009), and the South Orange County HMP (2012). In addition, a number of HMPs were implemented while agencies developed their final plans. Interim HMPs are not detailed in this report because these plans have adopted findings from the above listed HMPs. A summary of flow control standards adopted in each of the approved HMPs in California and western Washington is given in **Table 7**.

Table 7 - Summary of Flow Control Standards – Approved HMPs

Permitting Agency	Q_{cp}	Largest Managed Flow
Alameda County	10% of the 2-year flow (0.1Q2)	10-year flow (Q10)
Contra Costa County	10% of the 2-year flow (0.1Q2)	10-year flow (Q10)
Fairfield-Suisun Urban Runoff Management Program	20% of the 2-year flow (0.2Q2)	10-year flow (Q10)
San Diego County	10, 30, or 50 % of the 2-year flow (0.1Q2, 0.3Q2, or 0.5Q2)	10-year flow (Q10)
San Mateo County	10% of the 2-year flow (0.1Q2)	10-year flow (Q10)
Santa Clara County	10% of the 2-year flow (0.1Q2)	10-year flow (Q10)
South Orange County	10% of the 2-year flow (0.1Q2)	10-year flow (Q10)
Western Washington State	50% of the 2-year flow (0.5Q2)	50-year flow (Q50)

C.2.3. Applicable Flow Thresholds for the SMR

HMPs that have been developed in the San Francisco Bay Area, Northern California (Contra Costa, Santa Clara, and Alameda Counties and the Sacramento area), in Southern California (San Diego, South Orange Counties) vary with regard to the emphasis placed on lower flow control thresholds as compared to other approaches, such as distributed LID methods. The SMR HMP was developed using the lower flow control threshold approach. There is consensus in that both the frequency and duration of flows must be controlled using continuous simulation hydrologic modeling (rather than the standard design storm approach used for flood control design) to manage for potential development impacts. At this point, it is generally accepted that events more frequent than the 10-year flow are the most critical for Hydromodification management, since flows within this range of return period (up to the 10-year event) have been documented to perform the most work on the channel bed and banks. However, the range of analysis could potentially change in the future if new studies provide sufficient evidence warranting a modification.

Rates of sediment production from Southern California rivers depend upon bedrock geology, rates of tectonic uplift, land use, and precipitation (Warrick et al., 2003). The California Geological Survey agency identifies 13 unique geomorphic zones based on geology, faults, topographic relief, and climate (California Department of Conservation, 2002). The SMR is located within the Peninsular Ranges geomorphic zone, whose geology is characterized by the granitic rocks intruding the older metamorphic rocks. South Orange County and San Diego County are also located within the same geomorphic zone, thus exhibits similar macro-scale geomorphic trends to those in the SMR.

The approaches developed for the San Diego County HMP and the South Orange County HMP were approved by the SDRWQCB and selected as the base approach for the SMR HMP. However, the South Orange County program elected not to perform the extensive susceptibility mapping required to correlate channel reaches with variable low flow discharge thresholds. The implementation of HMPs in Northern California, and in San Diego County has shown that numerically larger low flow thresholds generally have very limited applicability in practice. Accordingly, a base low flow threshold (0.1Q2) was selected for this HMP. The selection of the low flow threshold (0.1Q2) was based on other approved HMPs in California with similar hydrologic and geologic conditions. The low flow threshold (0.1Q2) is the most conservative of the potential range identified in the San Diego HMP. Nonetheless, the User may compute a site-specific low flow threshold at their option, following a methodology developed by the User. An example of such a procedure is described in the San Diego County HMP.

If the User opts for developing a site-specific criterion, the selected lower flow threshold should correspond to the critical channel flow that produces the critical shear stress that initiates channel Bed Sediment movement or that erodes the toe of channel banks. For a channel segment that is lined but not exempt by this HMP, the low flow threshold must be computed assuming the lining has been removed.

C.3. Classification and Geomorphic Stability of Channels

Numerous channel stability assessment methods have been proposed to help distinguish which channels are most at risk from hydrograph modification impacts and/or define where HMP Performance Standards should apply. Assessment strategies range from purely empirical approaches to channel evolution models to energy-based models (see Simon et al., 2007 for a critical evaluation). Channel stability assessment methods are useful in assessing the impact of urban development or control programs over time. Their value lies in showing trends as changes in a watershed occur, rather than classifying the reach of a discrete channel section at a given point in time.

C.3.1. Empirical approaches and Models

A recent study by Bledsoe et al. (2008) for SCCWRP describes nine types of classification and mapping systems with an emphasis on assessing channel susceptibility in Southern California. The summary below is taken from that study. Bledsoe also provides a summary of the implications of these classification and mapping systems to the development of Hydromodification tools for Southern California. The article provides a detailed breakdown of guidelines for developing Hydromodification tools given the advantages and disadvantages of each system previously assessed.

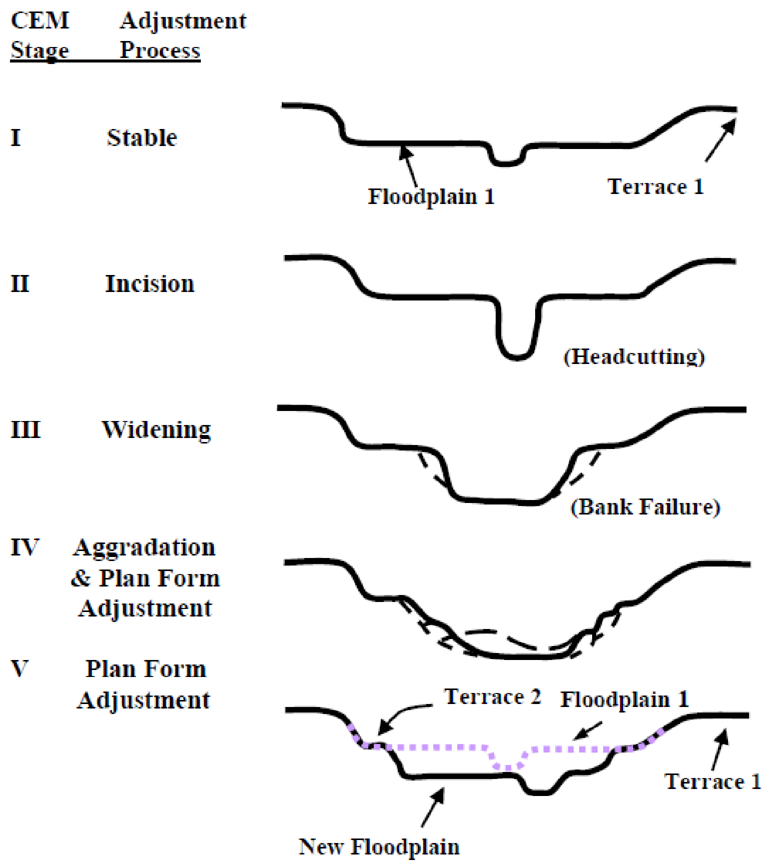
General Stability Assessment Procedures

By assessing an array of qualitative and quantitative parameters of channels and floodplains, several investigators have developed qualitative assessment systems for channel and river networks. These assessment methods have been incorporated into models used to analyze channel evolution and stability. Many parameters used to establish methodologies such as the Rosgen approach are extendable to a qualitative assessment of channel response in Californian river networks. Field investigations in Southern California have shown that grade control can be the most important factor in assessing the severity of channel response to Hydromodification. Qualitative methodologies have proven extendable to many regions, and they use many parameters that may provide valuable information for similar assessments in California.

Channel Evolution Models of Incising Channels

The Channel Evolution Model (CEM) developed by Schumm et al. (1984) posits five stages of incised channel instability organized by increasing degrees of instability severity, followed by a final stage of quasi-equilibrium. Work has been done to quantify channel parameters, such as sediment load and specific stream power, through each phase of the CEM. A dimensionless stability diagram was developed by Watson et al. (2002) to represent thresholds in hydraulic and bank stability. This conceptual diagram can be useful for engineering planning and design purposes in channel restoration projects requiring an understanding of the potential for shifts in bank stability.

Figure 15 - Five Stages of the Channel Evolution Model (CEM)



Channel Evolution models Combining Vertical and Lateral Adjustment Trajectories (Schumm et al. 1984)

Originally, CEMs focused primarily on incised channels with geotechnically, rather than fluvially, driven bank failure. Several CEMs have been proposed that incorporate channel responses to erosion and sediment transport into the original framework for channel instability. In these new systems, an emphasis is placed on geomorphic adjustments and stability phases that consider both fluvial and geomorphic factors. The state of Vermont has developed a system of stability classification that suggests channel susceptibility is primarily a function of the existing Rosgen channel type and the current channel condition referenced to a range of variability. This system places more weight on entrenchment (vertical erosion of a channel that occurs faster than the channel can widen, resulting in a more confined channel) and slope than differentiation between bed types.

Equilibrium Models of Supply vs. Transport-capacity / Qualitative Response

The qualitative response model builds on an understanding of the dynamic relationship between the erosive forces of flow and slope relative to the resistive forces of grain size and sediment supply to describe channel responses to adjustments in these parameters. In this system, qualitative schematics provide predictions for channel response to positive or negative fluctuations in physical channel characteristics and Bed Sediment. Refinements to such frameworks have been made to account for channel susceptibility relative to existing capacity and riparian vegetation among other influential characteristics.

Hierarchical Approaches to Mapping Using Aerial Photographs / GIS

It has become an increasingly common practice to characterize channel networks as hierarchical systems. This practice has presented the value in collecting channel and floodplain attributes on a regional scale. Multiple studies have exploited geographical information systems (GIS) to assess hydrogeomorphic behavior at a basin scale. Important valley scale indices such as valley slope, confinement, entrenchment, riparian vegetation influences, and overbank deposits can provide information for river networks in California. Many agencies are developing protocols for geomorphic assessment using GIS and other database associated mapping methodologies. These tools may be useful as they are further developed in a monitoring program, but are not viable at a scale useful for reach-by-reach channel analysis.

The approach taken by this HMP to monitor its effectiveness is embedded in a derivative of the channel classification approach defined by Rosgen (1996). The author distinguishes three different levels of channel classification including: 1) Level I that generally describes channel relief, landform, and valley morphology; 2) Level II that describes the morphology of a channel and associates the later to a channel type based on channel form and Bed Sediment composition. Field measurements of entrenchment, width-to-depth ratio, sinuosity, slope, and representative sampling of channel material may be suitable; and 3) Level III that assesses channel condition and departure. A channel that is geomorphically stable per Rosgen's definition is characterized by two elements: 1) Dimension, pattern, and profile of a channel are maintained over time; and 2) the transport capacity of a watershed's flows and detritus is maintained. As such, physical and biological functions of a geomorphologically stable channel remain at an optimum.

C.3.2. Channel Classification System

Planform Classifications and Predictors

Alluvial channels form a continuum of channel types whose lateral variability is primarily governed by three factors: flow magnitude, bank erodibility, and relative sediment supply. Though many natural channels conform to a gradual continuum between straight and intermediate, meandering, and braided patterns, abrupt transitions in lateral variability imply the existence of geomorphic thresholds where sudden change can occur. The conceptual framework for geomorphic thresholds has proven integral to the study of the effects of disturbance on river and channel patterns. Many empirical and theoretical thresholds have been proposed relating channel power, sediment supply and channel gradient to the transition between braiding and meandering channels. Accounting for the effects of Bed Sediment particle size has been shown to provide a vital modification to the traditional approach of defining a discharge slope combination as the threshold between meandering and braided channel patterns. The many braided planforms in Southern California indicate the need to refine and calibrate established thresholds to river networks of interest. However, at this time there is not a well-accepted model to predict how Hydromodification affects channel planform.

Energy-Based Classifications

The link between channel degradation and urbanization has been studied; however, impervious area is not the solitary factor influencing channel response. Studies have shown that the ratio between specific channel power and median Bed Sediment size D50b, where b is approximately 0.4 to 0.5 for both sand-and gravel-bed channels, can be used as a valuable predictor of channel form. Stream power, which is linearly related to the total discharge, is the most comprehensive descriptor of hydraulic conditions and sedimentation processes in channels. Several studies have been performed relating channel stability to a combination of parameters such as discharge, median Bed Sediment size, and bed slope, as an analog for stream power.

A recent study by Bledsoe et al. (2008) for SCCWRP describes nine types of classification and mapping systems with an emphasis on assessing channel susceptibility in Southern California. The summary below is taken from that study. Bledsoe also provides a summary of the implications of these classification and mapping systems to the development of Hydromodification tools for Southern California. The article provides a detailed breakdown of guidelines for developing Hydromodification tools given the advantages and disadvantages of each system previously assessed.

Sand vs. Gravel Behavior / Threshold vs. Live-Bed Contrasts

It is well recognized that the fluvial-geomorphic behavior varies greatly between sand and gravel/cobble systems. Live bed channels (of which sand channels are good examples) are systems where sediment moves at low flows, and where sediment is frequently in motion. Threshold channels, such as gravel channels, by contrast, require considerable flow to initiate Bed Sediment Load movement. Live bed channels are more sensitive to increases in flow and decreases in sediment supply than threshold channels. Scientific consensus shows that sand bed channels lacking vertical control show greater sensitivity to changes in flow and sediment transport regimes than do their gravel/cobble counterparts. Factors such as slope, and sedimentation regimes are known to have greater impact on sand bed channels. This can be an important issue for stormwater systems receiving runoff from watersheds composed primarily of channels with sandy substrate. The transition between sand and gravel bed behavior can be rapid, enabling the use of geographic mapping methods to prioritize channel segments according to their susceptibility to the effects of Hydromodification.

Bank Instability Classifications

Early investigations provided the groundwork for bank instability classifications by analyzing shear, beam, and tensile failure mechanisms. The dimensionless stability approach developed by Watson characterized bank stability as a function of hydraulic and geotechnical stability. Rosgen (1996) proposed the widely applied Bank Erosion Hazard Index (BEHI) as a qualitative approach based on the general stability assessment procedures outlined above. Other classification systems, like the CEM, determine bank instability according to channel characteristics that control hydrogeomorphic behavior.

As required per 2010 SMR MS4 Permit Provision F.1.h(1)(a), a Hydromodification Susceptibility Study has been performed as part of this HMP effort to identify and map channel segments that may be vulnerable to Hydromodification and cause a Hydrologic Condition of Concern (HCOC). The study located in APPENDIX D helps Users determine whether or not a project will drain to a potentially susceptible channel segment.

APPENDIX D - Hydromodification Susceptibility Documentation Report and Mapping: Santa Margarita Region

Restoration and Rehabilitation Opportunities in the Santa Margarita Region (refer to Appendix D)

APPENDIX E - HSPF Pervious Land Parameters for SMRHM

Pervious Land Hydrology (PWATER) Parameters

The HSPF hydrology parameters of PWATER are divided into four sections, titled PARM1-4. PARM1 is a series of checks to outline any monthly variability versus constant parameter values within the simulated algorithm; whereas, PARM2 and 3 are a series of climate, geology, topography, and vegetation parameters that require numerical values to be input.

PARM2 involves the basic geometry of the overland flow, the impact of groundwater recession, potential snow impact due to forest cover and the expected infiltration and soil moisture storage. The main parameters of groundwater recession are KVARY and AGWRC. The infiltration and soil moisture storage parameters are INFILT and LZSN.

PARM3 involves the impact of climate temperature during active snow conditions, a wide range of evaporation parameters due to the variability of the onsite soil and existing vegetation and subsurface losses due to groundwater recharge or the existing geology. The main evaporation parameters are INFEXP, INFILD, BASETP, and AGWETP. The parameter for subsurface loss is DEEPFR, which accounts for one of only three major losses from the PWATER water balance (i.e., in addition to evaporation, and lateral and channel outflows).

PARM4 involves the flow and hydrograph characteristics, the expectation of rain interception due to the inherent moisture storage capacity from existing vegetation, land use and/or near surface soil conditions and evaporation due to the root zone of the soil profile. The main interception parameters are CEPSC and UZSN. The parameter for evaporation as a primary function of vegetation is LZETP.

PARM2

KVARY – A groundwater recession flow parameter used to describe non-linear groundwater recession rate (per inches) (initialize with reported values, then calibrate as needed). KVARY is usually one of the last PWATER parameters to be adjusted; it is used when the observed groundwater recession demonstrates a seasonal variability with a faster recession (i.e., higher slope and lower AGWRC values) during wet periods, and the opposite during dry periods. Value ranges are shown in Table A-4. Values that are representative of the conditions in South Orange County have been selected for the SOCHM. Plotting daily flows with a logarithmic scale helps to elucidate the slope of the flow recession.

AGWRC – A groundwater recession rate, or ratio of current groundwater discharge to that from 24 hours earlier (when KVARY is zero) (per day) (estimate, then calibrate).

The overall watershed recession rate is a complex function of watershed conditions, including climate, topography, soils, and land use. Hydrograph separation techniques can be used to estimate the recession rate from observed daily flow data (such as plotting on a logarithmic scale).

INFILT – Index to mean soil infiltration rate (in/hr); (estimate, then calibrate). In HSPF, INFILT is the parameter that effectively controls the overall division of the available moisture from precipitation (after interception) into surface runoff. Since INFILT is not a maximum rate nor an infiltration capacity term, its values are normally much less than published infiltration rates, percolation rates (from soil percolation tests), or permeability rates from the literature. INFILT is primarily a function of soil characteristics, and value ranges have been related to the Soil Conservation Source (SCS) hydrologic soil groups (Donigian and Davis, 1978, p.61, variable INFIL) as follows (**Table 8**):

Table 8 - SCS Hydrologic Soil Group Characteristics

SCS Hydrologic Soil Group	INFILT Estimate		Runoff Potential
	(in/hr)	(mm/hr)	
A	0.4 – 1.0	10.0 – 25.0	Low
B	0.1 – 0.4	2.5 – 10.0	Moderate
C	0.05 – 0.1	1.25 – 2.5	Moderate to High
D	0.01 – 0.05	0.25 – 1.25	High

An alternate estimation method that has not been validated is derived from the premise that the combination of infiltration and interflow in HSPF represents the infiltration commonly modeled in the literature (e.g., Viessman et al., 1989, Chapter 4). With this assumption, the value of 2.0*INFILT*INTFW should approximate the average measured soil infiltration rate at saturation, or mean permeability.

LZSN – Lower zone nominal soil moisture storage (inches). LZSN is related to both precipitation patterns and soil characteristics in the region. Viessman, et al, 1989, provide initial estimates for LZSN in the Stanford Watershed Model (SWM-IV, predecessor model to HSPF) as one-quarter of the mean annual rainfall plus four inches for arid and semiarid regions, or one-eighth annual mean rainfall plus four inches for coastal, humid, or subhumid climates.

PARM3

INFEXP – Exponent that determines how much a deviation from nominal lower zone storage affects the infiltration rate (HSPF Manual, p. 60).

Variations of the Stanford approach have used a POWER variable for this parameter; various values of POWER are included in Donigian and Davis (1978, p. 58). However, the vast majority of HSPF applications have used the default value of 2.0 for this exponent.

INFILD – Ratio of maximum and mean soil infiltration capacities. In the Stanford approach, this parameter has always been set to 2.0, so that the maximum infiltration rate is twice the mean (i.e., input) value; when HSPF was developed, the INFILD parameter was included to allow investigation of this assumption. However, there has been very little research to support using a value other than 2.0.

DEEPFR - The fraction of infiltrating water which is lost to deep aquifers (i.e., inactive groundwater), with the remaining fraction (i.e., 1-DEEPFR) assigned to active groundwater storage that contributes baseflow to the channel.

It is also used to represent any other losses that may not be measured at the flow gauge used for calibration, such as flow around or under the gauge site. Watershed areas at high elevations, or in the upland portion of the watershed, are likely to lose more water to deep groundwater (i.e., groundwater that does not discharge within the area of the watershed), than areas at lower elevations or closer to the gauge.

BASETP – ET by riparian vegetation as active groundwater enters the channel bed; specified as a fraction of potential ET, which is fulfilled only as outflow exists.

If significant riparian vegetation is present in the watershed then non-zero values of BASETP are typically applied. If riparian vegetation is significant, a generic BASETP value of 0.2 is typically representative of the evapotranspiration conditions in the San Juan Hydrologic Unit. This value was established in conjunction with a satisfactory annual water balance.

AGWETP – Fraction of model segment (i.e., pervious land segment) that is subject to direct evaporation from groundwater storage, e.g., wetlands or marsh areas, where the groundwater surface is at or near the land surface, or in areas with phreatophytic vegetation drawing directly from groundwater. This is represented in the model as the fraction of remaining potential ET (i.e., after base ET, interception ET, and upper zone ET are satisfied), that can be met from active groundwater storage.

A value of 0.05 has been selected for inclusion into the SOCHM. This value was adjusted and calibrated in the Aliso Creek watershed HSPF model (Orange County) based on adjustment of the low flow simulation, and ultimately the annual water balance.

PARM4

CEPSC – Amount of rainfall, in inches, which is retained by vegetation, that never reaches the land surface, and is eventually evaporated (estimate, then calibrate). Typical guidance for CEPSC for selected land surfaces is provided in Donigian and Davis (1978, p. 54, variable EPXM) (**Table 9**).

Table 9 - CEPSC for Selected Land Surfaces

Land Cover	Maximum Interception (in)
Grassland	0.10
Cropland	0.10 – 0.25
Forest Cover, light	0.15
Forest Cover, heavy	0.20

LZETP – Index to lower zone evapotranspiration (unitless). LZETP is a coefficient to define the ET opportunity; it affects evapotranspiration from the lower zone, which represents the primary soil moisture storage and root zone of the soil profile. LZETP behaves much like a "crop coefficient" with values mostly in the range of 0.2 to 0.7; as such, it is primarily a function of vegetation. Typical and possible value ranges are shown in **Table 11**, and the following ranges for different vegetation are expected for the "maximum" value during the year (**Table 10**):

Table 10 - LZETP Value Ranges

Land Cover Type	Input Coefficient
Forest	0.6 – 0.8
Grassland 0.4	0.4 - 0.6
Row Crops 0.5	0.5 – 0.7
Barren 0.1	0.1 – 0.4
Wetlands 0.6	0.6 – 0.9

Table 11 - Typical permanent channel cross-section with benchmark locations and points of measurement – Rosgen (1996)

HSPF HYDROLOGY PARAMETERS AND VALUE RANGES

			RANGE OF VALUES					
NAME	DEFINITION	UNITS	TYPICAL		POSSIBLE		FUNCTION OF ...	COMMENT
			MIN	MAX	MIN	MAX		
PWAT - PARM2								
FOREST	Fraction forest cover	none	0.0	0.50	0.0	0.95	Forest cover	Only impact when SNOW is active
LZSN	Lower Zone Nominal Soil Moisture Storage	inches	3.0	8.0	2.0	15.0	Soils, climate	**Calibration**
INFILT	Index to Infiltration Capacity	in/hr	0.01	0.25	0.001	0.50	Soils, land use	**Calibration**, divides surface and subsurface flow
LSUR	Length of overland flow	feet	200	500	100	700	Topography	Estimate from high resolution topo maps or GIS
SLSUR	Slope of overland flow plane	ft/ft	0.01	0.15	0.001	0.30	Topography	Estimate from high resolution topo maps or GIS
KVARY	Variable groundwater recession	1/inches	0.0	3.0	0.0	5.0	Baseflow recession variation	Used when recession rate varies with GW levels
AGWRC	Base groundwater recession	none	0.92	0.99	0.85	0.999	Baseflow recession	**Calibration**
PWAT - PARM3								
PETMAX	Temp below which ET is reduced	deg. F	35.0	45.0	32.0	48.0	Climate, vegetation	Reduces ET near freezing, when SNOW is active
PETMIN	Temp below which ET is set to zero	deg. F	30.0	35.0	30.0	40.0	Climate, vegetation	Reduces ET near freezing, when SNOW is active
INFEXP	Exponent in infiltration equation	none	2.0	2.0	1.0	3.0	Soils variability	Usually default to 2.0
INFILD	Ratio of max/mean infiltration capacities	none	2.0	2.0	1.0	3.0	Soils variability	Usually default to 2.0
DEEPFR	Fraction of GW inflow to deep recharge	none	0.0	0.20	0.0	0.50	Geology, GW recharge	Accounts for subsurface losses
BASETP	Fraction of remaining ET from baseflow	none	0.0	0.05	0.0	0.20	Riparian vegetation	Direct ET from riparian vegetation
AGWETP	Fraction of remaining ET from active GW	none	0.0	0.05	0.0	0.20	Marsh/wetlands extent	Direct ET from shallow GW
PWAT - PARM4								
CEPSC	Interception storage capacity	inches	0.03	0.20	0.01	0.40	Vegetation type/density, land use	Monthly values usually used
UZSN	Upper zone nominal soil moisture storage	inches	0.10	1.0	0.05	2.0	Surface soil conditions, land use	Accounts for near surface retention
NSUR	Manning's n (roughness) for overland flow	none	0.15	0.35	0.05	0.50	Surface conditions, residue, etc.	Monthly values often used for croplands
INTFW	Interflow inflow parameter	none	1.0	3.0	1.0	10.0	Soils, topography, land use	**Calibration**, based on hydrograph separation
IRC	Interflow recession parameter	none	0.5	0.7	0.3	0.85	Soils, topography, land use	Often start with a value of 0.7, and then adjust
LZETP	Lower zone ET parameter	none	0.2	0.7	0.1	0.9	Vegetation type/density, root depth	**Calibration**

Source: USEPA BASINS Technical Note 6

Model assumptions for channel reach infiltration rates were derived through calibration based on data collected within the reaches of Aliso Creek (11 stations) and Rose Creek (6 stations). In the model, infiltration rates vary by soil type. Channel infiltration was calibrated by adjusting a single infiltration value, which was varied for each soil type by factors established from literature ranges (USEPA 2000) of infiltration rates specific to each soil type. The final resulting infiltration rates were 1.368 in/hr (Soil Group A), 0.698 in/hr (Soil Group B), 0.209 in/hr (Soil Group C) and 0.084 in/hr (Soil Group D). The infiltration rates for Soil Groups B, C, and D are within the infiltration range given in literature (Wanielisata et al. 1997). The result for Soil Group A is below the range given in Wanielisata et al. (1997).

APPENDIX F - Channel Classification Procedure

The procedure derives from the "Stream Stability Validation" approach that is described by Rosgen (1996). Channel stability over time may be assessed by monitoring the channel for five factors: 1) aggradation; 2) degradation; 3) shifting of particle sizes of channel Bed Sediment; 4) changing the rate of lateral extension through accelerated bank erosion; and 5) morphological changes following the CEM (Simon et al., 1992). If any hydrological changes or disturbance occurs in the watershed, the five elements defined above are critical to analyze the channel response to the implementation of Hydrologic Control BMPs.

One reference channel station will be used for comparison purposes and should coincide with the station selected for the bioassessment. The reference station should be located in a channel that shows the same lithology, sediment regime, and morphometric parameters as the study channel stations. Annual comparisons of channel stability will be carried out at the same time of the year, at the end of the spring season, thus maximizing the chances to monitor similar weather patterns.

Channel stability will be evaluated on an annual basis at selected cross-sections in the SMR. Evaluation of the vertical or bed stability will serve as the reference method to understand the geomorphological changes of a channel over time. Vertical or bed stability will be evaluated at each of the identified cross-sections; this field method will identify a potential aggradation or degradation, if any, of the channel. Rate, magnitude, and direction of vertical change, if any, will be quantified.

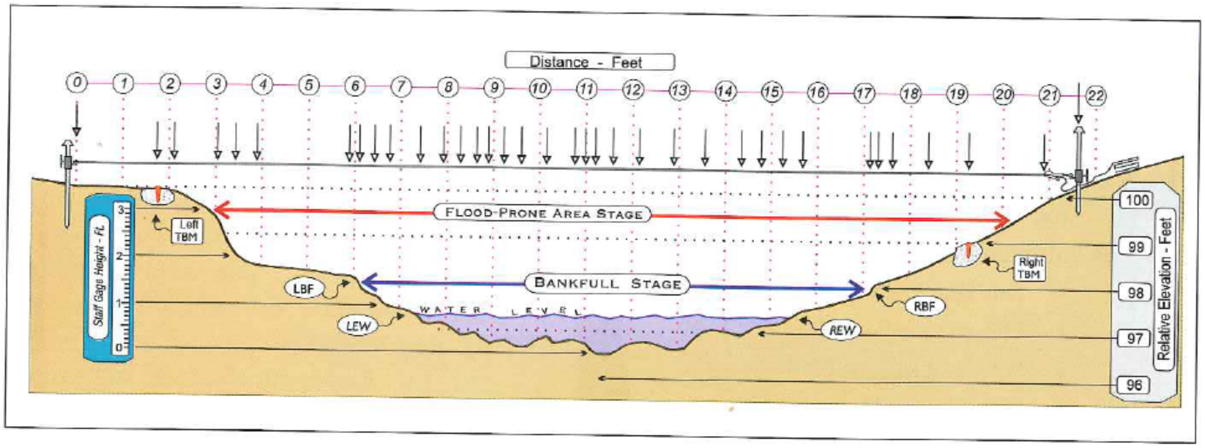
Vertical or bed stability

Rosgen (1996) has documented a couple methods including one, known as the "Monumented Cross-sections Method". At each selected site, the method consists of setting permanently monumented cross-sections that are located on a riffle and pool segment (or step/pool segment), i.e., two monumented cross-sections per site. Annual measurements at the two monumented cross-sections per site will be compared to the reference elevations taken during the initial survey.

Initially, one permanent benchmark should be installed on each bank of the channel: a left temporary benchmark and a right temporary benchmark. These should be made permanent by digging a hole in which a 10-inch stove bolt will be set up by a pad of concrete. The intent is to avoid vandalism damage. These two benchmarks will be located at the cross-section on a stable site above and away from the bankfull channel. Additionally, an elevation cross-section is often needed if the left or right side of the cross-section is located on an unstable slope. An elevation benchmark is established and often does not represent a true representation, but rather a relative elevation set at 100 feet.

During each cross-section survey, a leveled tape line is set above the channel. Measurements originate from the intercept of the rod with the leveled tape line (**Figure 16**).

Figure 16 - Typical permanent channel cross-section with benchmark locations and points of measurement – Rosgen (1996)



Simple measurements are made with the measuring tape and elevation rod method as described by Rosgen (1996):

- Locate the permanent benchmark on both sides of the channel (or, if on one side, a bearing for the transect is needed)
- Stretch the tape very tight with spring clamp and tape level
- Locate tape at same elevation as reference bolt on benchmark
- Read distance and elevation reading of rod intercept with tape
- Measure major features, such as:
    - Left benchmark (LBM)
    - Left terrace/floodplain (LT, LFP)
    - Left bankfull (LBF)
    - Left bank (LB)
    - Left edge of water (LEW)
    - Various bed features, bars, etc.
    - Thalweg (TW)
    - Inner berm features (IB)
    - Right edge of water (REW)
    - Right bank (RB)
    - Right bankfull (RBF)
    - Right terrace/floodplain (RT, RFP)
    - Right benchmark (RBM)

Measurements must include the floodplain, terraces, and channel adjacent slopes. Other surveying procedures such as auto or laser levels and total station surveys may be adapted from the described "measuring tape and elevation rod" method. If technically feasible, any exceptional event associated with a level higher than the bankfull level needs to be marked and indicated on the cross-section. The cross-section needs to be plotted for each measurement and compared to previous cross-sections to evaluate bed stability.

Finally, the longitudinal slope will be assessed based on measurements taken at two consecutive cross-sections. Rosgen (1996) also recommends developing a vicinity map and detailed site map indicating the locations of monumented cross-sections, as well as upstream and downstream photographs for site documentation. Dimensions for channel classification need to be correlated in order to document morphological comparisons for extrapolation.

Each channel segment being surveyed will be classified on an annual basis per the simplified Rosgen system of channel classification (Rosgen, 1996). Classification will be possible upon identification of the following parameters: floodprone width, bankfull width, bankfull depth, and longitudinal slope. **Figure 17** shows the different types of channels per Rosgen channel classification (Rosgen, 1996).

Figure 17 - Simplified Rosgen Channel Classification (Rosgen, 1996)

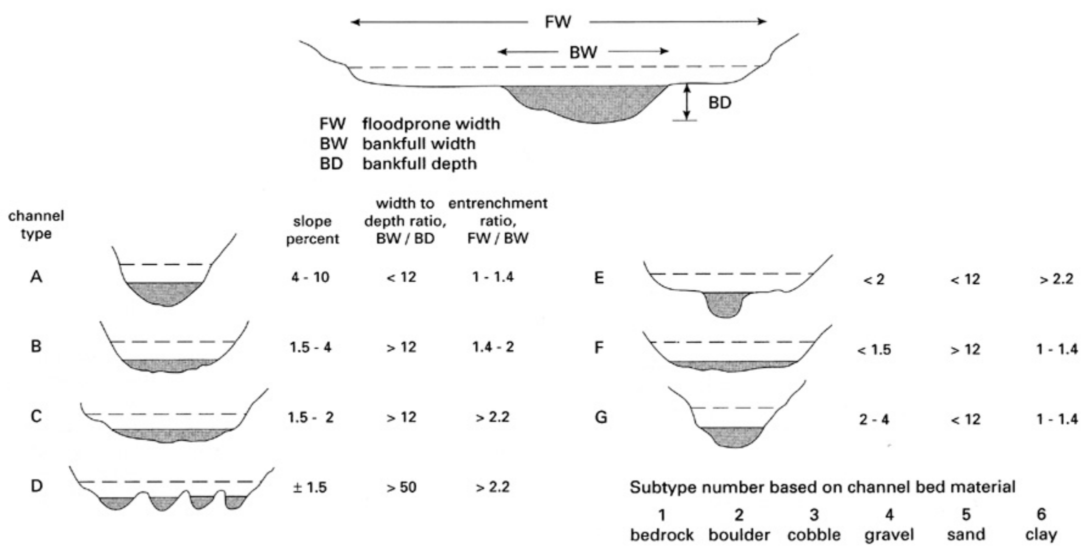


Figure 1.12 The Rosgen system of channel classification.

APPENDIX G - Santa Margarita Region Hydrology Model Guidance Manual

- The *Santa Margarita Region Hydrology Model* program can be downloaded for free on the Riverside County Flood Control and Water Conservation District's NPDES/Municipal Stormwater Management Program website.

http://www.rcflood.org/NPDES/Default.aspx

APPENDIX H - Conducting a Site-Specific Hydromodification Analysis

A User may choose to develop a site-specific Hydromodification susceptibility analysis in lieu of using the continuous simulation tool provided by the SMR HMP. The site-specific analysis must be developed to demonstrate that the project will not adversely impact the receiving channel through either changes in the receiving channel hydrograph, or changes in Bed Sediment Load supply to the channel.

The following items are not intended to be an approach to complete the analysis, rather, they are provided for information as suggestions for the engineering analysis. Each project will have unique conditions and will require a customized approach for analysis. A site-specific analysis may or may not be ultimately approved by the Copermittee with jurisdiction over the project site. It is the responsibility of the User to assess the potential for an analysis to successfully demonstrate that the project is consistent with the guidelines of this HMP.

1. It is recommended that the User develop a study approach and outline, and review it with the Copermittee with jurisdiction over the project site prior to beginning the full study.
2. The study must demonstrate that the project is consistent with the requirements of the 2010 SMR MS4 Permit and this HMP.
3. Site-specific information to characterize Bed Sediment gradation, flow and rainfall data, and watershed hydrologic parameters will be required. Continuous simulation is required.
4. An objective of the study may be to determine if the loss of Bed Sediment Load from the project-site to the receiving channel can be partially or fully managed by additional management of the runoff discharge from the project-site.
5. Sediment transport modeling has inherent uncertainty. The Copermittee with jurisdiction over the project site may not approve a site-specific analysis if it is apparent that the change in conditions that will be modeled are about the same magnitude as the model uncertainty.

The selected lower flow threshold should correspond to the critical channel flow that produces the Critical Shear Stress that initiates channel Bed Sediment Load movement or that erodes the toe of channel banks of a comparable soft-bottom channel.

The method of analysis, including the specific modeling program, the sediment transport function, the reach of the receiving water to be modeled, the method of determining Bed Sediment discharge in the receiving channel, the method of determining Bed Sediment discharge from the project-site, the period of record for continuous simulation and other parameters are left to the discretion of the User. The study report should document and justify the approach, selected models and methods, data requirements, analysis method and results for review.

APPENDIX I - Identification of a Site-Specific Low Flow Threshold

If allowed by the Copermittee with jurisdiction over the project site, Users have the option to use a site-specific low flow threshold for individual projects instead of 10% of the 2-year peak flow specified in the HMP.

A User may assess the viability of pursuing a site-specific low flow threshold based on the results of a planning-level analysis that is presented in this Appendix. The planning-level analysis consists of a critical flow sensitivity assessment, which provides the User with a general indication that a site-specific low flow threshold may be appropriate, but is not sufficient to quantify the threshold. The stepwise approach is consistent with that developed for the San Diego County HMP (2011).

The demonstration of an applicable low flow threshold must be performed based on field geomorphic evaluation, non-uniform hydraulic modeling, and sediment continuity modeling. This Appendix provides general concepts on these topics. A person knowledgeable in sediment processes should be consulted if the User desires to take the next step and establish a site-specific low flow threshold.

A. For Planning Purposes Only: Simplified Stepwise Approach
For initial planning purposes, the User may run the desktop-level analysis using the proposed empirical equations and assess the viability of pursuing a site-specific low flow threshold. To establish viability of a site-specific threshold, the User may perform and document the findings of each of the following six steps.

The simplified stepwise approach is only provided as an attempt to assist the User with a simplified method. The uncertainty associated with each of the variables of the simplified approach can potentially falsely influence the results. It is the User's responsibility to analyze the results and the geomorphic environment of the downstream channel before attempting to pursue a site-specific low flow threshold.

Step A-1: Identify the Typical Range of Rainfall Conditions for the HMP Area

The purpose of Step 1 is to identify the mean annual precipitation at the project site based on existing records from a nearby precipitation station. The mean annual precipitation serves as an input to characterize the dominant discharge for the receiving channel. Based on 70+ years of District SMR rainfall records, the mean annual precipitation ranges from 11.6 to 20.6 inches in the SMR. The User should identify on **Figure 3** of the main document, the meteorological zone where the project site is located, and subsequently refer to **Table 12** to select the associated mean annual precipitation.

Table 12 - SMR Mean Annual Precipitation per Meteorological Zone

Meteorological Zone	Mean Annual Precipitation (in inches)
Eastern Slopes	14.7
Temecula Valley	15.8
Western Plateau	20.6
Wildomar / North Murrieta	11.6

Step A-2: Identify a Range of Typical Receiving Channel Dimensions for Each Watershed Area

Empirical relationships have been developed to express channel dimensions (width, depth, and to a lesser extent, gradient) as a function of the dominant discharge. For undeveloped channels in semi-arid parts of the U.S. such as in the SMR, dominant discharge can be approximated by the 5-year discharge flow.

Step A-2.a – The dominant discharge, Qbf, assumed to be approximately equivalent to the 5-year peak discharge (Q5), may be estimated using the USGS regional regression for undeveloped watersheds in the South Coast Region (Waananen and Crippen, 1977). This equation calculates Q5 (cfs) as a function of watershed area (sq. mi.) as determined in Step 2, and mean annual precipitation (MAP, in/yr) as determined in Step 1. The relationship is:

$$Q_5(cfs) = 0.4 \cdot [Watershed\ Area\ (sq.mi)]^{0.77} \cdot [Mean\ Annual\ Precipitation\ (inches)]^{1.69}$$

Step A-2.b –Identification of the width and the depth of each channel reach: The User may iteratively identify the type of channel as defined in **Table 13** that most corresponds to each individual channel reach that is selected within the domain of analysis (defined in APPENDIX C). In addition to the channel type, **Table 13** identifies the source and the empirical channel geometry relationships. Empirical relationships were developed based on channel geometry and hydrology in Southern California.

Table 13 - Empirical relationships for Channel Dimensions

Channel Type	Source	Empirical Channel Geometry Relationships
Undeveloped channels in Southern California – narrow, deep, and steep dimensions	Coleman et al., 2005	$Width(ft) = 0.6012 \cdot Q_{bf}^{0.6875}$ $Depth(ft) = 0.3854 \cdot Q_{bf}^{0.3652}$ Q_{bf} in cfs
Gravel channels – wide, shallow, flat braided dimensions	Parker et al., 2007	$Width(m) = 4.63 \cdot \frac{Q_{bf}^{2/5}}{9.81^{1/5}} \cdot \left[\frac{Q_{bf} \cdot d_{50}^2}{\sqrt{9.81 \cdot d_{50}}}\right]^{0.0667}$ $Depth(m) = 0.382 \cdot \frac{Q_{bf}^{2/5}}{9.81^{1/5}}$ Q_{bf} in the bankfull discharge in m^3/s d_{50} is the diameter of median channel material in m
Medium width, depth, and gradient channels	Hey and Thorne, 1986	$Width(m) = 2.73 \cdot Q_{bf}^{0.5}$ $Depth(m) = 0.22 \cdot Width^{0.37} \cdot d_{50}^{-0.11}$ Q_{bf} in the bankfull discharge in m^3/s d_{50} is the diameter of median channel material in m

Step A-3.c – Compute a channel slope using Manning's equation such that the wetted cross-sectional area at bankfull depth conveys the dominant discharge. Manning's equation is expressed as:

$$Q = 1.486 \cdot \frac{A \cdot R^{0.67} \cdot \sqrt{s}}{n}$$

Where:

- Q = Flowrate (cfs)
- A = Cross-Section Flow Area (ft2)
- R = Hydraulic Radius (ft) = A / P
- P = Wetted Perimeter (ft)
- s = Energy Gradient Assumed Equal to Longitudinal Slope (ft/ft)
- n = Manning Roughness (unitless)

For planning purposes, the User can assume a Manning Roughness value of 0.025, corresponding to a non-vegetated, straight channel of small slope, after aging whose Bed Sediment is composed of colloidal alluvial silt (ASCE No.77, 1992). However, it is suggested that the User determine the retardance coefficient from

Table 14. This reflects the small, ephemeral receiving channels which are prevalent in Southern California. A different Manning Roughness value may be used only if it has been previously approved by the Copermittee with jurisdiction over the project site. A sensitivity analysis performed in the San Diego HMP found that the retardance coefficient had little effect on the estimated critical shear flow rate.

Table 14 - Critical Shear Stress per Sediment Type (Source: ASCE No.77, 1992)

Material	n	Clear Water		Water Transporting Colloidal Silts	
		V (fps)	τ (lb/ft2)	V (fps)	τ (lb/ft2)
Fine sand, colloidal	0.020	1.50	0.027	2.50	0.075
Sand loam, noncolloidal	0.020	1.75	0.037	2.50	0.075
Silt loam, noncolloidal	0.020	2.00	0.048	3.00	0.11
Alluvial silts, noncolloidal	0.020	2.00	0.048	3.50	0.15
Ordinary firm loam	0.020	2.50	0.075	3.50	0.15
Volcanic ash	0.020	2.50	0.075	3.50	0.15
Stiff clay, very colloidal	0.025	3.75	0.26	5.00	0.46
Alluvial silts, colloidal	0.025	3.75	0.26	5.00	0.46
Shales and hardpans	0.025	6.00	0.67	6.00	0.67
Fine gravel	0.020	2.50	0.075	5.00	0.32
Graded loam to cobbles when noncolloidal	0.030	3.75	0.38	5.00	0.66
Graded silts to cobbles when colloidal	0.030	4.00	0.43	5.50	0.80
Coarse gravel, noncolloidal	0.025	4.00	0.30	6.00	0.67
Cobbles and shingles	0.035	5.00	0.91	5.50	1.10

Step A-3: Identify a Range of Typical Channel Material for Receiving Channels

The User should identify the weakest predominant type of Bed Sediment in each section of the receiving channel within the domain of analysis. A simple identification from aerial imagery, available photography, or existing technical documentation is deemed sufficient for planning purposes, or a field review or a geotechnical investigation can be used. The User should subsequently identify the critical shear stress associated with each type of predominant Bed Sediment using Error! Reference source not found.

Table 14 presents a nonexhaustive list of critical shear stresses for typical channel materials and covers the range of Critical Shear Stresses to be encountered in the SMR.
Table 14 may be used for planning purposes only.

Appropriate references for Critical Shear Stress values are provided in ASCE No.77 (1992) and Fischenich (2001). To account for the effects of vegetation density and channel irregularities, the applied shear stress can be partitioned into form and bed/bank roughness components, and the lowest value of d50 be used for calculations. Other references include the procedure for application of allowable velocity to determine the Critical Shear Stress or equivalent allowable velocity associated with a specific type of Bed Sediment. Design of Open Channels, TR-25 (USDA, 1977) will guide the User through the allowable velocity approach, which relates allowable velocity to sediment concentration, grain diameter of the non-cohesive boundary material, and plasticity index and soil characteristics for cohesive boundary material. Another effective reference is the National Engineering Handbook Part 654, Chapter 8, which contains the Shields diagram and describes the allowable shear stress approach (NEH, 2007).

Step A-4: Identify the Flow Rate at Which Boundary Shear Stress Exceeds Critical Shear Stress for the Channel and Material

The tractive force theory was initially described in Shield's diagram (1936) and further translated into an equation by the Bureau of Reclamation (1987). The tractive force theory establishes that Bed Sediment Load is being displaced when the shear stress applied on the boundary of a particle of Bed Sediment exceeds the critical shear stress associated with that particle. The average boundary shear stress on a particle of Bed Sediment may be expressed as:

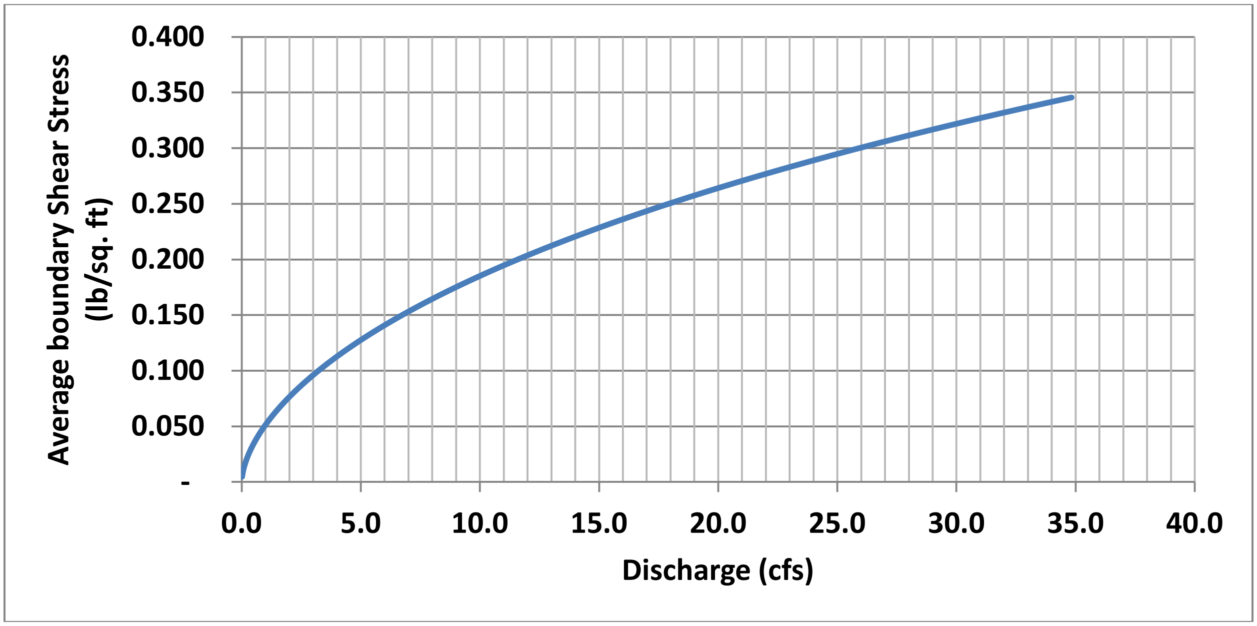
$$\tau = \gamma \cdot R \cdot s$$

Where:

- τ = Effective Shear Stress of d_{50} from sieve analysis (lb/ft2)
- γ = Unit Weight of Water (62.4 lb/ft3)
- R= Hydraulic Radius (ft) as determined in Step 2
- s = Longitudinal slope (ft/ft) as determined in Step 2.c

Using Manning's equation for the established channel cross-section, roughness, and gradient, the flow depth is iterated to produce a shear stress rating curve for each of the channel section selected within the domain of analysis. A shear stress rating curve correlates the average boundary shear stress to a discharge, which can be as high as the dominant discharge in this exercise. For the purpose of the exercise, an example shear stress rating curve is shown in **Figure 8**. The example shear stress rating curve was developed with the following parameters: s= 0.005 ft/ft; n= 0.035; side slope = 1H: 1W; bankfull depth = 1.51 feet; bankfull width = 7.91 feet.

Figure 18 - Example Shear Stress Rating Curve



Based on the Critical Shear Stress identified in Step 4, the User should identify on each shear stress rating curve, Qcrit, or the flow rate at which boundary shear stress equals critical shear stress.

Step A-5: Express Critical Flow As A Function of Q2

The User may use the USGS regional regression of the 2-year peak discharge for the South Coast Region (Waananen and Crippen, 1977) to determine the 2-year peak discharge in each channel reach selected within the domain of analysis. The regression equation is expressed, as follows:

$$Q_2(\text{cfs}) = 0.14 \cdot [\text{Watershed Area (sq. mi)}]^{0.72} \cdot [\text{Mean Annual Precipitation (inches)}]^{1.62}$$

The critical flow (Qcrit) is expressed as a function of Q2 to remain consistent with the standardized relationship stated in existing HMPs throughout California.

Step A-6: Identify the Most Conservative Low Flow Threshold

In a final step, the User should summarize in a tabular format the findings of the stepwise approach applied to each section of channel. An example of such tabular representation is showcased in **Table 15**, in which critical flow rates are grouped by type of channel material.

Table 15 - Summary Table of Critical Flow Rates per Section of Channel

Drainage Management Area	Trib Area	Mean Annual Precip	5-year Flowrate	2-year Flowrate	Critical Flowrate	Low Flow Threshold	Bankfull Width	Bankfull Depth
	A	MAP	Q5	Q2	Qcrit	Qcrit/Q2	W	D
	sq mi	in/yr	cfs	cfs	cfs	% of Q2	ft	ft
τ_{crit} = 0.025 lb/ft2, sand bed (low end)								
Section A1	1	15.8	42.5	12.2	0.296	**2.4%**	7.91	1.51
τ_{crit} = 0.05 lb/ft2, sand bed (high end)								
Section A2	1	15.8	42.5	12.2	0.947	**7.7%**	7.91	1.51
τ_{crit} = 0.12 lb/ft2, gravel								
Section A3	1	15.8	42.5	12.2	4.452	**36.4%**	7.91	1.51

In the above example, for Section A1, the ratio between the critical flow and the 2-year peak flow is computed as: (0.296 cfs) / (12.2 cfs) = 0.024 = 2.4%.

From the summary table, the User should identify the most conservative low flow threshold among all downstream sections. For instance, in the presented example, the User should select 2.4% Q2 as the site-specific low flow threshold. In this instance, a site-specific low flow threshold would not be advantageous for the project.

B. For Consideration and Approval by the Copermittee with jurisdiction over the project site: Full-Scale Geomorphic Assessment

For consideration and approval of a site-specific low flow threshold by the Copermittee with jurisdiction over the project site, demonstration must be established based on field geomorphic evaluation, nonuniform hydraulic modeling, and sediment continuity modeling. A person familiar with sediment transport should be consulted if the User was to establish a site-specific low flow threshold.

The field geomorphic assessment, to be performed within the domain of analysis, should identify the geometry of each selected cross-section and characterize the associated Bed Sediment Load. The geomorphic evaluation requires surveying the cross-section and longitudinal profile geometry of the active channel, estimating the hydraulic roughness of the channel, and evaluating the critical shear stress (pounds per square foot) of the most sensitive bed and bank material. For non-cohesive material, a Wolman pebble count or sieve analysis is used to obtain a grain size distribution, which can be converted to Critical Shear Stress using an empirical relationship or reference tables in the literature. For cohesive material, an in-situ jet test or reference tables are used. For banks reinforced with vegetation, reference tables are generally used.

The site-specific hydrologic and hydraulic evaluation should determine the 2-year peak discharge Q2 based on a flow gage record in the receiving channel or a continuous hydrologic model, if available. In computing Q2, the original condition of the watershed tributary to the channel, before development, should be considered. This provides a means of apportioning the critical flow in a channel to individual projects (on a pro-rata area basis) that discharge to that channel, such that cumulative discharges do not exceed the critical flow (Qcrit) in the channel of concern. This flow apportionment must be provided as a part of the analysis by the User.

The User must demonstrate through a channel stability impact assessment that the changes to both the amount of Bed Sediment transported and the amount of Bed Sediment supplied to the channel, will maintain the general trends of aggradation and degradation in the impacted channel reaches, which are representative of the dynamic equilibrium of a channel.

APPENDIX J – Flow Control Threshold Analysis Report (Appendix A of 2011 San Diego HMP)

APPENDIX K – SMR HMP Evaluation Program