

San Diego County Regional Watershed Management Area Analysis



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October 1, 2015

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EXEMPTION	

ACRONYMS AND ABBREVIATIONS

%	percent
>	greater than
<	less than
BMP	Best Management Practice
CB	Coarse Bedrock
CEG	Certified Engineering Geologist
CIP	Capital Improvement Project
CLRP	Comprehensive Load Reduction Plan
CSI	Coarse Sedimentary Impermeable
CSP	Coarse Sedimentary Permeable
E_p	Erosion Potential
ET	Evapotranspiration
FB	Fine Bedrock
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
FSI	Fine Sedimentary Impermeable
FSP	Fine Sedimentary Permeable
GIS	Geographic Information System
GLU	Geomorphic Landscape Unit
HA	Hydrologic Area
HCP	Hydromodification Control Plan
HMP	Hydromodification Management Plan
HRU	Hydrologic Response Unit
HSA	Hydrologic Sub Area
HSG	Hydrologic Soil Group
IRWM	Integrated Regional Water Management
JURMP	Jurisdictional Urban Runoff Management Plan
LDW	Land Development Workgroup
LID	Low Impact Development
MAP	Mean Annual Precipitation

ACRONYMS AND ABBREVIATIONS continued

MHPA	Multiple Habitat Planning Area
MS4	Municipal Separate Storm Sewer System
MSCP	Multiple Species Conservation Program
NED	National Elevation Dataset
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
PDP	Priority Development Project
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
SCAMP	Southern California Aerial Mapping Project
SCCWRP	Southern California Coastal Water Research Project
SD	San Diego
SDRWQCB	San Diego Regional Water Quality Control Board
S _p	Sediment Supply Potential
SSURGO	Soil Survey Geographic Database
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WMA	Watershed Management Area
WMAA	Watershed Management Area Analysis
WQIP	Water Quality Improvement Plan
WURMP	Watershed Urban Runoff Management Plan

1. Introduction

1.1. Background

On May 8, 2013 the California Regional Water Quality Control Board, San Diego Region adopted Order No. R9-2013-0001; NPDES No. CAS 0109266, National Pollutant Discharge Elimination System (NPDES) Permit and Waste Discharge Requirements for Discharges from the Municipal Separate Storm Sewer Systems (MS4s) Draining the Watersheds within the San Diego Region (Regional MS4 Permit). The Regional MS4 Permit, which became effective on June 27, 2013, replaces the previous MS4 Permits that covered portions of the Counties of San Diego, Orange, and Riverside within the San Diego Region. There were two main goals for the Regional MS4 Permit:

1. To have more consistent implementation, as well as improve inter-agency communication (particularly in the case of watersheds that cross jurisdictional boundaries), and minimize resources spent on the permit renewal process.
2. To establish requirements that focused on the achievement of water quality improvement goals and outcomes rather than completing specific actions, thereby giving the Copermittees more control over how their water quality programs are implemented.

To achieve the second goal, the Regional MS4 Permit requires that Water Quality Improvement Plans (WQIPs) be developed for each Watershed Management Area (WMA) within the San Diego Region. As part of the development of WQIPs, the Regional MS4 Permit provides Copermittees an option to perform a Watershed Management Area Analysis (WMAA) through which watershed-specific requirements for structural BMP implementation for Priority Development Projects can be developed for each WMA. This report presents the Copermittees' approach and results for the regional elements of the WMAA developed for the San Diego County area.

1.2. Watershed Management Area Analysis (WMAA)

The Regional MS4 Permit, through inclusion of the WMAA, provides an optional pathway for Copermittees to develop an integrated approach for their land development programs by promoting evaluation of multiple strategies for water quality improvement and development of watershed-scale solutions for improving overall water quality in the watershed. The WMAA comprises the following three components as indicated in the Regional MS4 Permit:

1. Perform analysis and develop Geographic Information System (GIS) layers (maps) by gathering information pertaining to the physical characteristics of the WMA (referred to herein as WMA Characterization). This includes, for example, identifying potential areas of coarse sediment supply, present and anticipated future land uses, and locations of physical structures within receiving streams and upland areas that affect the watershed hydrology (such as bridges, culverts, and flood management basins).
2. Using the WMA Characterization results, compile a list of candidate projects that could potentially be used as alternative compliance options for Priority Development Projects. Such projects may include, for example, opportunities for stream or riparian area

rehabilitation, opportunities for retrofitting existing infrastructure to incorporate storm water retention or treatment, or opportunities for regional BMPs, among others. Prior to implementing these candidate projects the Copermittees must demonstrate that implementing such a candidate project would provide greater overall benefit to the watershed than requiring implementation of the onsite structural BMPs. Note, compilation or evaluation of potential projects was not performed as part of this regional effort. Identification and listing of candidate projects will be performed for each WMA through the WQIP process for WMAs that elect to submit the optional WMAA as part of the WQIP.

3. Additionally, using the WMA Characterization maps, identify areas within the watershed management area where it is appropriate to allow for exemptions from hydromodification management requirements that are in addition to those already allowed by the Regional MS4 Permit for Priority Development Projects. The Copermittees shall identify such cases on a watershed basis and include them in the WMAA with supporting rationale to support claims for exemptions.

1.3.Scope of Work for Regional WMAA

In July 2013, the Copermittees elected to fund a regional effort to develop elements of the regional WMAA for the 9 San Diego-area WMAs within the County of San Diego that are currently subject to the Regional MS4 Permit, which include:

- Santa Margarita River (for portion in San Diego County)
- San Luis Rey River
- Carlsbad
- San Dieguito River
- Los Peñasquitos
- Mission Bay & La Jolla Watershed
- San Diego River
- San Diego Bay
- Tijuana River (for portion in San Diego County)

The regional-level information developed through this effort is intended to provide consistency across WMAs and serve as the foundation for developing watershed-specific information for each WMA to be developed through the WQIP process. The regional effort scope of work included:

1. Development of GIS map layers that characterize the WMAs using data previously collected, readily available, and provided by the Copermittees, including:
 - a. Description of dominant hydrologic processes, such as areas where infiltration or overland flow likely dominates;
 - b. Description of existing streams in the watershed, including bed material and composition, and if they are perennial or ephemeral;

- c. Current and anticipated future land uses;
 - d. Potential coarse sediment yield areas; and
 - e. Locations of existing flood control structures and channel structures, such as stream armoring, constrictions, grade control structures, and hydromodification or flood management basins.
2. Development of a Microsoft® Excel (Excel) template for use by Copermittees to compile lists of candidate projects for an optional alternative compliance program.
 3. Development of additional criteria and analyses to support reinstating the following proposed exemptions that were originally developed in the approved 2011 Final Hydromodification Management Plan but not included in the Regional MS4 Permit unless provided by the Copermittees in the WMAA. In addition, development of the associated Hydromodification Applicability/Exemption Mapping.
 - a. Exempt River Reaches including:
 - i. San Diego River;
 - ii. Otay River;
 - iii. San Dieguito River;
 - iv. San Luis Rey River; and
 - v. Sweetwater River
 - b. Stabilized Conveyance Systems Draining to Exempt Water Bodies
 - c. Highly Impervious/Highly Urbanized Watersheds and Urban Infill, and
 - d. Tidally Influenced Lagoons (where data/study provided)

The scope of work for the regional effort excluded performing analysis within the following areas unless data was readily available, as Copermittees do not have jurisdiction over these areas:

1. State Lands;
2. U.S. Departments of Defense land;
3. U.S. National Forest land;
4. U.S. Department of Interior land and
5. Tribal land

Additional description of excluded areas, for the purposes of the Regional WMAA, is indicated in Section 2.3 Land Uses.

1.4. Project Process

The process for developing the Regional WMAA included close coordination with the Land Development Workgroup (LDW) at key points during the project. The LDW is composed of the 21 San Diego-area Copermittees and serves to develop and implement regional land development plans and programs necessary to support the requirements of the Regional MS4 Permit. The consultant team (Geosyntec Consultants and Rick Engineering Company) presented

preliminary project assumptions and methodologies proposed to be used to develop the Regional WMAA to meet the requirements of the Regional MS4 Permit in December 2013. The consultant team incorporated workgroup feedback from this meeting and subsequently presented the preliminary Regional WMAA project results to the LDW in March 2014, again to receive direction and incorporate input on the preliminary results. Subsequently, the draft report was released to the public in July 2014, by a public workshop that included Consultation Panel members from each of the WMAs on July 29, 2014. This version of the report including all of the input described above is being issued for optional inclusion into the respective WQIP Provision B.3 submittals to the SDRWQCB in December 2014.

1.5. Report Organization

This report is organized as follows:

- Chapter 1 provides the project background and purpose;
- Chapter 2 describes the technical basis for characterizing the WMAs;
- Chapter 3 describes the template that can be used by Copermittees to compile the list of candidate projects;
- Chapter 4 summarizes the analyses performed to support reinstating select exemptions from hydromodification control requirements for PDPs;
- Chapter 5 presents the Regional WMAA conclusions;
- Chapter 6 presents the references used for the Regional WMAA;
- Attachment A presents the exhibits and additional supporting information for watershed management area characterization;
- Attachment B presents the exhibits and additional supporting information for hydromodification management applicability/exemptions;
- Attachment C expands on the structure of the geodatabase that hosts the GIS data developed by the WMAA; and
- Attachment D provides a crosswalk between the Regional MS4 Permit requirements for WMAA and this report.

1.6. Terms of Reference

The work described in this report was conducted by Geosyntec Consultants (Geosyntec) and Rick Engineering Company (RICK) on behalf of the County of San Diego and the regional Copermittees.

2. Watershed Management Area Characterization

Watershed health and function are strongly influenced by hydrological and geomorphological processes occurring in the watershed. Both hydrological response and geomorphological response of the watershed are dependent on a variety of physical characteristics of the watershed. To this end, the Regional MS4 Permit specifies a set of data that is required to adequately characterize overall watershed processes as a foundation to enhancing integration and effectiveness of watershed management and water quality programs. The following GIS map layers were developed to characterize the hydrological and geomorphological processes within the 9 WMAs:

- **Dominant Hydrologic Processes:** A description of dominant hydrologic processes, such as areas where infiltration or overland flow likely dominates;
- **Stream Characterization:** A description of existing streams in the watershed, including bed material and composition, and if they are perennial or ephemeral;
- **Land Uses:** Current and anticipated future land uses;
- **Potential Critical Coarse Sediment Yield Areas;** and
- **Physical Structures:** Locations of existing flood control structures and channel structures, such as stream armoring, constrictions, grade control structures, and hydromodification or flood management basins.

These GIS layers can be used to:

- Identify the nature and distribution of key macro-scale watershed processes;
- Identify potential opportunities and constraints for regional and sub-regional storm water management facilities that can play a critical role in meeting water quality, hydromodification, water supply, and/or habitat goals within the watershed;
- Assist with determining the most appropriate management actions for specific portions of the watershed; and
- Suggest where further study is appropriate.

2.1. Dominant Hydrologic Processes

The Regional MS4 Permit identifies in the provisions related to the WMAA that a description of dominant hydrologic processes within the watershed must be developed, with GIS layers (maps) as output. The Permit specifically calls for processes “*such as areas where infiltration or overland flow likely dominates.*” These particular aspects of the hydrological mechanics of watersheds are particularly important when attempting to understand the macro-scale opportunities for locating projects that take advantage of either capturing overland flow for treatment or for infiltration.

Investigation of the dominant hydrologic processes in the San Diego-area watersheds indicates that evapotranspiration (ET) is the most dominant hydrologic process for the region based on review of a published study (Sanford and Selnick, 2013). ET is the sum of evaporation and plant transpiration in the hydrologic cycle that transports water from land surfaces to the atmosphere. This conclusion is supported by comparing the 30-year average annual rainfall for the study area (San Diego County east of the peninsular divide) of between 15 and 18 inches per year (San Diego County, 2005) to the average annual ET rates. According to the California Irrigation Management Information System (CIMIS) Reference Evapotranspiration Map (CIMIS, 1999), the study area (within Zones 4, 6, and 9) experiences annual reference ET of 46.6, 49.7 and 59.9 inches, respectively. Therefore, theoretically, if all of the annual precipitation for the San Diego-area watersheds remained stationary where it fell and did not either infiltrate or runoff to local waterbodies where it would be conveyed downstream ultimately to the ocean, it all would be consumed by ET. As such, the effect of ET on the overall hydrologic processes within the San Diego watersheds is a function of the temporal scale over which it acts. Precipitation events often produce runoff in these watersheds, particularly in the urbanized portions, based on the topography and land cover that tend to accelerate the conveyance of runoff downstream rather than collecting, storing, or spreading out that then would maximize the effect of ET.

Because this study is focused on developing information and mapping for the portion of the hydrologic process that informs watershed management decisions, i.e., locating beneficial projects in areas of greatest opportunity, the next tier of dominant hydrologic processes are studied and mapped by this project. As such, the study area was characterized, based on the methodology described in the following section, according to the predicted fate of runoff within the watersheds being either overland flow or infiltration after considering the effects of ET (as well as an intermediate category of interflow). Areas that were mapped as overland flow do not necessarily preclude infiltration but rather indicate the dominant expected process that runoff would experience if not intercepted for the express purpose of infiltrating storm water runoff. The Model BMP Design Manual will provide more detailed guidance and procedures for determining the potential for infiltrating captured storm water at the project level irrespective of the mapping produced in the WMAA. To reiterate, the WMAA mapping is to provide macro-scale processes for high-level analysis and to inform decisions affecting regional scales. Furthermore, the Model BMP Design Manual will indicate the degree to which site-scale BMPs can expect to benefit from ET or how ET is considered in the sizing of BMPs. In brief, typical storm water BMPs only store water for a few days and therefore are not really capable of significant volume disposal through ET. However, pervious area dispersion (i.e., directing storm water runoff to flat areas for spreading and infiltration) has appreciable benefits with regard to ET and is a practice promoted in the BMP Design Manual.

The processes of interest are further defined as follows:

Overland flow: This process can be thought of as the inverse of infiltration; precipitation reaching the ground surface that does not immediately soak in must run over the land surface (thus, “overland” flow). It reflects the relative rates of rainfall intensity and the soil’s infiltration capacity: wherever and whenever the rainfall intensity exceeds the soil’s infiltration capacity, some overland flow will occur. Most uncompacted, vegetated soils have infiltration capacities of one to several inches per hour at the ground surface, which exceeds the rainfall intensity of even unusually intense storms. In contrast, pavement and hard surfaces reduce the effective infiltration capacity of the ground surface to zero, ensuring overland flow regardless of the meteorological attributes of a storm, together with a much faster rate of runoff relative to vegetated surfaces.

Infiltration and groundwater recharge: These closely linked hydrologic processes are most apparent near ephemeral and perennial conveyances in the San Diego region. Their widespread occurrence is expressed by the common absence of surface-water channels on even steep (undisturbed) hillslopes. Thus, on virtually any geologic material on all but the steepest slopes (or bare rock), infiltration of rainfall into the soil is inferred to be widespread, if not ubiquitous. With urbanization, changes to the process of infiltration are also quite simple to characterize: some (typically large) fraction of that once infiltrating water is now converted to overland flow.

Interflow: Interflow takes place following storm events as shallow subsurface flow (usually within 3 to 6 feet of the surface) occurring in a more permeable soil layer above a less permeable substrate. In the storm response of a stream, interflow provides a transition between the rapid response from surface runoff and much slower stream discharge from deeper groundwater. In some geologic settings, the distinction between “interflow” and “deep groundwater” is artificial and largely meaningless; in others, however, there is a strong physical discrimination between “shallow” and “deep” groundwater movement. Development reduces infiltration and thus interflow as discussed previously, as well as reducing the footprint of the area supporting interflow volume.

The datasets used, methodology for creating the dominant hydrologic processes maps, and the results are described in the sections below.

2.1.1. Datasets Used for identifying dominant hydrologic processes

The following datasets were used in the analysis:

Dataset	Source	Year	Description
Elevation	USGS	2013	1/3 rd Arc Second (~10 meter cells) digital elevation model for San Diego County
Soils Data	SanGIS	2013	NRCS (SSURGO) Database for San Diego County downloaded from SanGIS
Land Cover	SanGIS	2013	Ecology-Vegetation layer for San Diego County downloaded from SanGIS

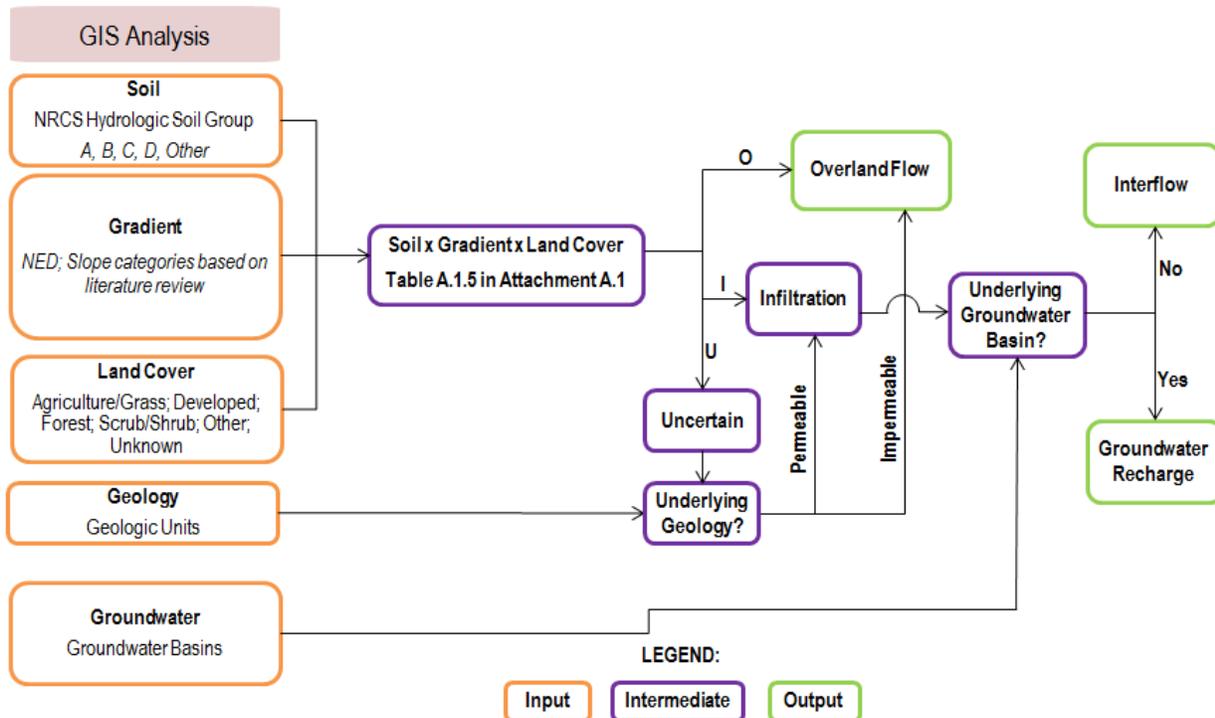
Dataset	Source	Year	Description
Geology	Kennedy, M.P., and Tan, S.S.	2002	Geologic Map of the Oceanside 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 2, 1:100,000 scale.
	Kennedy, M.P., and Tan, S.S.	2008	Geologic Map of the San Diego 30'x60' Quadrangle, California, California Geological Survey, Regional Geologic Map No. 3, 1:100,000 scale.
	Todd, V.R.	2004	Preliminary Geologic Map of the El Cajon 30'x60' Quadrangle, Southern California, United States Geological Survey, Southern California Aerial Mapping Project (SCAMP), Open File Report 2004-1361, 1:100,000 scale.
	Jennings et al.	2010	"Geologic Map of California," California Geological Survey, Map No. 2 – Geologic Map of California, 1:750,000 scale
Groundwater Basins	SanGIS	2013	Groundwater Basins in San Diego County downloaded from SanGIS

2.1.2. Methodology/Assumptions/Criteria for identifying dominant hydrologic processes

The methodology used to describe dominant hydrologic processes is based on recommendations included in the Southern California Coastal Water Research Project's (SCCWRP) Technical Report 605 titled "Hydromodification Screening Tools: GIS-Based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge" (SCCWRP, 2010). The foundation for this analysis was to incorporate the Report's concept of grouping common hydrologic attributes into Hydrologic Response Units (HRUs). The report states the following:

"Grouping common hydrologic attributes across a watershed into a tractable number of Hydrologic Response Units (HRUs: a term first used by England and Holtan 1969) has become a well-established approach for condensing the near-infinite variability of a natural watershed into a tractable number of different elements. The normal procedure for developing HRUs is to identify presumptively similar rainfall-runoff characteristics across a watershed by combining spatially distributed climate, geology, soils, land use, and topographic data into areas that are approximately homogeneous in their hydrologic properties (Green and Cruise 1995, Becker and Braun 1999, Beven 2001, Haverkamp et al. 2005). As noted by Beighley et al (2005), this process of merging the landscape into discrete HRUs is a common and effective method for reducing model complexity and data requirements. Using watershed characteristics to predict runoff is the explicit task of hydrologic models, and there is a host of such models available for application to hydromodification evaluation. For purposes of "screening," however, the goal is simplicity and ease of application even if the precision of the resulting analysis is crude."

The following process describes the methodology used to define Hydrologic Response Units (HRUs) and then relate the HRUs to the dominant hydrologic processes (i.e., overland flow, interflow, and groundwater recharge) in the 9 WMAs in San Diego County.



The first step is to define the HRUs. Once these are defined, the remaining steps determine the dominant hydrologic process.

1. **Integrate data sets used to determine HRU:** Categories for soil type, gradient, and land cover were defined based on readily available GIS datasets for the region and classifications found in relevant literature, as indicated below. The different combinations of these three categories comprise the distinct HRUs.

- **Soil Categories:** based on National Resource Conservation Service (NRCS) Hydrologic Soil Group (HSG) classifications, which are commonly used to describe runoff/infiltration potential of soils on a regional scale. These categories include: A, B, C, and D. HSG A soils have the lowest runoff potential, while HSG D soils have the highest runoff potential.
- **Gradient Categories:** based on slope ranges found in a review of relevant literature identified in Chapter 6. The spatial processing of the slope categories utilized the United States Geologic Survey (USGS) National Elevation Dataset (NED). Slopes were grouped (bins) into the following ranges: 0% to 2%; 2% to 6%; 6% to 10%; and greater than 10%. The 2% and 6% slope thresholds were based on slope ranges included in Table A.1.1 (McCuen, 2005) presented in Attachment A.1. This table provides runoff coefficients as a function of slope, soil group, land cover, and return period and was used for subsequent steps in the mapping effort. The 10% slope threshold was used in SCCWRP's Technical

Report 605 (SCCWRP, 2010) and is a logical cutoff since slopes steeper than 10% are assumed to be dominated by overland flow.

- **Land Cover Categories:** were defined using the Ecology Vegetation GIS map layer developed by the City of San Diego, the County of San Diego and SANDAG and downloaded from SanGIS (2013). The vegetation categories in the GIS layer were grouped (Table A.1.2 in Attachment A.1) to match the following categories used in SCCWRP's Technical Report 605 (SCCWRP, 2010): Agriculture/Grass; Developed; Forest; Scrub/Shrub, Other (Water), and Unknown.
2. **Evaluate Land Cover:** Land cover categories for Agriculture/Grass, Forest, Scrub/Shrub and Other were related to land use categories defined in Table A.1.1 as shown in Table A.1.3 in Attachment A.1. Relating a land use category for the Developed land cover category was not necessary because all Developed cover was assumed to have overland flow as its dominant hydrologic process.
 3. **Determine Hydrology Characteristics for Land Covers:** For each of the land cover/land use categories listed in Table A.1.3, the ratio of precipitation lost to evapotranspiration (i.e. an evapotranspiration coefficient) was estimated using Table A.1.1 using the process described below. Since precipitation is considered to be the sum of the resulting runoff, infiltration, and evapotranspiration, the coefficients for these three hydrologic pathways sum to one, as indicated below.

$$\text{Runoff Coefficient} + \text{Infiltration Coefficient} + \text{Evapotranspiration Coefficient} = 1$$

- i) **Estimate Evapotranspiration:** To estimate the evapotranspiration (ET) coefficient for each land cover, first the runoff coefficient was identified in Table A.1.1 for the highest runoff potential (i.e., Group D soil and 6%+ slope) and most common storm conditions (i.e., storm recurrence intervals less than 25 years). The infiltration for these high runoff conditions was assumed to be negligible, resulting in an infiltration coefficient of zero. Since the sum of the three coefficients should sum to one, the ET coefficient was assumed to be the remaining difference (i.e., ET Coefficient = 1 – Runoff Coefficient). The ET coefficient calculated for the highest runoff potential was then applied to all soil types and slopes within that land use category. The calculated ET coefficient for each applicable HRU is provided in Table A.1.4 in Attachment A.1. The ET coefficient for HRUs that have a Developed land cover or a gradient greater than 10% were not calculated since these HRUs were assumed to have overland flow as the dominant hydrologic process.
- ii) **Estimate Infiltration:** The infiltration coefficient for each applicable HRU (i.e., combination of soil, gradient, and land cover) was estimated by subtracting both the runoff coefficient, provided in Table A.1.1, and the ET coefficient, calculated in step 3(i), from one (i.e., Infiltration Coefficient = 1 – Runoff Coefficient – ET Coefficient). The calculated infiltration coefficient for each applicable HRU is provided in Table A.1.4 in Attachment A.1.
- iii) **Estimate Runoff:** For each applicable HRU, the runoff coefficient was divided by

the infiltration coefficient to obtain a ratio representing the potential for runoff or infiltration. The higher the ratio, the greater the potential for runoff to be a more dominant hydrologic process than infiltration. Similarly, the lower the ratio, the greater the potential for infiltration to be a more dominant hydrologic process than runoff. The calculated runoff to infiltration ratios are provided in Table A.1.4 in Attachment A.1.

4. **Associate Runoff and Infiltration to HRUs:** The following designations were assigned to each applicable HRU based on the runoff to infiltration ratio (i.e., runoff coefficient/infiltration coefficient). These designations were based on best engineering judgment with the underlying assumption that if a runoff or infiltration coefficient is more than 50% greater than its counterpart, then the prevailing process is considered dominant.
 - HRUs with runoff to infiltration ratios greater than 1.5 (3:2 ratio) were assumed to have relatively high runoff and overland flow was considered its dominant hydrologic process. These HRUs are designated by the letter “O” (Overland flow is dominant process) in Tables A.1.4 and A.1.5 in Attachment A.1.
 - HRUs with runoff to infiltration ratios less than 0.67 (2:3 ratio) were assumed to have relatively high infiltration and its dominant hydrologic process was either interflow or groundwater recharge, based on analysis described in subsequent steps. These HRUs are designated by the letter “I” (Interflow is dominant process) in Tables A.1.4 and A.1.5.
 - For HRUs with runoff to infiltration ratios between, and including, 1.5 and 0.67 it was uncertain whether it was dominated by overland flow or infiltration. These HRUs are designated by the letter “U” (Dominant process is uncertain) in Tables A.1.4 and A.1.5.
 - For HRUs that have a Developed land cover or a gradient greater than 10%, the runoff to infiltration ratios were not calculated because these HRUs were assumed to have overland flow as the dominant hydrologic process. These HRUs are designated by the letter “O” (Overland flow is dominant process) in Table A.1.5.
5. **Uncertain HRUs Assignment:** For HRUs with an uncertain designation (“U”) in Table A.1.5 in Attachment A.1, the underlying regional geology (Kennedy and Tan, 2002 & 2008; Todd, 2004 and Jennings et al., 2010) was used to evaluate whether overland flow or infiltration were dominant. If the underlying geology was considered impermeable, then these uncertain areas were considered to have overland flow as its dominant hydrologic process. If the underlying geology was considered permeable, then these uncertain areas were considered to be dominated by infiltration. The determination of whether a geologic unit is impermeable or permeable was based on desktop evaluation and the best professional judgment of a Certified Engineering Geologist (CEG). This analysis was performed in GIS and is illustrated in the flowchart above.

6. **Associate Infiltration HRUs with Known Groundwater Basins:** For HRUs with relatively high infiltration and have a designation of “T” in Table A.1.5 in Attachment A.1, the presence or absence of a regional groundwater basin (SanGIS, 2013) underlying these areas determined whether the dominant hydrologic process was designated as interflow or groundwater recharge. The groundwater recharge hydrologic process was assigned as dominant for those applicable areas which had an underlying groundwater basin. The interflow hydrologic process was assigned as dominant for those applicable areas which did not have an underlying groundwater basin directly below it. This analysis was performed in GIS and is illustrated in the flowchart above.
7. **Resulting HRU Data:** The resulting GIS map of dominant hydrologic processes was reviewed by engineering professionals familiar with the hydrology in the County of San Diego to confirm that the mapping is consistent with their experience working in the region.

2.1.3. Results for identifying dominant hydrologic processes

The resulting GIS map showing the spatial distribution of dominant hydrologic processes (i.e., overland flow, interflow, and groundwater recharge) within the 9 WMAs is provided in Attachment A.1. An ArcMap document which presents the results from each step of the methodology is included in Attachment C, as well as a Google Earth KMZ file. Based on this analysis, overland flow is the predominant hydrologic process in all 9 WMAs, which is consistent with the experience of engineering professionals familiar with the hydrology of the County of San Diego.

Summary of Deliverables for Dominant Hydrologic Processes

Format	Item	Description	Location
Report	Figure	"Dominant Hydrologic Processes"	Attachment A.1
GIS	Map Group Title	Hydrologic Processes	Attachment C
	Map Layer Title	Soil Land Cover Slope Hydrologic Response Unit Initial Rating Permeability Groundwater Basin Dominant Hydrologic Processes	
	Geodatabase Feature Dataset	HydrologicProcesses	
	Geodatabase Feature Class	HRUAnalysis	
	Geodatabase Geometry Type	Polygon	
KMZ ¹	KMZ File Name	Dominant Hydrologic Processes	Attachment C
¹ To enhance the utilization of this data, the Dominant Hydrological Processes map is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (http://www.google.com/earth/).			

2.1.4. Limitations for identifying dominant hydrologic processes

The resulting GIS map layer only lists the dominant hydrological process (i.e., an HRU assigned a dominant process of overland flow can also experience small amounts of infiltration) and provides a useful, rapid framework to perform screening-level analysis that is appropriate for watershed-scale planning studies. When more precise estimates are required for a particular site and subarea it is recommended that this analysis be augmented with site-specific analysis.

2.2.Stream Characterization

For the purpose of WMAA, the Regional MS4 Permit requires a description of existing streams in the watershed, including bed material and composition, and if they are perennial or ephemeral. This analysis was prepared for 27 streams throughout the San Diego Region agreed upon by the consultant team and Copermittees. The 27 streams are listed below and are identified on the exhibit titled "Watershed Management Area Streams" located in Attachment A.2. Streams were selected to provide at least one in each WMA and at least one in each jurisdiction. There is no numeric threshold defining a "stream" for the purpose of the Regional WMAA. Throughout the Regional WMAA, the term "stream" is used as a general term to call out any of the reaches selected for analysis, regardless of watershed area, stream order, flow rate, channel size, length, or designation of "Creek" or "River" within the name.

Regional WMAA Streams:

1. Santa Margarita River
2. San Luis Rey River
3. Buena Vista Creek
4. Agua Hedionda Creek
5. San Marcos Creek
6. Encinitas Creek
7. Cottonwood Creek (Carlsbad WMA)
8. Escondido Creek
9. San Dieguito River – Reach 1
10. San Dieguito River – Reach 2
11. Lusardi Creek
12. Los Peñasquitos/Poway Creek
13. Rattlesnake Creek
14. Carroll Canyon Creek
15. Rose Creek
16. San Diego River
17. Sycamore Creek
18. Woodglen Vista Creek
19. San Vicente Creek
20. Forrester Creek
21. Chollas Creek
22. Sweetwater River – Reach 1
23. Sweetwater River – Reach 2
24. Otay River
25. Jamul/Dulzura Creek
26. Tijuana River
27. Cottonwood Creek (Tijuana WMA)

2.2.1. Datasets Used for stream characterization

The following data were referenced for the purpose of stream characterization:

- USGS National Hydrography Dataset, downloaded from USGS November 2013

- USGS 7.5-minute quadrangles, compiled image of quadrangles covering San Diego County, various dates
- Floodplains: "National Flood Hazard Layer," provided by Federal Emergency Management Agency October 2012
- Various datasets provided by Copermitees depicting existing storm water conveyance infrastructure within their jurisdictions.
- Aerial photography by Digital Globe dated 2012

2.2.2. Methodology/Assumptions/Criteria for stream characterization

The analysis was prepared by digitizing each of the 27 streams based on review of data listed above. Within the pre-existing datasets depicting streams, floodplains, or infrastructure, no single dataset included a complete, accurate alignment of each stream. Digitizing the streams based on review of all of the data listed above allowed creation of GIS linework with a continuous corrected alignment for each stream. The following data were recorded as GIS attributes for each stream as the stream was digitized:

- River name
- Reach type (engineered or natural, constrained or un-constrained)
- Bed material
- Bank material
- Hydrographic category (perennial or intermittent)

The attributes listed above were collected manually based on interpretation of the reference data. Assumptions used in making the interpretations are listed below. The *Hydrographic Category* section below will provide the rationale as to why perennial and intermittent were the hydrographic categories chosen for this WMAA and not perennial and ephemeral.

Note that stream classification was not prepared within areas of Federal/State/Indian lands unless data was readily available. Stream lines were prepared within these areas for continuity, but some data fields were not populated within these areas.

Reach Type

Streams were classified as either engineered or natural, and either constrained or un-constrained. See the exhibit titled, "Watershed Management Area Streams by Reach Type" in Attachment A.2. The purpose of this exercise was to identify whether the stream has been modified by human activity within the stream itself, which may include addition of crossing structures, stabilization of banks, dredging, or any other human activity. This aids the identification of physical structures including stream armoring, constrictions, grade control, and other modifications as required by the Regional MS4 Permit.

Classification of the streams as either “**engineered**” or “**natural**” was based on the following criteria:

Engineered

- A classification of "engineered" was assigned where the stream itself has been modified by human activity.
- All culvert/bridge/pipe crossings either provided in the Copermittees' storm water conveyance system data or clearly visible on the aerial photo have been assigned as engineered within the limits of the crossing.
- If the Copermittees did not provide storm water conveyance system data for the dirt road crossings/dip sections the streams have been assigned as engineered within the limits of the crossing. These crossings may or may not have culverts.
- If the Copermittees' storm water conveyance system data stated the facility is a detention or desilting basin, they were assigned as engineered.
- Golf courses have been assigned as engineered.
- If aerial photography showed large water bodies (lake, pond, irrigation pond, etc.) they were assigned as engineered.
- If the storm water conveyance system data provided by the Copermittees has identified the stream as "rockbs", the assumption has been made that these streams have rocks on their bottom and the sides ("bs"), and have been assigned as engineered.
- Sand mining operations have been assigned as engineered. Sand mining is an operation that is in continuous flux and does not typically result in a discrete, engineered geometry in any given channel cross section until restoration is implemented at the conclusion of the sand mining operation. It is assigned as engineered to acknowledge human alteration of the stream.

Natural

- Streams that have no apparent alteration within the stream itself by human activity have been assigned as natural.

Classification of the streams as either "**constrained**" or "**un-constrained**" was based on the following criteria:

Constrained

- All culvers/bridge/pipe crossings either provided in the Copermittees' storm water conveyance system data or clearly visible on the aerial photo have been assigned as constrained.
- If the Copermittees did not provide storm water conveyance system data for the dirt road crossings/dip sections the streams have been assigned as constrained. These crossings may or may not have culverts.
- If the Copermittees' storm water conveyance system data stated the facility is a detention or desilting basin, they were assigned as constrained.
- Golf courses have been assigned as constrained if located within the Federal Emergency Management Agency (FEMA) floodway based on the "National Flood Hazard Layer" data.

- The USGS National Hydrographic Dataset in their hydrographic category had assigned some reaches as artificial paths. In these situations and if the aerial photography shows large water bodies (lake, pond, irrigation pond, etc.) these streams have been assigned as constrained.
- Sand mining operations located within the FEMA floodway based on the “National Flood Hazard Layer” have been assigned as constrained.

Un-constrained

- Golf courses have been assigned as un-constrained if not located within the FEMA floodway based on the “National Flood Hazard Layer” data.
- Sand mining operations not located within the FEMA floodway based on the “National Flood Hazard Layer” data have been assigned un-constrained.
- If the stream is located within the FEMA floodway based on the “National Flood Hazard Layer” and there is available land in the floodway fringe (the area between the floodway and the 100-year floodplain) the area has been assigned un-constrained. Note that there may be only one side or both sides of the stream with available land in the floodway fringe therefore a note was added as to which side of the stream is constrained and un-constrained.
- If the stream is located within a FEMA 100-year floodplain based on the “National Flood Hazard Layer” data with no floodway and the FEMA floodplain width is not within an existing development or bordered by roads have been assigned as un-constrained.

Bed Material and Bank Material

The following bed and bank materials were identified:

- Concrete
- Riprap
- Pipe / culvert
- Earth

The assumptions made to identify the streams bed and bank materials were based on the following criteria:

- If the data provided by the Copermitees provided information about the stream bed and bank material, the provided data was used for the bed and bank material.
- Generally the data provided by the Copermitees did not identify the crossing type (pipe, box culvert, bridge with or without piers, etc.) or the material (RCP, RCB, earth, riprap, concrete, etc.). In that case, all culvert/bridge/pipe crossings were assigned as pipe/culvert for the bed and bank material.
- If the Copermitees did not provide data for the dirt road crossings/dip sections the bed and bank material have been assigned as pipe/culvert. These crossings may or may not have culverts.

- If the Copermittees' storm water conveyance system data stated the facility is a detention or desilting basin, the bed and bank material have been assigned as earth.
- If aerial photography showed large water bodies (lake, pond, irrigation pond, etc.) they were assigned as earth bed and bank material. The USGS National Hydrographic Dataset in their hydrographic category had assigned some of these types of reaches as artificial paths.
- Sand mining operations within the stream have been assigned as earth for bed and bank material.
- If the Copermittees did not provide data for the stream material the bed and bank material have been assigned based on the aerial photography.

See exhibits titled, "Watershed Management Area Streams by Bed Material" in Attachment A.2.

After stream bed and bank material was classified, earthen reaches were further classified by geologic group. This was accomplished by intersecting the streams with the geologic group layer that had been prepared for use in the dominant hydrologic process and potential coarse sediment yield analyses. The result is displayed in exhibits titled, "Watershed Management Area Streams by Geologic Group" in Attachment A.2.

Hydrographic Category

Streams were classified as "perennial" or "intermittent." See exhibits titled, "Watershed Management Area Streams by Hydrographic Category" in Attachment A.2. Classification was obtained from the USGS National Hydrography Dataset (NHD). The definitions of these categories in the USGS National Hydrography Dataset are:

- **Perennial:** Contains water throughout the year, except for infrequent periods of severe drought.
- **Intermittent:** Contains water for only part of the year, but more than just after rainstorms and at snowmelt.

While the specific Regional MS4 Permit language requested classification of perennial or ephemeral, rather than perennial or intermittent, the data that was referenced in order to classify streams did not include "ephemeral" streams. For reference, the USGS National Hydrography Dataset definition of "ephemeral" is: "contains water only during or after a local rainstorm or heavy snowmelt." None of the stream reaches in the study were classified as ephemeral in the NHD dataset, therefore none are classified as ephemeral in the WMAA product. The City of San Diego provided a map titled "City of San Diego Stream Survey" dated April 3, 2013 prepared by AMEC that shows streams that are "dry" and streams that are "flowing". This information in conjunction with the other parameters listed in this section was used to determine if a stream was perennial or intermittent.

USGS NHD includes hydrographic category classification for many of the streams. However data was not available for all reaches of all streams. In order to classify reaches of streams that did not already contain this data in NHD, these assumptions were made:

- The USGS NHD information for the stream hydrographic category has been used when available.
- When USGS NHD has “artificial paths” for portions of the stream, the hydrographic category of the upstream portion of the stream have been assigned to the stream unless other assumptions took precedence.
- If aerial photography shows large waterbody (lake, pond, irrigation pond, etc.) perennial has been assumed for the hydrographic category.
- For ponded areas shown on the aerial photography and if the USGS 7.5-minute quadrangles shows cross hatching for the area, intermittent has been assigned unless the upstream portion of the stream was assigned as perennial pursuant to the USGS National Hydrography Dataset then assigned perennial for the ponded area.
- USGS has a dashed line for intermittent streams. USGS has a solid line for perennial streams. In some situations this information was used to assist in the determination of assigning perennial or intermittent to a stream.

2.2.3. Results for stream characterization

The 27 streams and data are contained in a GIS file titled "SD_Regional_WMAA_Streams" located in Attachment C. The streams are shown in watershed maps included in Attachment A.2.

Summary of Deliverables for Stream Characterization

Format	Item	Description	Location
Report	Title of Figures	<ul style="list-style-type: none"> • "Watershed Management Area Streams" • "Watershed Management Area Streams by Hydrographic Category" • "Watershed Management Area Streams by Bed Material" • "Watershed Management Area Streams by Geologic Group" • "Watershed Management Area Streams by Reach Type" 	Attachment A.2
GIS	Map Group Title	Not Grouped	Attachment C
	Map Layer Title	SD_Regional_WMAA_Streams	
	Geodatabase Feature Dataset	Streams	
	Geodatabase Feature Class	SD_Regional_WMAA_Streams	
	Geodatabase Geometry Type	Line	
KMZ ¹	KMZ File Name	SD_Regional_WMAA_Streams	Attachment C

¹ To enhance the utilization of this data, the Stream Characterization map is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (<http://www.google.com/earth/>).

In addition to the 27 streams that were subject of detailed analysis, NHD streams have been included on maps and within the geodatabase for reference. The NHD stream alignments have not been corrected and in some cases may be inconsistent with the existing infrastructure. The NHD streams are contained in a GIS file titled, "SD_NHD_Streams."

2.2.4. Limitations for stream characterization

- Only a desktop analysis was performed and no field verification was conducted.
- Infrastructure is only based on storm water conveyance system data provided by Copermittees or clearly visible on aerial photography. If the Copermittee used a numbering or lettering system for describing bed and bank material for example, since the metadata was not provided the bed and bank material could not be verified.
- In some instances concrete channels cannot be identified on aerial photography if it is filled with sediment and/ or vegetation.

2.3.Land Uses

For the purpose of the WMAA, the Regional MS4 Permit requires a description of current and anticipated future land uses. This is presented in the final GIS deliverable as "Land Use Planning" and includes the following representations of land uses in the watersheds: existing land uses, planned land uses, developable lands, redevelopment and infill areas, floodplains, Multiple Species Conservation Program (MSCP) designated areas, and areas not within the Copermittees' jurisdictions (tribal lands, state lands, and federal lands).

2.3.1. Datasets Used for land uses

The following existing regional datasets were referenced to meet this requirement:

- Municipal boundaries: "Municipal_Boundaries" dated August 2012, available from SanGIS/SANDAG
- Ownership: "Parcels" dated December 2013, available from SanGIS/SANDAG
- Existing land use: "SANGIS.LANDUSE_CURRENT" dated December 2012, available from SanGIS/SANDAG (existing land use)
- Planned land use: "PLANLU" (Planned Land Use for the Series 12 Regional Growth Forecast (2050)), dated December 2010, available from SanGIS/SANDAG
- Developable land: "DEVABLE" (Land available for potential development for the Series 12 Regional Growth Forecast), dated December 2010, available from SanGIS/SANDAG
- Redevelopment and infill areas: "REDEVINF" (Redevelopment and infill areas for the Series 12 Regional Growth Forecast), dated December 2010, available from SanGIS/SANDAG
- Floodplains: "National Flood Hazard Layer" provided by Federal Emergency Management Agency October 2012
- Multiple Species Conservation Program (MSCP), total of four datasets available from SanGIS/SANDAG: "MHPA_SD," dated 2012, (Multiple Habitat Planning Areas for City of San Diego); "MSCP_CN," dated 2009 (designations of the County of San Diego's Multiple Species Conservation Program South County Subregional Plan); "MSCP_EAST_DRAFT_CN," dated 2009 (draft East County MSCP Plan); and "Draft_North_County_MSCP_Version_8.0_Categories," dated 2008 (draft North County MSCP Plan)

2.3.2. Methodology/Assumptions/Criteria for land uses

The existing regional datasets for existing land use, planned land use, developable land, redevelopment and infill areas, floodplains, and MSCP designated areas were referenced with no modifications. Areas not within the Copermittees' jurisdictions (tribal lands, state lands, and federal lands) were compiled from SanGIS parcel data (December 2013) based on the "ownership" value. The owners listed below were excluded from the Copermittees jurisdictions and represent the "Federal/State/Indian" layer, which is displayed on various maps included in Attachment A.2.

- Bureau of Land Management
- California Department of Fish and Game
- Indian Reservations
- Military Reservations

- Other Federal
- State
- State of California Land Commission
- State Parks
- U.S. Fish and Wildlife Service
- U.S. Forest Service

When available, relevant data from these areas was included in analyses (e.g., developable land areas within Federal/State/Indian areas). Stream lines were prepared within these areas for continuity. However, stream classification (e.g., bed and bank material) was not prepared within these areas unless data was readily available (e.g., hydrographic category data available from NHD)

2.3.3. Results for land uses

The existing regional datasets are compiled into the Geodatabase in a group titled, "Land Use Planning." Current and anticipated future land uses are depicted in watershed maps included in Attachment C. Federal/State/Indian Lands are also referenced on all other map exhibits included in Attachment A.2.

Summary of Deliverables for Land Uses

Format	Item	Description	Location
Report	Title of Figures	<ul style="list-style-type: none"> • "Existing Land Use" • "Planned Land Use" • "Developable Land" • "Redevelopment and Infill Areas" 	Attachment A.3
GIS	Map Group Title	Land Use Planning	Attachment C
	Map Layer Title	Municipal Boundaries Federal/State/Indian Lands SanGIS_ExistingLandUse SanGIS_PlannedLandUse SanGIS_DevelopableLand SanGIS_RedevelopmentandInfill FEMA Floodplain MHPA_SD MSCP_CN MSCP_EAST_DRAFT_CN Draft_North_County_MSCP_Version_8_Categories	
	Geodatabase Feature Dataset	LandUsePlanning	
	Geodatabase Feature Class	SanGIS_MunicipalBoundaries Federal_State_Indian_Lands SanGIS_ExistingLandUse SanGIS_PlannedLandUse	

Format	Item	Description	Location
		SanGIS_DevelopableLand SanGIS_RedevelopmentandInfill FEMA_NFHL SanGIS_MHPA_SD SanGIS_MSCP_CN SanGIS_MSCP_EAST_DRAFT_CN SanGIS_Draft_North_County_MSCP_Version_8_Categories	
	Geodatabase Geometry Type	Polygon	
KMZ ¹	KMZ File Name	Municipal Boundaries Federal/State/Indian Lands Floodplains Due to file size limitations, SanGIS land use datasets were not converted to KMZ.	Attachment C
¹ To enhance the utilization of this data, the Land Uses map is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zippered) file that can be viewed with the free download version of Google Earth (http://www.google.com/earth/).			

2.3.4. Limitations

Some jurisdictions may have compiled GIS land use layers that include more detailed or more current information than the regional datasets available from SanGIS. SanGIS layers were selected for the Regional WMAA to provide consistent land use characterization region-wide, and to provide for repeatability of GIS analyses when a land use layer is required for input data. The definition of non-Copermittee areas identified in this document as "Federal/State/Indian Lands" is for the Regional WMAA. Some WQIPs may define non-Copermittee areas differently.

2.4.Potential Critical Coarse Sediment Yield Areas

The Regional MS4 Permit identifies in the provisions related to the WMAA that potential coarse sediment yield areas within the watershed be identified, with GIS layers (maps) as output. With regard to the function and importance of coarse sediment, SCCWRP Technical Report 667 titled “Hydromodification Assessment and Management in California” states the following:

“Coarse sediment functions to naturally armor the stream bed and reduce the erosive forces associated with high flows. Absence of coarse sediment often results in erosion of in-channel substrate during high flows. In addition, coarse sediment contributes to formation of in-channel habitats necessary to support native flora and fauna.”

This report identifies the potential critical coarse sediment yield areas for the 9 WMAs in compliance with this permit provision. The applied datasets and methodologies for identifying the coarse sediment yield areas, along with their respective results, are described in the sections below.

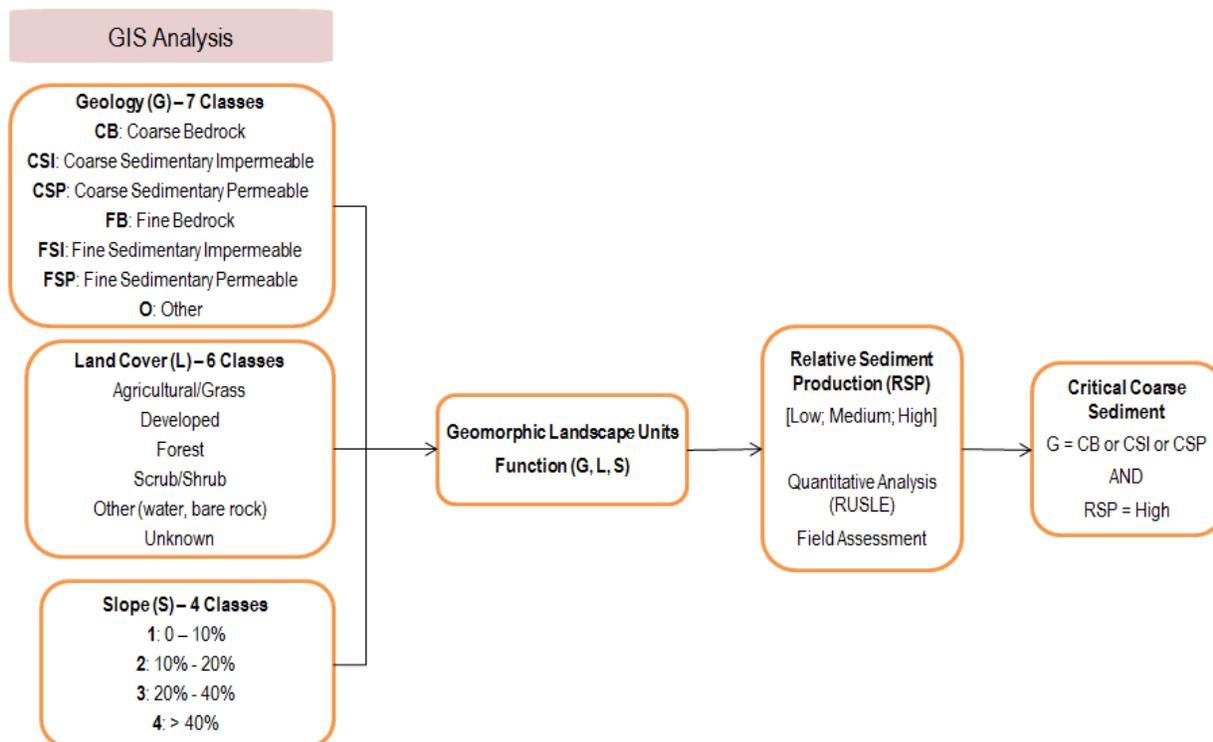
2.4.1. Datasets Used for identifying potential critical coarse sediment yield areas

The following datasets were used in the analysis

Dataset	Source	Year	Description
Elevation	USGS	2013	1/3 rd Arc Second (~10 meter cells) digital elevation model for San Diego County
Land Cover	SanGIS	2013	Ecology-Vegetation layer for San Diego County downloaded from SanGIS
Geology	Kennedy, M.P., and Tan, S.S.	2002	Geologic Map of the Oceanside 30’x60’ Quadrangle, California, California Geological Survey, Regional Geologic Map No. 2, 1:100,000 scale.
	Kennedy, M.P., and Tan, S.S.	2008	Geologic Map of the San Diego 30’x60’ Quadrangle, California, California Geological Survey, Regional Geologic Map No. 3, 1:100,000 scale.
	Todd, V.R.	2004	Preliminary Geologic Map of the El Cajon 30’x60’ Quadrangle, Southern California, United States Geological Survey, Southern California Areal Mapping Project (SCAMP), Open File Report 2004-1361, 1:100,000 scale.
	Jennings et al.	2010	“Geologic Map of California,” California Geological Survey, Map No. 2 – Geologic Map of California, 1:750,000 scale

2.4.2. Methodology/Assumptions/Criteria for identifying potential critical coarse sediment yield areas

The methodology used to identify coarse sediment yield areas is based on Geomorphic Landscape Unit (GLU) methodology presented in the SCCWRP Technical Report 605 titled “Hydromodification Screening Tools: GIS-Based Catchment Analyses of Potential Changes in Runoff and Sediment Discharge” (SCCWRP, 2010). Geomorphic Landscape Units characterize the magnitude of sediment production from areas through three factors judged to exert the greatest influence on the variability on sediment-production rates: geology types, hillslope gradient, and land cover. The GLU approach provides a useful, rapid framework to identify sediment-delivery attributes of the watershed. The process to integrate these factors into GLUs is indicated in the flow chart below.



The following steps were used to define Geomorphic Landscape Units (GLUs), which were then related to the coarse sediment and critical coarse sediment yield areas in the 9 WMAs in San Diego County.

1. **Integrate data sets used to determine GLU:** Categories for geology, gradient, and land cover were defined based on readily available GIS datasets for the region and classifications found in relevant literature listed in Chapter 6. The different combinations of these categories make up distinct GLUs.
 - **Geologic Categories:** based on methodology listed in Attachment A.4.1 of Attachment A.4. Resulting geologic categories from this analysis are: Coarse Bedrock (CB), Coarse Sedimentary Impermeable (CSI), Coarse Sedimentary Permeable (CSP), Fine Bedrock (FB), Fine Sedimentary Impermeable (FSI), Fine Sedimentary

Permeable (FSP), and Other (O). An exhibit showing the regional geology groupings is presented in Attachment A.4.

- **Land cover categories:** defined using the Ecology Vegetation GIS map layer developed by the City of San Diego, the County of San Diego and SANDAG which were downloaded from SanGIS (2013). The vegetation categories in the GIS layer were grouped (Table A.1.2 in Attachment A.1) to match the following categories used in SCCWRP's Technical Report 605 (SCCWRP, 2010): Agriculture/Grass; Developed; Forest; Scrub/Shrub, Other (Water) and Unknown.
 - **Gradient Categories:** based on slope ranges found in a review of relevant literature (GLU methodology applied in California) listed in Chapter 6. The spatial processing of the slope categories utilized the USGS National Elevation Dataset (NED). Slope ranges used include: 0% to 10%, 10% to 20%, 20% to 40%, and greater than 40%.
2. **GLU Union Results:** GIS mapping exercise for the study area resulted in 166 GLUs within the 9 WMAs in San Diego County. Table A.4.2 in Attachment A.4 provides the list of the 166 GLUs.

For implementing hydromodification management performance standards in the Regional MS4 Permit, the Copermitttees need to identify Critical Coarse Sediment Yield areas in the study region. To provide information on the identification of Critical Coarse Sediment yield, the study assumed that critical coarse sediment would be generated from GLUs that are composed of geologic units likely to generate coarse sediment (based on the methodology listed in Step 3) and have the potential for high relative sediment production (as estimated using the methodology listed in Step 4).

3. **Define Pertinent Geologic groups:** the geologic groups (Attachment A.4.1) considered in this study to have the potential to generate coarse sediment are Coarse Bedrock (CB), Coarse Sedimentary Impermeable (CSI), and Coarse Sedimentary Permeable (CSP). An exhibit showing the regional geologic grouping is presented in Attachment A.4.
4. **Relate GLU to Sediment Production:** For assigning GLUs with a relative sediment production, the following methodology was utilized:
- Conducted quantitative analysis to assign relative sediment production. Analysis was performed based on the assumption that sediment production from an area is proportional to the soil loss from the area, as evaluated using standard soil loss equation. Detailed analysis steps are documented in Attachment A.4.2;
 - To validate the quantitative assignment above, a qualitative field assessment was conducted for 40 sites. Site selection and findings from the field assessment is documented in Attachment A.4.3.
 - The result of the field assessment indicated a 65% match between field conditions and the quantitative assignments. The mismatches are attributed to differences in percent land cover as assumed for the quantitative analysis and those observed in the field. As such, the quantitative assignments were considered to be valid for the purposes of assigning relative sediment production.

2.4.3. Results for identifying potential critical coarse sediment yield areas

The resulting GIS maps showing the spatial distribution of geologic grouping and critical coarse sediment yield areas within the 9 WMAs in San Diego Region are provided in Attachment A.4. An ArcMap document which presents the results from each step of the methodology is included in Attachment C. Based on this analysis it was estimated that 82% of the study area is a potential coarse sediment yield area and 20% of the study area is a potential critical coarse sediment yield area. The majority of the potential critical coarse sediment yield areas were identified to be on slopes greater than 25% and/or on federal/state lands.

As a result of the regional-scale datasets, and commensurate data resolution, used to map the potential critical coarse sediment yield areas, some areas may have been mapped that in reality do not produce critical coarse sediment as they are existing developed areas. As such, an opportunity for jurisdictions to incorporate more refined data into the preliminary WMAA GIS dataset based on local knowledge and review of current aerial images was provided. The City of Escondido, the City of Encinitas, the City of Del Mar, the City of Poway, National City, and the County of San Diego provided augmented data in their respective jurisdictional areas.

Summary of Deliverables for Potential Critical Coarse Sediment Yield Areas

Format	Item	Description	Location
Report	Figures	“Geologic Grouping” "Potential Critical Coarse Sediment Yield Areas"	Attachment A.4
GIS	Map Group Layer Name	Potential Coarse Sediment Yield	Attachment C
	Map Layer Title	Geologic Grouping Land Cover Slope Category Geomorphic Landscape Unit Potential Coarse Sediment Yield Area Relative Sediment Production Potential Critical Coarse Sediment Yield Area	
	Geodatabase Feature Dataset	PotentialCoarseSedimentYield	
	Geodatabase Feature Class	GLUAnalysis PotentialCoarseSedimentYieldAreas PotentialCriticalCoarseSedimentYieldAreas	
	Geodatabase Geometry Type	Polygon	
KMZ ¹	KMZ File Name	Potential Critical Coarse Sediment Yield Areas	Attachment C

¹ To enhance the utilization of this data, the Geomorphic Landscape Unit Analysis is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (<http://www.google.com/earth/>).

2.4.4. Limitations for identifying potential critical coarse sediment yield areas

The resulting GIS layers were developed using regional datasets and provide a useful, rapid

framework to perform screening-level analysis that is appropriate for watershed-scale planning studies. The methodology used to identify potential coarse sediment yield areas does not account for instream sediment supply and sediment production from mass failures like landslides which are difficult to estimate on a regional scale without performing extensive field investigation. This data set also does not account for potential existing impediments that may hinder delivery of coarse sediment to receiving waters or downstream locations within the watershed as this was beyond the scope of a regional study. Where more precise estimates are required for a particular site or subarea it is recommended that this analysis be augmented with site-specific analysis. It is also recognized that this regional data set is a function of the inherent data resolution and therefore may not conform to all site conditions, or does not reflect changes to particular areas that have occurred since the underlying data was developed. As such, the Regional WMAA data for the potential critical coarse sediment yield areas should be verified in the field according to the procedures outlined in the Model BMP Design Manual and/or jurisdiction specific BMP Design Manual.

2.5. Physical Structures

The Regional MS4 Permit requires the Copermitees to identify information regarding locations of existing flood control structures and channel structures, such as stream armoring, constrictions, grade control structures, and hydromodification or flood management basins with GIS layers (maps) as output, for each WMA being analyzed for the purpose of developing watershed-specific requirements for structural BMP implementation. This study identified the physical structures using a desktop-level analysis for the 27 streams identified in Section 2.2 in the 9 WMAs in compliance with this permit provision.

2.5.1. Approach for identifying physical structures

The intent of this portion of the WMAA project was to provide an initial assessment of the structures of interest for the 27 river reaches identified in Section 2.2. This desktop-level analysis was conducted primarily as a visual survey of aerial imagery and FEMA flood insurance study (FIS) profiles where available. The collected information was entered into a GIS layer for inclusion into the overall WMAA geodatabase containing the characterization layers required by the Regional MS4 Permit. To support overall WMA characterization, the information derived in this task provides insight into water and sediment movement through the watershed (SCCWRP, 2012), the opportunities and limitations for infrastructure retrofits and also informs efforts to identify appropriate locations for habitat or riparian area rehabilitation in relation to proximate infrastructure. Specific information regarding how the survey was performed and the attributes of the generated data is presented in Attachment A.5. Note that concrete channels, pipes/culverts, riprap or other artificial stream armoring, and basins have also been identified in the linework generated for the 27 streams (see Section 2.2).

2.5.2. Results for identifying physical structures

The resulting GIS maps showing the spatial locations of the physical structures within the 9 WMAs are provided in Attachment A.5.

Summary of Deliverables for Physical Structures

Format	Item	Description	Location
Report	Figure	Watershed Management Area Streams by Reach Type with Channel Structures	Attachment A.5
GIS	Map Group Layer Name	Channel Structures	Attachment C
	Map Layer Title	Channel Structures	
	Geodatabase Feature Dataset	ChannelStructures	
	Geodatabase Feature Class	ChannelStructures	
	Geodatabase Geometry Type	Point	
KMZ ¹	Kmz File Name	ChannelStructures	Attachment C

¹ To enhance the utilization of this data, the Physical Structures map is provided in both traditional GIS file format (ESRI software license purchase required) and as a Google Earth KMZ (Keyhole Markup Language/Zipped) file that can be viewed with the free download version of Google Earth (<http://www.google.com/earth/>).

3. Template for Candidate Project List

The Regional MS4 Permit requires each WMA to use the results from the WMA characterization to compile a list of candidate projects that could potentially be used as alternative compliance options for Priority Development Projects should an agency or jurisdiction opt to develop an alternative compliance program. Copermittees must first conclude that implementing such a candidate project would provide greater overall benefit to the watershed than requiring implementation of structural BMPs onsite prior to implementing these candidate projects as alternative compliance projects.

The Copermittees elected to identify potential candidate projects as a separate effort from this regional project, and therefore the process for identifying candidate projects is not documented in this report. Instead, this project only developed a template, in a spreadsheet format, for use by the Copermittees to compile lists of potential candidate projects. The template is intended to enhance regional consistency of the information that is gathered for candidate projects. The template spreadsheet file was distributed to the Copermittees on January 28, 2014. A table of the template components is indicated below:

Column	Primary Heading	Secondary Heading	Guidance for Completing the Project List
A	Project Identifier	-	Unique identifier for the project.
B	Watershed Management Area	-	Dropdown menu to select the watershed management area the project is located in
C	Hydrologic Area (HA)	-	Dropdown menu to select the hydrologic area the project is located in Select a WMA in column B for HA (Column C) dropdown menu to activate.
D	Hydrologic Subarea (HSA)	-	Dropdown menu to select the hydrologic subarea the project is located in. Select a HA in column C for HSA (Column D) dropdown menu to activate.
E	Jurisdiction	-	Dropdown menu to select the jurisdiction the project is located in. Select a HSA in column D for Jurisdiction (Column E) dropdown menu to activate.
F	Project Name	-	Indicate the name of the project.
G	Ownership	Type	Dropdown menu to select if the project is a public project, private project, or public-private partnership.
H	Ownership	Ownership Information	List the details for the owner.
I	Project Location	Address	List the address of the project site.
J	Project Location	APN	List the APN of the parcel.
K	Project Location	Latitude	List the latitude of the project site.
L	Project Location	Longitude	List the longitude of the project site.

Column	Primary Heading	Secondary Heading	Guidance for Completing the Project List
M	Project Origination/ Originator	Name	List the name of the report/organization/individual that provided the idea for the project. Potential origination sources: WQIP, WMAA, JURMPs, WURMPs, CLRPs, IRWM, MSCP, MHPA, Other.
N	Project Origination/ Originator	Contact Information	Link or report title if the proposed project is from a report [or] contact information if from an organization/individual.
O	Project Category	-	Drop Down menu to select the project category; In addition to the 6 project categories explicitly listed in the Regional MS4 Permit, the drop down menu also has a category "Other project types allowed by the MS4 Permit". Example for "Other" project types are agency CIP programs such as Green Streets, LID conversions (medians, parks), agency filter installation, etc.
P	Specific Project Type	-	List the subcategory of the project; for example, list Regional BMP type (i.e. infiltration basin, wetland, etc.).
Q	Potential Pollutant	-	Identify the potential pollutant(s) that can be treated by the proposed project.
R	Project Size & Parameters	Contributing Drainage Area (acres)	List the contributing drainage area to the project.
S	Project Size & Parameters	Parcel Size (acres)	List the size of the parcel the project is located on.
T	Project Size & Parameters	Project Footprint (acres)	List the size of the project footprint.
U	Project Size & Parameters	Parameters (with units as necessary)	Parameters needed to quantify benefits from the project; i.e. for an infiltration basin, list the water quality volume, long-term infiltration rate, depth of the basin, etc.
V	Regulatory Requirement	-	Indicate if the project is proposed to meet particular regulatory requirement such as TMDL, etc.
W	Project Timeline	-	Indicate if a project must be implemented by certain date to meet a grant deadline or other time commitment.
X	Other Notes	-	List any other relevant notes; for example, when retrofitting existing infrastructure project category is selected, input parameters needed to quantify benefits from existing infrastructure into this column as these will be needed to estimate additional benefits that can be used for alternative compliance. If N/A is selected in any dropdown menus, add additional explanation in here

4. Hydromodification Management Applicability/Exemptions

Hydromodification, which is caused by both altered storm water flow and altered sediment flow regimes, is largely responsible for degradation of creeks, streams, and associated habitats in the San Diego Region. The purpose of the hydromodification management requirements in the Regional MS4 Permit is to maintain or restore more natural hydrologic flow regimes to prevent accelerated, unnatural erosion in downstream receiving waters.

The Regional MS4 Permit allows exemptions at the discretion of the local agency for priority development projects that discharge runoff to receiving waters that are not susceptible to erosion (e.g., a reservoir, lake, enclosed embayment, or the Pacific Ocean) either directly or via hardened systems including concrete-lined channels or existing underground storm drain systems.

The March 2011 Final Hydromodification Management Plan (HMP) identified certain exemptions from hydromodification management requirements by presenting "HMP applicability criteria." The Regional MS4 Permit maintains some of these HMP applicability criteria. However, some of the applicability criteria are not included under the Regional MS4 Permit unless the area or receiving water is mapped in the WMAA. The intent of this Section is to provide supporting technical analyses for exemptions that are recommended by the WMAA, and to provide mapping of areas exempt from hydromodification management requirements.

4.1. Additional Analysis for Hydromodification Management Exemptions

This section documents additional analysis performed to further evaluate the following exemptions that were already approved by the San Diego Regional Board with the 2011 Final HMP. This study only provides additional analysis, data, and rationale for supporting or eliminating the following existing exemptions and does not propose or study any new exemptions.

- Exempt River Reaches
- Stabilized Conveyance Systems Draining to Exempt Water Bodies
- Highly Impervious Watersheds and Urban Infill and
- Tidally Influenced Lagoons

4.1.1. Exempt River Reaches

4.1.1.1. History

The March 2011 Final HMP, approved by the SDRWQCB under the 2007 MS4 Permit, provided a potential exemption from hydromodification management requirements for projects discharging runoff directly to certain major river reaches, provided that the outlet elevation of the project's outfall(s) to an identified exempt river reach are between the river bottom elevation and the 100-year floodplain elevation, and properly sized energy dissipation is provided at the outfall(s).

Exempt river systems/reaches from the 2011 Final HMP:

River	Downstream Limit	Upstream Limit
Otay River	Outfall to San Diego Bay	Lower Otay Reservoir Dam
San Diego River	Outfall to Pacific Ocean	Confluence with San Vicente Creek
San Dieguito River	Outfall to Pacific Ocean	Lake Hodges Dam
San Luis Rey River	Outfall to Pacific Ocean	Upstream river limit of Basin Plan subwatershed 903.1 upstream of Bonsall and near Interstate 15
Sweetwater River	Outfall to San Diego Bay	Sweetwater Reservoir Dam

Exemptions related to runoff discharging directly to the above river reaches were based on the flow duration analysis performed for the San Diego River in the Final HMP and the Technical Advisory Committee (formed to provide input on the development of the Final HMP) members' opinion (based on field observations and years of historical perspective) that the above river reaches have very low gradients, were depositional (aggrading), have very wide floodplain areas when in the natural condition and that the effects of cumulative watershed impacts to these reaches is minimal provided that properly sized energy dissipation is provided at outfalls to the rivers.

4.1.1.2. Status under 2013 Regional MS4 Permit

Under the Regional MS4 Permit, exempt river reaches would not qualify for exemption from hydromodification management controls unless the optional WMAA is developed with additional rationale/analyses to support reinstating exemptions to these river reaches. Additional analysis performed as part of the WMAA to evaluate hydromodification management control exemptions to the previously exempt reaches is presented below.

4.1.1.3. Research, Approach and Results

Hydromodification impacts can be caused due to increase in flows, changes in sediment transport capacity and changes in sediment supply to the streams (SCCWRP, 2012). In order to evaluate the cumulative impacts due to development and determine if hydromodification management control exemptions can be reinstated for the river reaches that were exempt in the previous permit term, erosion potential (Ep) analysis was used to evaluate the increase in flows and changes in sediment transport capacity. In addition, sediment supply potential (Sp) analysis was used to evaluate the changes in sediment supply in this study. In regards to Ep analysis

SCCWRP Technical Report 667 “Hydromodification Assessment and Management in California” states:

“The underlying premise of the erosion potential approach advances the concept of flow duration control by addressing in-stream processes related to sediment transport. An erosion potential calculation combines flow parameters with stream geometry to assess long term (decadal) changes in the sediment transport capacity. The cumulative distribution of shear stress, specific stream power and sediment transport capacity across the entire range of relevant flows can be calculated and expressed using an erosion potential metric, E_p (e.g., Bledsoe, 2002).”

The approach used in this study is explained in detail in Attachment B.1.1.1. The following WMA characterization maps developed in Section 2 were used to select inputs for the exempt river reach analysis:

- Planning land use layers from Section 2.3 were used to estimate the existing impervious area and identify the developable parcels in each watershed. A GIS exercise was performed to identify the developable parcels in each watershed that will be exempt from hydromodification management requirements if the exemption is granted.
- Stream type classification analysis from Section 2.2 was used to select a conservative cross section (segments that are assigned naturally constrained) to be used in analysis for each watershed.
- GLU analysis and its associated quantitative analysis described in Section 2.4 were used to determine S_p metric for each watershed. In this study coarse sediment supply changes were limited to changes in hill slope erosion between existing condition and future condition (for parcels that are proposed to be exempt from hydromodification management) of the watershed. It was assumed that the changes in instream sediment supply between existing and future condition for these large depositional river systems are very minimal.

Selection of inputs for the analysis is explained in detail in Attachment B.1.1.2 and results from the analysis are presented in Attachment B.1.1.3 in tabular format. The E_p analysis performed in this study does not account for the following Regional MS4 permit requirements as a conservative assumption. If accounted for, it will result in a smaller E_p than what is currently reported in Attachment B.1.1.3:

- New development priority development projects including projects that are proposed to be exempt from hydromodification management requirements through this WMAA study must implement retention BMPs to the extent feasible if alternative compliance option is not selected or not available.
- Redevelopment priority development projects must mitigate to the pre-developed condition.

4.1.1.4. Recommendation

Based on the results from this study reported in Attachment B.1.1.3, the flow duration analysis performed in the Final HMP, and the Technical Advisory Committee (TAC) recommendations provided during the Final HMP development, it is recommended that hydromodification

management exemption be reinstated for projects discharging runoff directly to the following exempt river reaches:

River	Downstream Limit	Upstream Limit
Otay River	Outfall to San Diego Bay	Interstate 805
San Diego River	Outfall to Pacific Ocean	Confluence with San Vicente Creek
San Dieguito River	Upstream edge of the railroad crossing	Lake Hodges Dam
San Luis Rey River	Outfall to Pacific Ocean	Upstream river limit of Basin Plan subwatershed 903.1 upstream of Bonsall and near Interstate 15
Sweetwater River	Outfall to San Diego Bay	Sweetwater Reservoir Dam

Each municipality must define/approve “direct discharge” based on the project site conditions. To qualify for the potential exemption, the outlet elevation must be between the river bottom elevation and the 100-year floodplain elevation and properly designed energy dissipation must be provided. Mapping of these exempt river reaches is presented in Attachment B.2.

Additional studies to establish a site-specific allowable Ep metric for the Otay River from east of Interstate 805 to Lower Otay Reservoir Dam, more closely representing actual measured and observed characteristics of this river system, may result in allowing hydromodification management exemptions not currently supported by this desktop assessment which was based on an allowable Ep metric from literature. However, any future proposed HMP exemptions would need to be approved through the WQIP Annual Update process (Regional MS4 Permit Section F.1.2.c.).

4.1.1.5. Limitations

The analysis and associated recommendations as presented above were based on instream erosion as the primary consideration to support reinstatement of exemptions from hydromodification management controls for discharges directly to these river reaches. While it is recognized that other factors contribute to adverse impacts (e.g., salinity imbalance, pollutants) to instream habitat and resulting biotic integrity, hydromodification management control has traditionally been considered an “umbrella process” that encompasses most of the highest risk stressors (percent sands and fines present, channel alteration, and riparian disturbance) to physical habitat. Beyond demonstrating that instream erosion is not anticipated as a result of reinstating hydromodification management control exemptions for discharges to these river reaches, a focused method for correlating physical and biotic integrity to modified hydrological conditions has not been performed in this analysis, as an assessment method has not yet been developed.

The current assessment methods may yield inconclusive results when attempting to identify causal relationships between degraded instream habitat solely due to increased flows and erosive force from hydromodification. A causal assessment recently conducted in the lower reaches of the San Diego River, conducted as a partnership between the Southern California Coastal Water

Research Project (SCCWRP), the City of San Diego, the County of San Diego, and the San Diego RWQCB, focused on stressors potentially responsible for known biological impairment of the river. Once the data of the causal assessment become available, it may be useful in classifying the potential stressors such as altered physical habitat as likely, unlikely, or an uncertain cause to biological impairment.

With respect to adverse impacts to habitat as a result of pollutants entrained in storm water discharges, these areas will still be subject over time to the pollutant control requirements of the Regional MS4 Permit as areas develop or redevelop. The current requirements obligate development to maximize retention of the design storm volume which will mitigate a portion of the volume that would otherwise be controlled with hydromodification management BMPs. In some cases, this offsetting of volume reduction through pollutant control BMPs may exceed the HMP volumes. In addition, the development that occurs within the exempted watershed areas is still required to provide any applicable flood control measures. Risk of flooding as a result of exemption from hydromodification controls is unlikely as the control thresholds are significantly lower (order of magnitude) than flood control requirements implemented to protect life and property.

4.1.2. Stabilized Conveyance Systems Draining to Exempt Water Bodies

4.1.2.1. History

The March 2011 Final HMP, approved by the SDRWQCB under the 2007 MS4 Permit, provided a potential exemption from hydromodification management requirements for projects discharging runoff directly to hardened or rehabilitated systems that extend to exempt receiving waters. As described in the HMP, hardened or rehabilitated systems could include existing storm drain systems, existing concrete channels, or stable engineered unlined channels. To qualify for this exemption, the existing hardened or rehabilitated conveyance system must continue uninterrupted to the exempt system. In other words, the hardened or rehabilitated conveyance system cannot discharge to an unlined, non-engineered channel segment prior to discharge to the exempt system. Additionally, the project proponent must demonstrate that the hardened or rehabilitated conveyance system has capacity to convey the 10-year ultimate condition flow through the conveyance system. The 10-year flow should be calculated based upon single-event hydrologic criteria as detailed in the San Diego County Hydrology Manual.

This exemption was consistent with 2007 MS4 Permit language allowing exemption for discharges into "channels that are concrete-lined or significantly hardened (e.g., with rip-rap, sackrete, etc.) downstream to their outfall in bays or the ocean." The HMP language also allowed for channels stabilized by soft methods such as turf reinforcement mat or vegetation to be considered for exemption. Under these criteria, an engineered channel that is stabilized with riprap, turf reinforcement mat, vegetation, or other materials other than concrete could be determined to be exempt from hydromodification management requirements, pending demonstrating that it has capacity to convey the 10-year ultimate condition flow.

4.1.2.2. Status under 2013 Regional MS4 Permit

A significant change under the Regional MS4 Permit is the requirement that exempt systems draining to exempt water bodies either be "existing underground storm drain systems," or "conveyance channels whose bed and banks are concrete lined" all the way to exempt water bodies. The Regional MS4 Permit language does not include engineered channels that are stabilized with materials other than concrete, such as riprap, turf reinforcement mat, or vegetation. However, areas identified by Copermittees as appropriate for an exemption may be identified in the optional WMAA incorporated into the WQIP.

4.1.2.3. Research and Results

To provide a process for engineered channels that are stabilized with materials other than concrete, such as riprap, turf reinforcement mat, or vegetation to be identified in the WMAAs, an example study was prepared for an existing engineered channel stabilized with vegetation. The study demonstrates that a channel stabilized with materials other than concrete can be stable or have minimal potential for erosion. In order to allow for other channels that are stabilized with materials other than concrete to be identified in each WMAA, criteria for defining what is "stable" or "minimal potential for erosion" was determined.

Forrester Creek in the City of Santee was selected for the sample channel analysis. Forrester Creek is stabilized with vegetation from its confluence with the San Diego River downstream to Prospect Avenue upstream. For the purpose of this discussion, the confluence is the location where the floodplain of Forrester Creek meets the San Diego River floodplain, just west of

Gorge Avenue and Willowgrove Avenue, at the eastern side of the Carlton Oaks Golf Course. Stabilization occurred in two separate projects. The reach from the San Diego River confluence downstream to Mission Gorge Road upstream was constructed in 1990. The reach from Mission Gorge Road downstream to Prospect Avenue upstream is known as the Forrester Creek Improvement Project and was constructed in 2006-2007. Forrester Creek includes energy dissipators stabilized with riprap, concrete, and articulated concrete block at Mission Gorge Road undercrossing and Prospect Avenue undercrossing. Other than at bridge crossings, the engineered un-lined reach of Forrester Creek is stabilized with native vegetation. There is dense growth of trees in the channel.



Vegetation in Forrester Creek Downstream of Mission Gorge Road



Vegetation in Forrester Creek Upstream of Mission Gorge Road between Mission Gorge Road and State Route 52



Vegetation in Forrester Creek between State Route 52 and Olive Lane

Upstream of Prospect Avenue, Forrester Creek is a concrete-lined channel serving an urban area that is almost fully built out and served by existing underground storm drain systems and concrete-lined channels. Because of the vegetated reaches of Forrester Creek extending to the San Diego River, the concrete-lined portion of Forrester Creek and tributary underground storm drain systems and concrete-lined channels are not exempt from hydromodification management requirements unless the vegetated reaches of Forrester Creek are identified in the optional WMAA incorporated into the WQIP.

An erosion potential analysis was prepared for the vegetated reaches of Forrester Creek. An erosion potential analysis compares cumulative excess shear stress over all flows capable of transporting the channel-bed material from post-development to pre-development condition. The analysis used the same methods for determining erosion potential as presented in Section 4.1.1 and Attachment B.1.1 for the major river reaches.

For the purpose of determining flow rates and durations (hydrologic analysis), a regional scaling procedure developed by Hawley & Bledsoe in 2011 was used, the same method as presented in Section 4.1.1 and Attachment B.1.1 for the major river reaches. The method uses Duration Density Functions (DDFs) presented in the 2011 paper, "How do flow peaks and durations change in suburbanizing semi-arid watersheds? A southern California case study," to estimate cumulative durations for geomorphically-effective flows in a logarithmically-binned histogram format. Using these flows, long-term sediment transport can be subsequently estimated. The

analysis requires the following data, summarized below.

Summary of Input Data for Hydrologic Calculations for Forrester Creek Erosion Potential Analysis

Data	Units	Forrester Creek Watershed Existing Condition	Forrester Creek Watershed Future Condition
Tributary Area, A	square miles (mi ²)	23.36	23.36
Mean Annual Precipitation, MAP	inches	14	14
Length of Daily Flow Record	Years	30	30
Minimum Flow Rate	cubic feet per second	0.01	0.01
Number of Flow Bins	--	25	25
Impervious Cover	mi ² / mi ²	0.4634	0.4792

Impervious cover for the Forrester Creek watershed was determined by assigning land-use specific imperviousness values to the land use categories presented in the SanGIS land use data sets (existing land use in 2012 and planned land use, described in Chapter 2.3). The composite imperviousness of the watershed was then calculated based on the existing condition and future condition land use distribution within the watershed. The Forrester Creek watershed is nearly fully built out therefore there is little change in imperviousness from existing to future condition. Impervious area calculations for the Forrester Creek watershed are provided in Attachment B.1.2.

For the purpose of determining shear stress in the channel (hydraulic analysis), normal depth calculations for the binned flow rates determined from the DDF analysis were prepared for two channel cross sections. One cross section was taken in the reach constructed in 1990, and one cross section in the Forrester Creek Improvement Project reach. For each reach, the cross section expected to experience the greatest shear stress was selected, based on channel width and slope. The analysis requires the following data, summarized below.

Summary of Input Data for Hydraulic Calculations for Forrester Creek Erosion Potential Analysis

Data	Units	Forrester Creek Watershed Cross Section 1300	Forrester Creek Watershed Cross Section 2475
Channel Bottom Width, b	feet	84	155
Channel Side Slopes, z1 and z2	Horizontal:Vertical	z1 = 1.5:1 z2 = 2:1	z1 = z2 = 2:1
Channel Slope	foot/foot	0.006	0.003
Channel Roughness (Manning's n)	--	0.100	0.100
Critical Shear Stress	pounds per square foot (lb/ft ²)	2.1	2.1

Critical shear stress for the reaches was estimated to be greater than or equal to 2.1 pounds per square foot (lb/ft²), based on review of permissible shear stress values presented in "Stability Thresholds for Stream Restoration Materials" (Fischenich 2001) and "Streambank Soil Bioengineering Considerations for Semi-Arid Climates" (Hoag and Fripp 2005). Based on Fischenich 2001, permissible shear stress for "live willow stakes" is approximately 2.10 to 3.10 lb/ft².

The analysis results, presented in Attachment B.1.2, show that for both the existing and future condition, the shear stress for all geomorphically-effective flows based on the DDF analysis is less than the estimated critical shear stress of 2.1 lb/ft². This means that no excess shear stress or "work" occurs in the channel in either the existing or future condition. Therefore, there is no increase in the duration of "work" (cumulative work), in the future condition, and erosion potential is 1.0.

Note that while the flow rates are the same in both the existing and future condition analyses, the duration of each flow rate is increased in the future condition. The flow rates in the flow bins are based on the watershed area, mean annual precipitation, and length of the synthetic record. These do not change from existing to future condition. The duration for each flow bin is related to the watershed area, mean annual precipitation, length of the synthetic record, and the impervious area. The duration increases in the future condition based on the increased impervious area. The increase in duration would result in increased cumulative work in the future condition if any of the flow rates resulted in shear stress greater than the estimated critical shear stress (excess shear stress, or "work"), because cumulative work is the product of work times duration.

The scenario that occurred in the Forrester Creek analysis, in which no work occurred in the expected range of geomorphically-effective flow rates, is a potential scenario for engineered channels because engineered conveyance systems are typically engineered for flood flows much greater and less frequent than the geomorphically-effective flows. For example, Forrester Creek is engineered to convey a 100-year single-storm event flow rate of approximately 12,450 to 13,840 cubic feet per second (cfs) within the channel. ForresterThe maximum geomorphically-effective flow rate for Forrester Creek based on the DDF analysis is 836 cfs.

4.1.2.4. Recommendation

Based on the study that was prepared for this Regional WMAA, the vegetated reaches of Forrester Creek from its confluence with the San Diego River downstream to Prospect Avenue upstream are recommended to be exempt from hydromodification management requirements. The analysis has shown that future increases in impervious area within the watershed are not expected to increase the erosion potential in Forrester Creek. The concrete-lined portion of Forrester Creek and existing storm drain systems draining directly to the concrete-lined portion of Forrester Creek should also be exempt. Storm drain systems draining directly to the vegetated reaches of Forrester Creek would also be exempt if there is no evidence of localized erosion issues at the storm drain outfall.

Because engineered conveyance systems are typically engineered to convey flood flows much greater than the geomorphically-effective flows, some engineered conveyance systems may be capable of conveying all geomorphically-effective flows at very low depths with shear stress less than critical shear stress, as was the case for Forrester Creek. Based on this, other engineered conveyance systems that are stabilized with materials other than concrete, such as riprap, turf reinforcement mat, or vegetation, including rehabilitated stream systems, and/or existing natural

stream systems that appear stable based on visual inspection may be studied using the exemption methodology presented in Attachment E. Systems evaluated using this methodology and that meet the criteria presented below, may be recommended as exempt systems in the optional WMAA incorporated into the WQIP. However, any future proposed HMP exemptions would need to be approved through the WQIP Update process (Regional MS4 Permit Section F.2.c.).

The following are additional requirements and criteria for the qualifying for potential exemption:

- To qualify for exemption, the studied conveyance system must discharge to an exempt system (i.e., an exempt water body, an exempt river reach, or an existing storm drain system or concrete-lined channel that extends all the way to an exempt water body or exempt river reach). In other words, the studied conveyance system cannot discharge to a non-exempt channel segment prior to discharge to the exempt system.
- The river reach exemptions were established based on assumptions that certain stabilized conveyance systems were exempt and associated tributary developments were exempt from hydromodification management flow control requirements. Therefore if a conveyance system that is being studied for exemption is tributary to an exempt river reach, exemption of the studied conveyance system is only feasible if the conveyance system was included in the analysis of the exempt river reach (see Attachment B.1.1), or pending submittal of an updated analysis for the exempt river reach to include the additional stabilized conveyance system.
- Channel cross section(s) must be selected to represent the condition where the greatest shear stress is expected in the channel(s).

4.1.3. Highly Impervious/Highly Urbanized Watersheds and Urban Infill

4.1.3.1. History

The March 2011 Final HMP, approved by the SDRWQCB under the 2007 MS4 Permit, provided a potential exemption from hydromodification management requirements for projects discharging runoff to a highly urbanized watershed (defined as an existing, pre-project impervious percentage greater than 70 percent) (herein "highly impervious / highly urbanized watersheds exemption") and another potential exemption for urban infill projects discharging runoff to an existing hardened or rehabilitated conveyance system, where the existing impervious area percentage in the watershed exceeds 40 percent (herein "urban infill exemption").

To qualify for the highly impervious / highly urbanized watersheds exemption, watershed impervious area calculations must be measured between the project site discharge location and the connection to a downstream exempt system. If a tributary area connects with the main line drainage path between the project site and the exempt system, then the entire watershed area contributing to the tributary shall be included in the calculation.

To apply the urban infill exemption for a project, the domain of analysis must be determined and the existing hardened or rehabilitated conveyance system must extend beyond the downstream terminus of the domain of analysis. The hardened or rehabilitated conveyance system must discharge to a receiving channel with a Low potential for channel susceptibility for this exemption to be granted (channel susceptibility determined using SCCWRP tool). Additionally, the exemption could only be granted if the potential future development impacts in the watershed would increase the watershed's impervious area percentage by less than 3 percent (as compared to the existing condition in the year 2010). If the potential future cumulative impacts in the watershed could increase the impervious area percentage by more than 3 percent (as compared to existing condition), then no exemption could be granted based on this item. Watershed impervious area calculations for this potential exemption must be measured upstream from the outfall of the urban conveyance system (to a non-concrete, non-riprap-lined or non-engineered channel) to the contributing watershed boundary (the entire watershed contributing to the discharge outfall).

4.1.3.2. Status under 2013 Regional MS4 Permit

Under the Regional MS4 Permit, highly impervious / highly urbanized watersheds and urban infill areas would fall under the category of areas identified by Copermittees as appropriate for an exemption. These areas may be identified in the optional WMAA incorporated into the WQIP.

4.1.3.3. Research and Results

The highly impervious / highly urbanized watersheds exemption was based on 2007 MS4 Permit language that exempted "construction of projects where the sub-watersheds below the projects' discharge points are highly impervious (e.g., >70%) and the potential for single-project and/or cumulative impacts is minimal." No modeling was prepared in support of this exemption during development of the March 2011 Final HMP – the exemption was provided by the 2007 MS4 Permit.

The urban infill exemption was based on a sensitivity analysis presented in Appendix F of the March 2011 Final HMP. The analysis was prepared using continuous simulation modeling of synthetic unit watersheds. The level of imperviousness was progressively increased for each synthetic unit watershed to simulate infill development. The flow duration statistics were examined to determine at what level of increased development the statistics became noticeably altered. Based on the study it was determined that urban infill projects have a relatively minor effect on the overall watershed's flow duration curve if the future cumulative additional impacts have the potential to increase the existing watershed impervious area by less than 3 percent. "Relatively minor effect" was not defined with a numeric threshold in Appendix F of the March 2011 Final HMP.

The sensitivity analysis prepared for the urban infill exemption examined synthetic unit watersheds with 40, 50, and 60 percent imperviousness. The extent of the spread in the results of the 40, 50, and 60-percent models demonstrated that unchecked development within urbanized watershed would have a noticeable effect on the peak flows and flow durations observed within the receiving waters. While watersheds 70% impervious and above were not modeled, unchecked development within these "highly impervious / highly urbanized watersheds" may also have a noticeable effect on the peak flows and flow durations observed within the receiving waters.

Since the adoption of the March 2011 Final HMP, a study titled, "Channel Enlargement in Semiarid Suburbanizing Watersheds: A Southern California Case Study," prepared by R.J. Hawley and B.P. Bledsoe, was published in *Journal of Hydrology* 496 (2013). The study presented a numeric threshold at which channel enlargement could be expected. In the study, "the threshold corresponding to the presence/absence of headcutting varied based on substrate type, and was roughly quantified as a sediment-transport ratio greater than ~ 1.20 in systems with a median grain size > 16 mm, and $L_r \sim 1.05$ when $d_{50} < 16$ mm." Sediment-transport ratio or L_r is the ratio of the cumulative excess shear stress over all flows capable of transporting the channel-bed material from post-development to pre-development condition. This is also known as "effective work index" or "erosion potential."

Using thresholds of 1.20 for systems with a median grain size > 16 mm, and 1.05 for systems with a median grain size < 16 mm, Geosyntec Consultants prepared a study in support of the Ventura County Hydromodification Control Plan (Ventura County HCP) to evaluate thresholds for additional impervious cover, from existing conditions (at the time of the HCP effective date) to build-out conditions, for the area tributary to a susceptible receiving water below which the risk of hydromodification impacts is considered negligible for that channel. The study is titled, "Basis for Designating Negligible Risk Based on Cumulative Future Buildout," and is presented in Appendix D of the Ventura County HCP (Final Draft dated September 2013). A copy of Appendix D of the Ventura County HCP (Final Draft dated September 2013) is provided in Attachment B.1.3. The following are the results of the study, presented as a function of a susceptible channel's tributary area (A) and median grain size (D50):

- If $A > 1$ square mile and $D_{50} < 16$ mm, then the threshold of additional imperviousness is evaluated using a nomograph that is based on empirical flow duration equations (Hawley and Bledsoe, 2011), empirical channel geometry relationships (Coleman et al, 2005 and County of San Diego, 2009), and Erosion Potential analyses. The results range

from 0.46% to 1.00% additional imperviousness, depending on watershed size and mean annual precipitation (MAP).

- If $A < 1$ square mile and $D50 < 16$ mm, then the threshold of additional imperviousness is 0.44%.
- If $D50 > 16$ mm, then the threshold of additional imperviousness is 1.65%.

The thresholds of additional imperviousness presented in the Ventura County HCP (ranging from 0.44% to 1.65%) are lower than the 3% allowable limit presented in the San Diego County Final HMP dated March 2011.

4.1.3.4. Recommendation

Based on evaluation of the exemptions presented in the March 2011 Final HMP and comparison with more recent research prepared for the Ventura County HCP, resurrection of the highly impervious / highly urbanized and urban infill exemptions from the March 2011 Final HMP is not recommended. The research prepared in support of the Ventura County HCP determined lower thresholds of additional impervious area (ranging from 0.44% to 1.65%) than the limit presented in the San Diego County Final HMP dated March 2011 (3%).

4.1.4. Tidally Influenced Lagoons

4.1.4.1. History

The March 2011 Final HMP, approved by the SDRWQCB under the 2007 MS4 Permit, provided a potential exemption from hydromodification management requirements for projects discharging runoff directly to a tidally-influenced lagoon. To qualify for the potential exemption, additional analysis would be required to assess the effects of the freshwater / saltwater balance and the resultant effects on lagoon-system biology. This assessment, which would be required by other permitting processes such as the Army Corps of Engineers, California Department of Fish and Game, etc., must be provided by a certified biologist or other specialist as approved by the governing municipality. Additionally, project discharges must include an energy dissipation system (riprap, etc.) designed to mitigate 100-year outlet velocities based upon a free outfall condition.

4.1.4.2. Status under 2013 Regional MS4 Permit

The Regional MS4 Permit language discussing exemptions from hydromodification management does not specifically include the terminology that was used in the Final HMP including, "tidally influenced lagoons" or "tidally influenced areas." The Permit does indicate that exemptions from hydromodification management may be granted for discharges from existing underground storm drains and concrete lined conveyance channels to "enclosed embayments" (lagoons). However, other drainage systems not meeting the above definition may be identified by Copermitees as appropriate for an exemption in the optional WMAA incorporated into the WQIP.

4.1.4.3. Recommendation

Engineered conveyance systems discharging to lagoons that are stabilized with materials other than concrete, such as riprap, turf reinforcement mat, or vegetation, including rehabilitated stream systems, and/or existing natural stream systems that appear stable based on visual inspection may be studied using the exemption methodology presented in Attachment E. Systems evaluated using this methodology and that meet the criteria presented below, may be recommended as exempt systems in the optional WMAA incorporated into the WQIP. However, any future proposed HMP exemptions would need to be approved through the WQIP Update process (Regional MS4 Permit Section F.2.c.).

The following are additional requirements and criteria for the qualifying for potential exemption:

- To qualify for exemption, the studied conveyance system must discharge to an exempt system (i.e., an exempt water body, an exempt river reach, or an existing storm drain system or concrete-lined channel that extends all the way to an exempt water body or exempt river reach). In other words, the studied conveyance system cannot discharge to a non-exempt channel segment prior to discharge to the exempt system.
- Channel cross section(s) must be selected to represent the condition where the greatest shear stress is expected in the channel(s)

5. Conclusions

5.1. Watershed Management Area Characterization

The WMA Characterization data was developed using available regional data to further understand the macro-scale watershed characteristics and processes in the San Diego permit region. The Regional MS4 Permit allows for flexibility in complying with land development requirements when using the information developed in the WMAA to improve water quality planning and implementation associated with land development. This dataset will assist with identifying the opportunities and constraints for projects and management decisions based on a watershed-scale (rather than piecemeal project identification without context within the watershed) and provides Copermitees the ability to exercise the option to create an alternative compliance program that offers the opportunity to develop watershed-specific alternatives to universal onsite structural BMP implementation. The characterization data includes:

Characterization Data	Utilization Potential
<p>Dominant Hydrologic Process:</p> <ul style="list-style-type: none"> • Overland flow • Infiltration • Interflow 	<ul style="list-style-type: none"> • Identify areas for enhanced infiltration or collection of storm water for treatment • Implement management measures that correspond to pre-development conditions – promotes long-term channel stability and health • Increases understanding of the natural functioning of the watershed and what has been (or is at risk of being) altered by urbanization.
<p>Stream Characterization:</p> <ul style="list-style-type: none"> • Reach type • Bed material • Bank material • Hydrographic category • Channel infrastructure 	<ul style="list-style-type: none"> • Preliminary dataset that can be used to conduct stream power evaluations • Identify channel systems for preservation or restoration • Identification of appropriate space for channel processes to occur (e.g., flood plain connectivity) • Insight to sensitivity of receiving stream reach • Indicates the features within channels that affect water and sediment movement through the watershed

Characterization Data	Utilization Potential
Land Use: <ul style="list-style-type: none"> • Existing • Future 	<ul style="list-style-type: none"> • Foresight (identifies relative risks, opportunities, or constraints) in comparing future to existing land uses, i.e., areas that may be more/less vulnerable to adverse impacts to changes in storm water runoff associated with development • Encourage infill development
Potential Critical Coarse Sediment Yield Areas	<ul style="list-style-type: none"> • Preservation of areas or function that contributes critical sediment within the watershed to stream armoring/stability • Assist with identifying potentially susceptible stream reaches that require uninterrupted coarse sediment supplies to remain stable • Dual goal of open space conservation

Regarding the identification of the potential critical coarse sediment yield areas in the Regional WMAA using readily available regional datasets, it is anticipated that when more precise estimates for potential critical coarse sediment yield areas are required for a particular site or subarea that this regional study will be augmented with site-specific analysis. Development projects must avoid critical sediment yield areas or implement measures that allow critical coarse sediment to be discharged to receiving waters, such that there is no net impact to the receiving water to meet the requirements of the Regional MS4 permit. As such, projects should consult the Model BMP Design Manual and/or jurisdiction specific BMP Design manual for options to meet the Regional MS4 permit requirements. It is anticipated that the data will not be static but will be enhanced over time through future studies or field assessments that will refine what is currently a macro-level data set.

5.2. Template for Candidate Project List

It is anticipated the Copermittees that elect to develop alternative compliance programs will conduct a separate exercise to nominate potential candidate projects for inclusion into the WQIPs using the template developed for this project.

5.3. Hydromodification Management Exemptions

Attachment B.2 presents hydromodification management applicability/exemption mapping. The mapping includes receiving waters that are exempt based on the Regional MS4 Permit or recommended exempt based on studies.

Receiving waters that are **exempt** based on the Regional MS4 Permit include:

- The Pacific Ocean
- San Diego Bay
- Mission Bay
- Lakes and Reservoirs
- Existing underground storm drains or concrete-lined channels draining directly to bays or the ocean

Receiving waters or conveyance systems that are recommended exempt based on studies that were prepared as part of the Regional WMAA or prepared by others and provided for this purpose include:

- Otay River from Outfall at San Diego Bay to Interstate 805
- San Diego River from Pacific Ocean to confluence with San Vicente Creek
- San Dieguito River from upstream edge of the railroad crossing to Lake Hodges Dam
- San Luis Rey River from Pacific Ocean to upstream river limit of Basin Plan subwatershed 903.1 upstream of Bonsall and near Interstate 15
- Sweetwater River from San Diego Bay to Sweetwater Reservoir Dam
- Forrester Creek stabilized reach from the confluence with the San Diego River to Prospect Avenue

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San Diego County Regional Watershed Management Area Analysis ATTACHMENTS



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October 2015

Prepared for:
San Diego County Copermittees



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ATTACHMENT A
WATERSHED MANAGEMENT AREA
CHARACTERIZATION

ATTACHMENT A.1
DOMINANT HYDROLOGICAL PROCESS

A.1 Dominant Hydrological Process

Table A.1.1: Runoff Coefficients versus Land Use, Hydrologic Soil Group (A, B, C, D), and Slope Range

Land Use	A			B			C			D		
	0-2%	2-6%	6% ^a	0-2%	2-6%	6% ^a	0-2%	2-6%	6% ^a	0-2%	2-6%	6% ^a
Cultivated land	0.08 ^a	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
	0.14 ^b	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Pasture	0.12	0.20	0.30	0.18	0.28	0.37	0.24	0.34	0.44	0.30	0.40	0.50
	0.15	0.25	0.37	0.23	0.34	0.45	0.30	0.42	0.52	0.37	0.50	0.62
Meadow	0.10	0.16	0.25	0.14	0.22	0.30	0.20	0.28	0.36	0.24	0.30	0.40
	0.14	0.22	0.30	0.20	0.28	0.37	0.26	0.35	0.44	0.30	0.40	0.50
Forest	0.05	0.08	0.11	0.08	0.11	0.14	0.10	0.13	0.16	0.12	0.16	0.20
	0.08	0.11	0.14	0.10	0.14	0.18	0.12	0.16	0.20	0.15	0.20	0.25
Residential lot size 1/8 acre	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
	0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Residential lot size 1/4 acre	0.22	0.26	0.29	0.24	0.29	0.33	0.27	0.31	0.36	0.30	0.34	0.40
	0.30	0.34	0.37	0.33	0.37	0.42	0.36	0.40	0.47	0.38	0.42	0.52
Residential lot size 1/3 acre	0.19	0.23	0.26	0.22	0.26	0.30	0.25	0.29	0.34	0.28	0.32	0.39
	0.28	0.32	0.35	0.30	0.35	0.39	0.33	0.38	0.45	0.36	0.40	0.50
Residential lot size 1/2 acre	0.16	0.20	0.24	0.19	0.23	0.28	0.22	0.27	0.32	0.26	0.30	0.37
	0.25	0.29	0.32	0.28	0.32	0.36	0.31	0.35	0.42	0.34	0.38	0.48
Residential lot size 1 acre	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.29	0.35
	0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Industrial	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
	0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.89	0.90
Streets	0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78
	0.76	0.77	0.79	0.80	0.82	0.84	0.84	0.85	0.89	0.89	0.91	0.95
Open space	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.15	0.21	0.28
	0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Parking	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87	0.85	0.86	0.87
	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97	0.95	0.96	0.97

^a Runoff coefficients for storm recurrence intervals less than 25 years.

^b Runoff coefficients for storm recurrence intervals of 25 years or longer.

Source: Table 7-9 in *Hydrologic Analysis and Design* (McCuen, 2005)

Table A.1.2: Land Cover Grouping

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
1	42000 Valley and Foothill Grassland	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Agricultural/Grass
2	42100 Native Grassland		Agricultural/Grass
3	42110 Valley Needlegrass Grassland		Agricultural/Grass
4	42120 Valley Sacaton Grassland		Agricultural/Grass

Regional WMAA Attachments

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping	
5	42200 Non-Native Grassland	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Agricultural/Grass	
6	42300 Wildflower Field		Agriculture/Grass	
7	42400 Foothill/Mountain Perennial Grassland		Agriculture/Grass	
8	42470 Transmontane Dropseed Grassland		Agriculture/Grass	
9	45000 Meadow and Seep		Agriculture/Grass	
10	45100 Montane Meadow		Agriculture/Grass	
11	45110 Wet Montane Meadow		Agriculture/Grass	
12	45120 Dry Montane Meadows		Agriculture/Grass	
13	45300 Alkali Meadows and Seeps		Agriculture/Grass	
14	45320 Alkali Seep		Agriculture/Grass	
15	45400 Freshwater Seep		Agriculture/Grass	
16	46000 Alkali Playa Community		Agriculture/Grass	
17	46100 Badlands/Mudhill Forbs		Agriculture/Grass	
18	Non-Native Grassland		Agriculture/Grass	
19	18000 General Agriculture		Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Agriculture/Grass
20	18100 Orchards and Vineyards			Agriculture/Grass
21	18200 Intensive Agriculture			Agriculture/Grass
22	18200 Intensive Agriculture - Dairies, Nurseries, Chicken Ranches			Agriculture/Grass
23	18300 Extensive Agriculture - Field/Pasture, Row Crops	Agriculture/Grass		
24	18310 Field/Pasture	Agriculture/Grass		
25	18310 Pasture	Agriculture/Grass		
26	18320 Row Crops	Agriculture/Grass		
27	12000 Urban/Developed	Developed		
28	12000 Urban/Develpoed	Developed		
29	81100 Mixed Evergreen Forest	Forest	Forest	
30	81300 Oak Forest		Forest	
31	81310 Coast Live Oak Forest		Forest	
32	81320 Canyon Live Oak Forest		Forest	
33	81340 Black Oak Forest		Forest	
34	83140 Torrey Pine Forest		Forest	
35	83230 Southern Interior Cypress Forest		Forest	
36	84000 Lower Montane Coniferous Forest		Forest	
37	84100 Coast Range, Klamath and Peninsular Coniferous Forest		Forest	

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Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
38	84140 Coulter Pine Forest	Forest	Forest
39	84150 Bigcone Spruce (Bigcone Douglas Fir)-Canyon Oak Forest		Forest
40	84230 Sierran Mixed Coniferous Forest		Forest
41	84500 Mixed Oak/Coniferous/Bigcone/Coulter		Forest
42	85100 Jeffrey Pine Forest		Forest
43	11100 Eucalyptus Woodland	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Forest
44	60000 RIPARIAN AND BOTTOMLAND HABITAT	Riparian and Bottomland Habitat	Forest
45	61000 Riparian Forests		Forest
46	61300 Southern Riparian Forest		Forest
47	61310 Southern Coast Live Oak Riparian Forest		Forest
48	61320 Southern Arroyo Willow Riparian Forest		Forest
49	61330 Southern Cottonwood-willow Riparian Forest		Forest
50	61510 White Alder Riparian Forest		Forest
51	61810 Sonoran Cottonwood-willow Riparian Forest		Forest
52	61820 Mesquite Bosque		Forest
53	62000 Riparian Woodlands		Forest
54	62200 Desert Dry Wash Woodland		Forest
55	62300 Desert Fan Palm Oasis Woodland		Forest
56	62400 Southern Sycamore-alder Riparian Woodland		Forest
57	70000 WOODLAND		Woodland
58	71000 Cismontane Woodland	Forest	
59	71100 Oak Woodland	Forest	
60	71120 Black Oak Woodland	Forest	
61	71160 Coast Live Oak Woodland	Forest	
62	71161 Open Coast Live Oak Woodland	Forest	
63	71162 Dense Coast Live Oak Woodland	Forest	
64	71162 Dense Coast Love Oak Woodland	Forest	

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Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping	
65	71180 Engelmann Oak Woodland	Woodland	Forest	
66	71181 Open Engelmann Oak Woodland		Forest	
67	71182 Dense Engelmann Oak Woodland		Forest	
68	72300 Peninsular Pinon and Juniper Woodlands		Forest	
69	72310 Peninsular Pinon Woodland		Forest	
70	72320 Peninsular Juniper Woodland and Scrub		Forest	
71	75100 Elephant Tree Woodland		Forest	
72	77000 Mixed Oak Woodland		Forest	
73	78000 Undifferentiated Open Woodland		Forest	
74	79000 Undifferentiated Dense Woodland		Forest	
75	Engelmann Oak Woodland		Forest	
76	52120 Southern Coastal Salt Marsh		Bog and Marsh	Other
77	52300 Alkali Marsh			Other
78	52310 Cismontane Alkali Marsh			Other
79	52400 Freshwater Marsh	Other		
80	52410 Coastal and Valley Freshwater Marsh	Other		
81	52420 Transmontane Freshwater Marsh	Other		
82	52440 Emergent Wetland	Other		
83	44000 Vernal Pool	Grasslands, Vernal Pools, Meadows, and Other Herb Communities	Other	
84	44320 San Diego Mesa Vernal Pool		Other	
85	44322 San Diego Mesa Claypan Vernal Pool (southern mesas)		Other	
86	13100 Open Water	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Other	
87	13110 Marine		Other	
88	13111 Subtidal		Other	
89	13112 Intertidal		Other	
90	13121 Deep Bay		Other	
91	13122 Intermediate Bay		Other	
92	13123 Shallow Bay		Other	
93	13130 Estuarine		Other	
94	13131 Subtidal		Other	
95	13133 Brackishwater		Other	

Regional WMAA Attachments

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
96	13140 Freshwater	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Other
97	13200 Non-Vegetated Channel, Floodway, Lakeshore Fringe		Other
98	13300 Saltpan/Mudflats		Other
99	13400 Beach		Other
100	21230 Southern Foredunes	Dune Community	Scrub/Shrub
101	22100 Active Desert Dunes		Scrub/Shrub
102	22300 Stabilized and Partially-Stabilized Desert Sand Field		Scrub/Shrub
103	24000 Stabilized Alkaline Dunes		Scrub/Shrub
104	29000 ACACIA SCRUB		Scrub/Shrub
105	63000 Riparian Scrubs	Riparian and Bottomland Habitat	Scrub/Shrub
106	63300 Southern Riparian Scrub		Scrub/Shrub
107	63310 Mule Fat Scrub		Scrub/Shrub
108	63310 Mulefat Scrub		Scrub/Shrub
109	63320 Southern Willow Scrub		Scrub/Shrub
110	63321 Arundo donnax Dominant/Southern Willow Scrub		Scrub/Shrub
111	63330 Southern Riparian Scrub		Scrub/Shrub
112	63400 Great Valley Scrub		Scrub/Shrub
113	63410 Great Valley Willow Scrub		Scrub/Shrub
114	63800 Colorado Riparian Scrub		Scrub/Shrub
115	63810 Tamarisk Scrub		Scrub/Shrub
116	63820 Arrowweed Scrub		Scrub/Shrub
117	31200 Southern Coastal Bluff Scrub	Scrub and Chaparral	Scrub/Shrub
118	32000 Coastal Scrub		Scrub/Shrub
119	32400 Maritime Succulent Scrub		Scrub/Shrub
120	32500 Diegan Coastal Sage Scrub		Scrub/Shrub
121	32510 Coastal form		Scrub/Shrub
122	32520 Inland form (> 1,000 ft. elevation)		Scrub/Shrub
123	32700 Riversidian Sage Scrub		Scrub/Shrub
124	32710 Riversidian Upland Sage Scrub		Scrub/Shrub
125	32720 Alluvial Fan Scrub		Scrub/Shrub
126	33000 Sonoran Desert Scrub		Scrub/Shrub
127	33100 Sonoran Creosote Bush Scrub		Scrub/Shrub
128	33200 Sonoran Desert Mixed Scrub		Scrub/Shrub
129	33210 Sonoran Mixed Woody Scrub		Scrub/Shrub

Regional WMAA Attachments

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
130	33220 Sonoran Mixed Woody and Succulent Scrub	Scrub and Chaparral	Scrub/Shrub
131	33230 Sonoran Wash Scrub		Scrub/Shrub
132	33300 Colorado Desert Wash Scrub		Scrub/Shrub
133	33600 Encelia Scrub		Scrub/Shrub
134	34000 Mojavean Desert Scrub		Scrub/Shrub
135	34300 Blackbush Scrub		Scrub/Shrub
136	35000 Great Basin Scrub		Scrub/Shrub
137	35200 Sagebrush Scrub		Scrub/Shrub
138	35210 Big Sagebrush Scrub		Scrub/Shrub
139	35210 Sagebrush Scrub		Scrub/Shrub
140	36110 Desert Saltbush Scrub		Scrub/Shrub
141	36120 Desert Sink Scrub		Scrub/Shrub
142	37000 Chaparral		Scrub/Shrub
143	37120 Southern Mixed Chaparral		Scrub/Shrub
144	37120 Southern Mixed Chapparal		Scrub/Shrub
145	37121 Granitic Southern Mixed Chaparral		Scrub/Shrub
146	37121 Southern Mixed Chaparral		Scrub/Shrub
147	37122 Mafic Southern Mixed Chaparral		Scrub/Shrub
148	37130 Northern Mixed Chaparral		Scrub/Shrub
149	37131 Granitic Northern Mixed Chaparral		Scrub/Shrub
150	37132 Mafic Northern Mixed Chaparral		Scrub/Shrub
151	37200 Chamise Chaparral		Scrub/Shrub
152	37210 Granitic Chamise Chaparral		Scrub/Shrub
153	37220 Mafic Chamise Chaparral		Scrub/Shrub
154	37300 Red Shank Chaparral		Scrub/Shrub
155	37400 Semi-Desert Chaparral		Scrub/Shrub
156	37500 Montane Chaparral		Scrub/Shrub
157	37510 Mixed Montane Chaparral		Scrub/Shrub
158	37520 Montane Manzanita Chaparral		Scrub/Shrub
159	37530 Montane Ceanothus Chaparral		Scrub/Shrub
160	37540 Montane Scrub Oak Chaparral		Scrub/Shrub
161	37800 Upper Sonoran Ceanothus Chaparral		Scrub/Shrub
162	37830 Ceanothus crassifolius Chaparral		Scrub/Shrub
163	37900 Scrub Oak Chaparral		Scrub/Shrub
164	37A00 Interior Live Oak Chaparral	Scrub/Shrub	

Id	SanGIS Legend	SanGIS Grouping	Land Cover Grouping
165	37C30 Southern Maritime Chaparral	Scrub and Chaparral	Scrub/Shrub
166	37G00 Coastal Sage-Chaparral Scrub		Scrub/Shrub
167	37K00 Flat-topped Buckwheat		Scrub/Shrub
168	39000 Upper Sonoran Subshrub Scrub		Scrub/Shrub
169	Diegan Coastal Sage Scrub		Scrub/Shrub
170	Granitic Northern Mixed Chaparral		Scrub/Shrub
171	Southern Mixed Chaparral		Scrub/Shrub
172	11000 Non-Native Vegetation	Non-Native Vegetation, Developed Areas, or Unvegetated Habitat	Unknown
173	11000 Non-Native VegetationVegetation		Unknown
174	11200 Disturbed Wetland		Unknown
175	11300 Disturbed Habitat		Unknown
176	13000 Unvegetated Habitat		Unknown
177	Disturbed Habitat		Unknown

Table A.1.3: Related Land Cover and Land Use Categories

Land Cover per San Diego County	Land Use per Table A.1.1
Agriculture/Grass	Meadow
Forest	Forest
Scrub/Shrub	Average (Meadow, Forest)
Unknown/Other	Meadow

Table A.1.4: Applicable Hydrologic Response Unit Calculations

Land Cover	Soil	Gradient	Runoff Coeff.	ET Coeff.	Infiltration Coeff.	Runoff/Infiltration Ratio	Hydrologic Process Designation
Agriculture/Grass	A	0-2%	0.10	0.60	0.30	0.33	I
Agriculture/Grass	A	2-6%	0.16	0.60	0.24	0.67	U
Agriculture/Grass	A	6-10%	0.25	0.60	0.15	1.67	O
Agriculture/Grass	B	0-2%	0.14	0.60	0.26	0.54	I
Agriculture/Grass	B	2-6%	0.22	0.60	0.18	1.22	U
Agriculture/Grass	B	6-10%	0.30	0.60	0.10	3.00	O
Agriculture/Grass	C	0-2%	0.20	0.60	0.20	1.00	U
Agriculture/Grass	C	2-6%	0.28	0.60	0.12	2.33	O
Agriculture/Grass	C	6-10%	0.36	0.60	0.04	9.00	O
Agriculture/Grass	D	0-2%	0.24	0.60	0.16	1.50	U
Agriculture/Grass	D	2-6%	0.30	0.60	0.10	3.00	O
Agriculture/Grass	D	6-10%	0.40	0.60	0.00	infinite	O

Regional WMAA Attachments

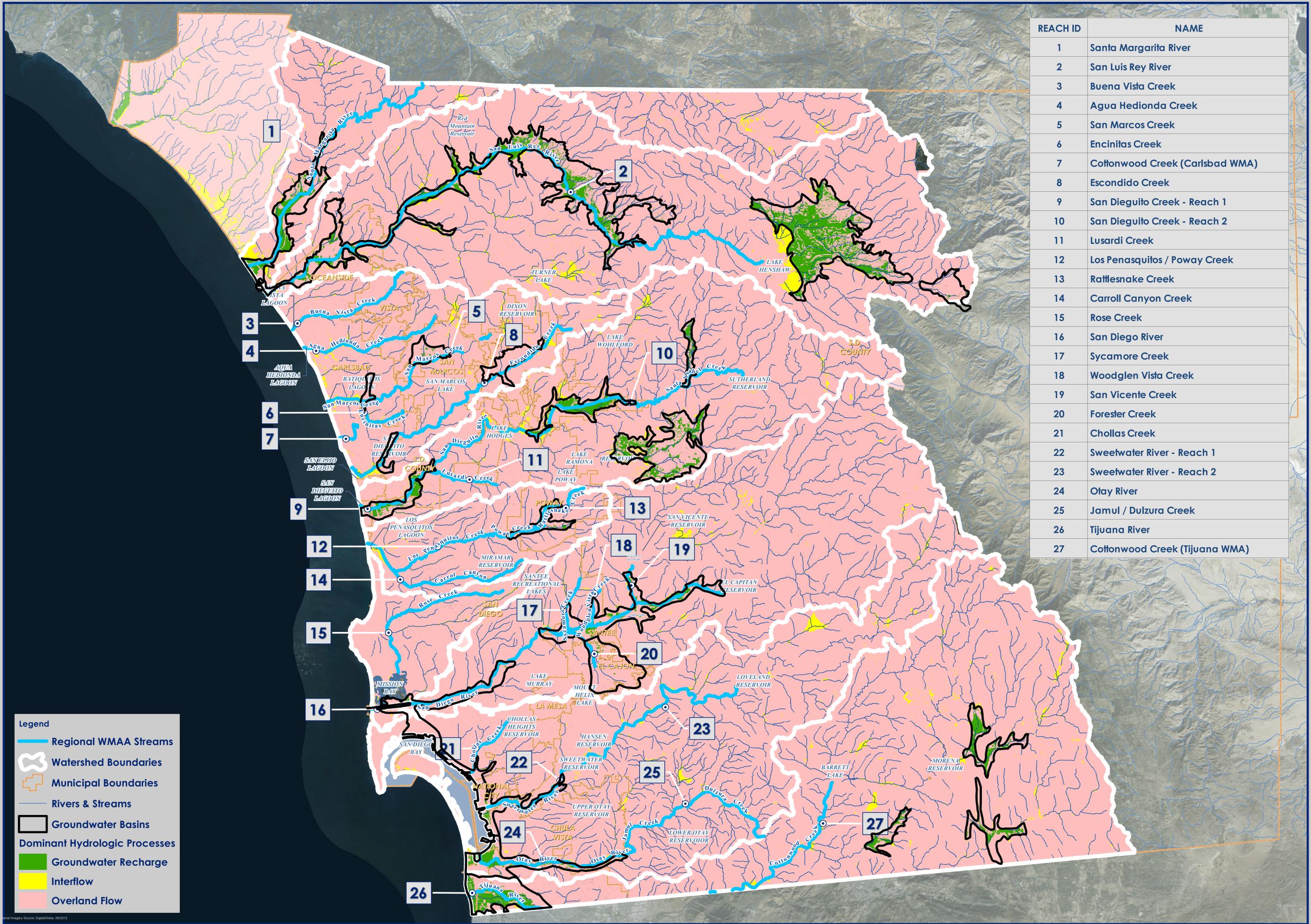
Land Cover	Soil	Gradient	Runoff Coeff.	ET Coeff.	Infiltration Coeff.	Runoff/ Infiltration Ratio	Hydrologic Process Designation
Forest	A	0-2%	0.05	0.80	0.15	0.33	I
Forest	A	2-6%	0.08	0.80	0.12	0.67	U
Forest	A	6-10%	0.11	0.80	0.09	1.22	U
Forest	B	0-2%	0.08	0.80	0.12	0.67	U
Forest	B	2-6%	0.11	0.80	0.09	1.22	U
Forest	B	6-10%	0.14	0.80	0.06	2.33	O
Forest	C	0-2%	0.10	0.80	0.10	1.00	U
Forest	C	2-6%	0.13	0.80	0.07	1.86	O
Forest	C	6-10%	0.16	0.80	0.04	4.00	O
Forest	D	0-2%	0.12	0.80	0.08	1.50	U
Forest	D	2-6%	0.16	0.80	0.04	4.00	O
Forest	D	6-10%	0.20	0.80	0.00	infinite	O
Scrub/Shrub	A	0-2%	0.08	0.70	0.23	0.33	I
Scrub/Shrub	A	2-6%	0.12	0.70	0.18	0.67	U
Scrub/Shrub	A	6-10%	0.18	0.70	0.12	1.50	U
Scrub/Shrub	B	0-2%	0.11	0.70	0.19	0.58	I
Scrub/Shrub	B	2-6%	0.17	0.70	0.14	1.22	U
Scrub/Shrub	B	6-10%	0.22	0.70	0.08	2.75	O
Scrub/Shrub	C	0-2%	0.15	0.70	0.15	1.00	U
Scrub/Shrub	C	2-6%	0.21	0.70	0.10	2.16	O
Scrub/Shrub	C	6-10%	0.26	0.70	0.04	6.50	O
Scrub/Shrub	D	0-2%	0.19	0.70	0.12	1.50	U
Scrub/Shrub	D	2-6%	0.23	0.70	0.07	3.29	O
Scrub/Shrub	D	6-10%	0.30	0.70	0.00	infinite	O

Hydrologic Process Designation: I = Interflow; O = Overland Flow; U = Uncertain

Table A.1.5: Hydrologic Response Unit Designations

Land Cover	Slope	Soil Type				
		A	B	C	D	Other (fill/water)
Agriculture/ Grass/Unknown/ Other	0-2%	I	I	U	U	U
	2-6%	U	U	O	O	U
	6-10%	O	O	O	O	O
	>10%	O	O	O	O	O
Developed	0-2%	O	O	O	O	O
	2-6%	O	O	O	O	O
	6-10%	O	O	O	O	O
	>10%	O	O	O	O	O
Forest	0-2%	I	U	U	U	U
	2-6%	U	U	O	O	U
	6-10%	U	O	O	O	U
	>10%	O	O	O	O	O
Scrub/Shrub	0-2%	I	I	U	U	U
	2-6%	U	U	O	O	U
	6-10%	U	O	O	O	U
	>10%	O	O	O	O	O

Hydrologic Process Designation: I = Interflow; O = Overland Flow; U = Uncertain



REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

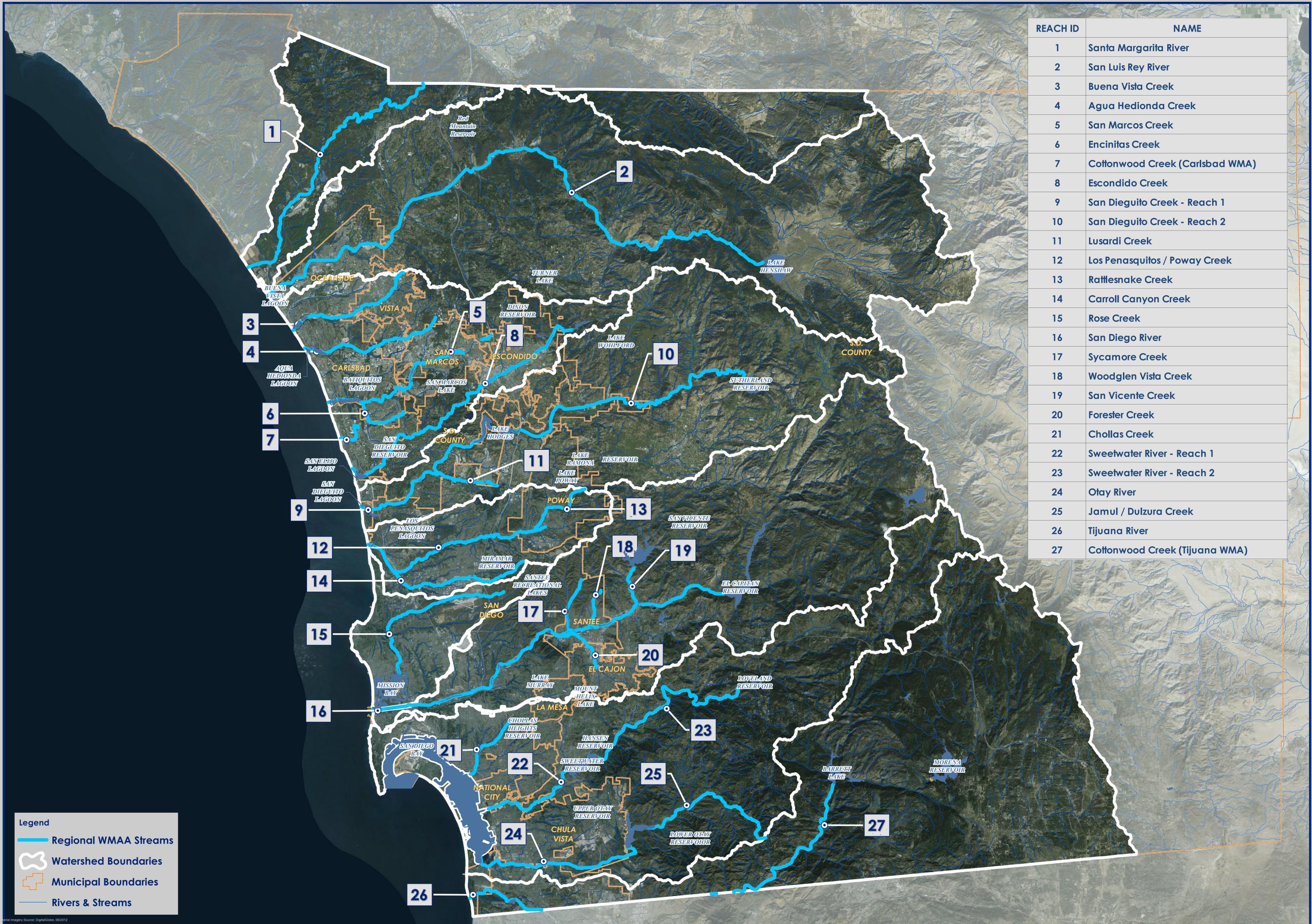
Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams
- Groundwater Basins
- Dominant Hydrologic Processes**
- Groundwater Recharge
- Interflow
- Overland Flow

Dominant Hydrologic Processes Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014

ATTACHMENT A.2
STREAM CHARACTERIZATION



REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
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21	Chollas Creek
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23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

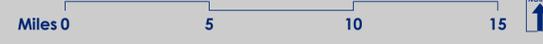
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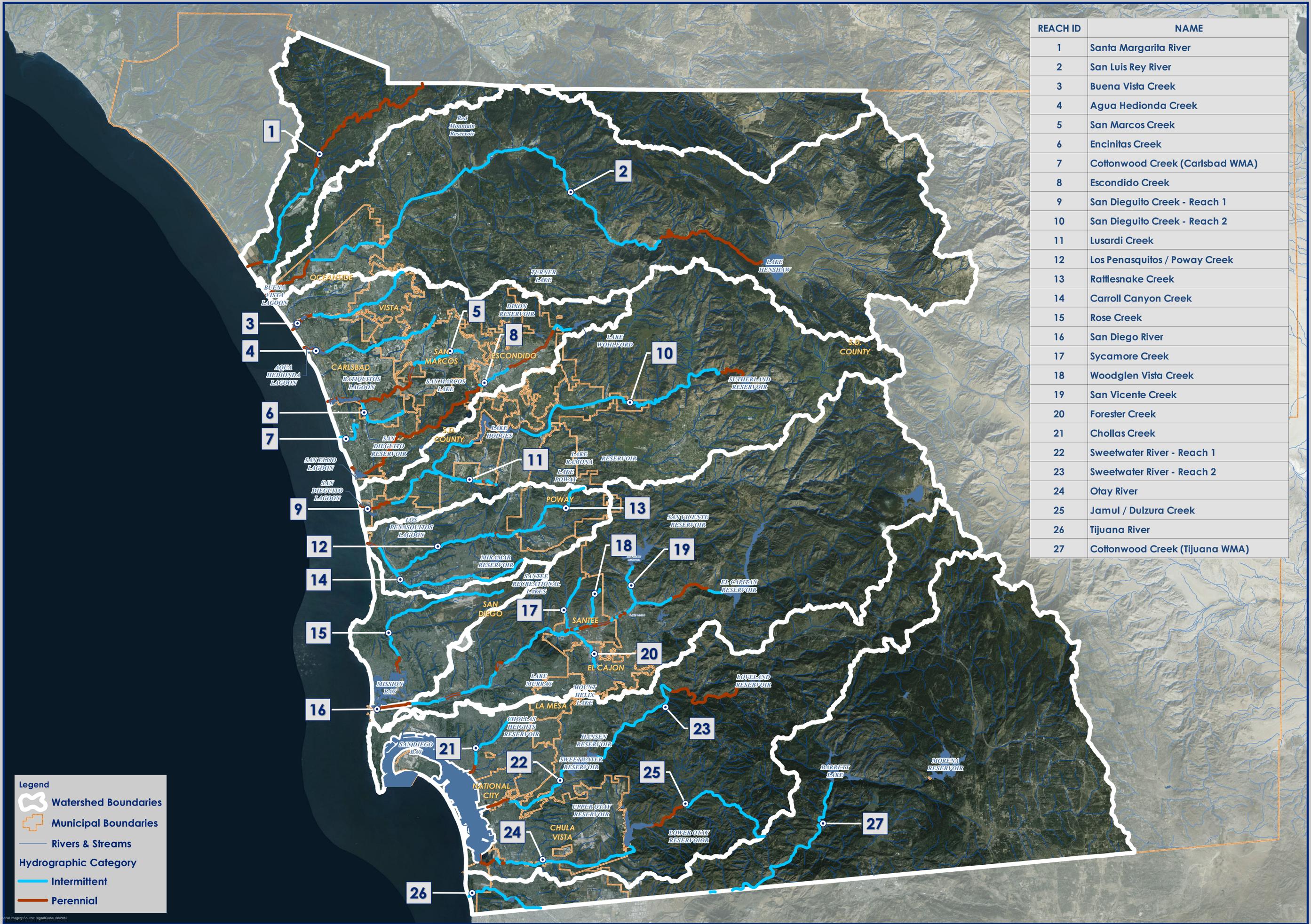
- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams

Watershed Management Area Streams

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014





REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
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10	San Dieguito Creek - Reach 2
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14	Carroll Canyon Creek
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23	Sweetwater River - Reach 2
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25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams

Hydrographic Category

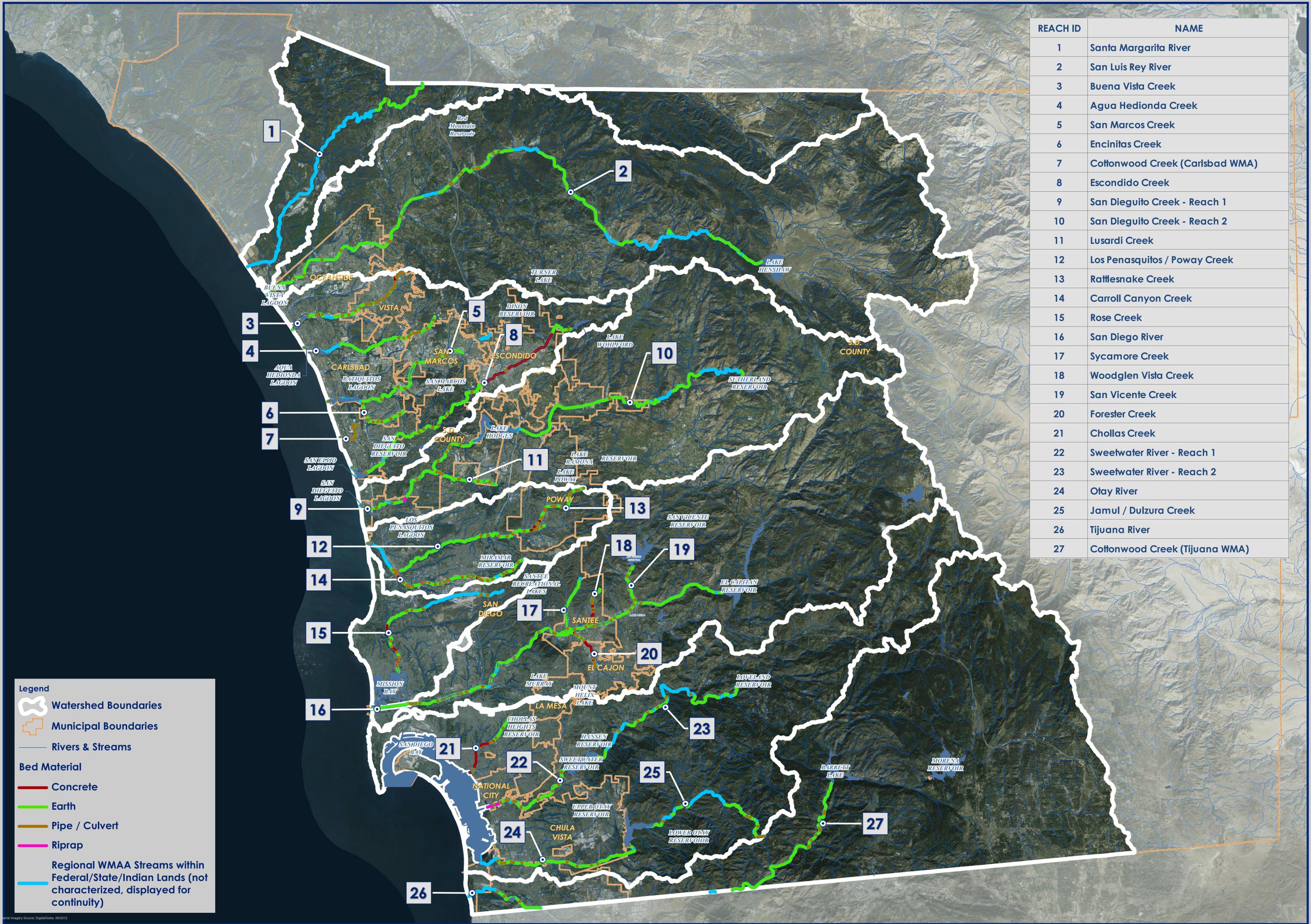
- Intermittent
- Perennial

Watershed Management Area Streams by Hydrographic Category

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014

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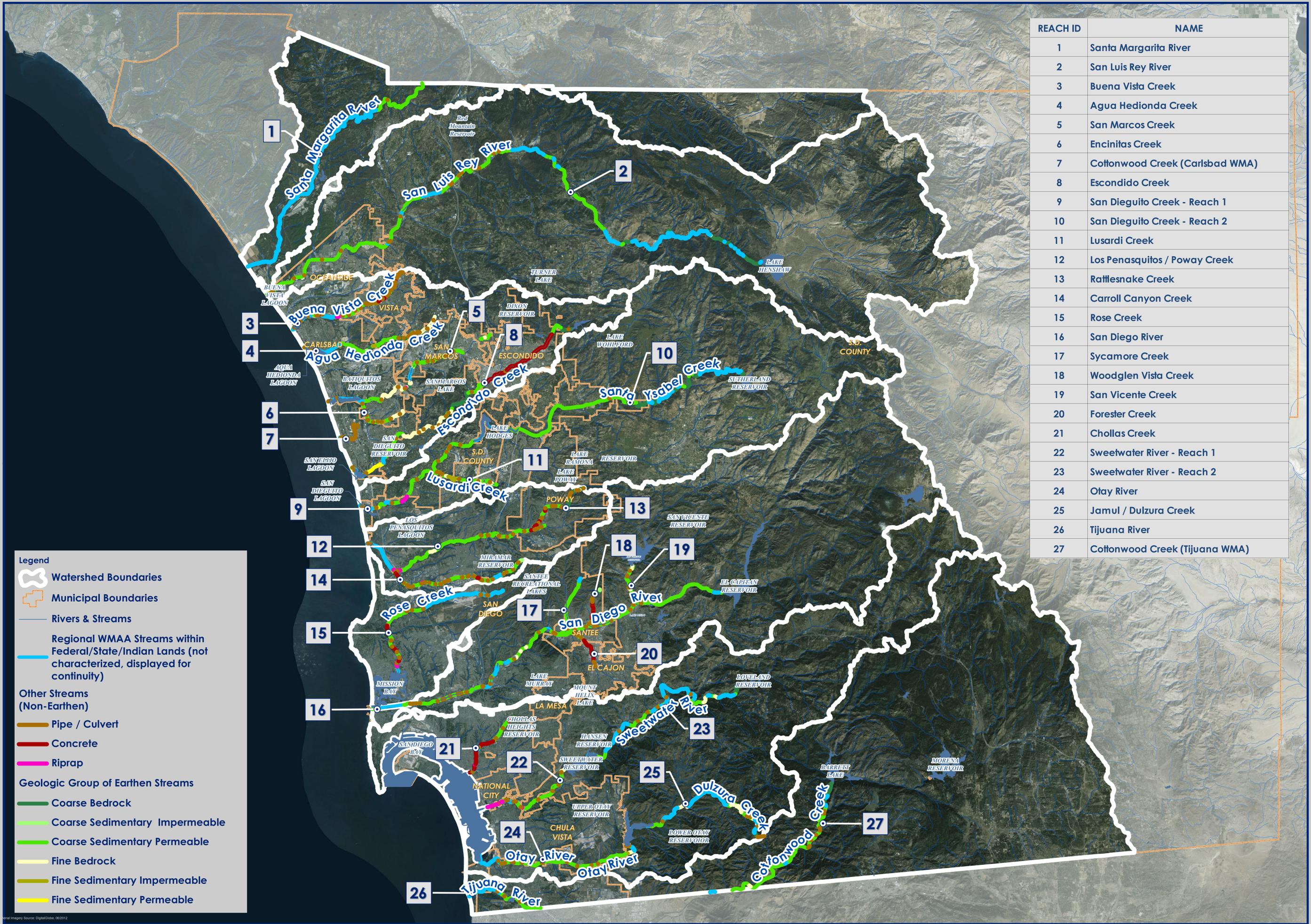


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26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Watershed Management Area Streams by Bed Material

Regional San Diego County Watersheds

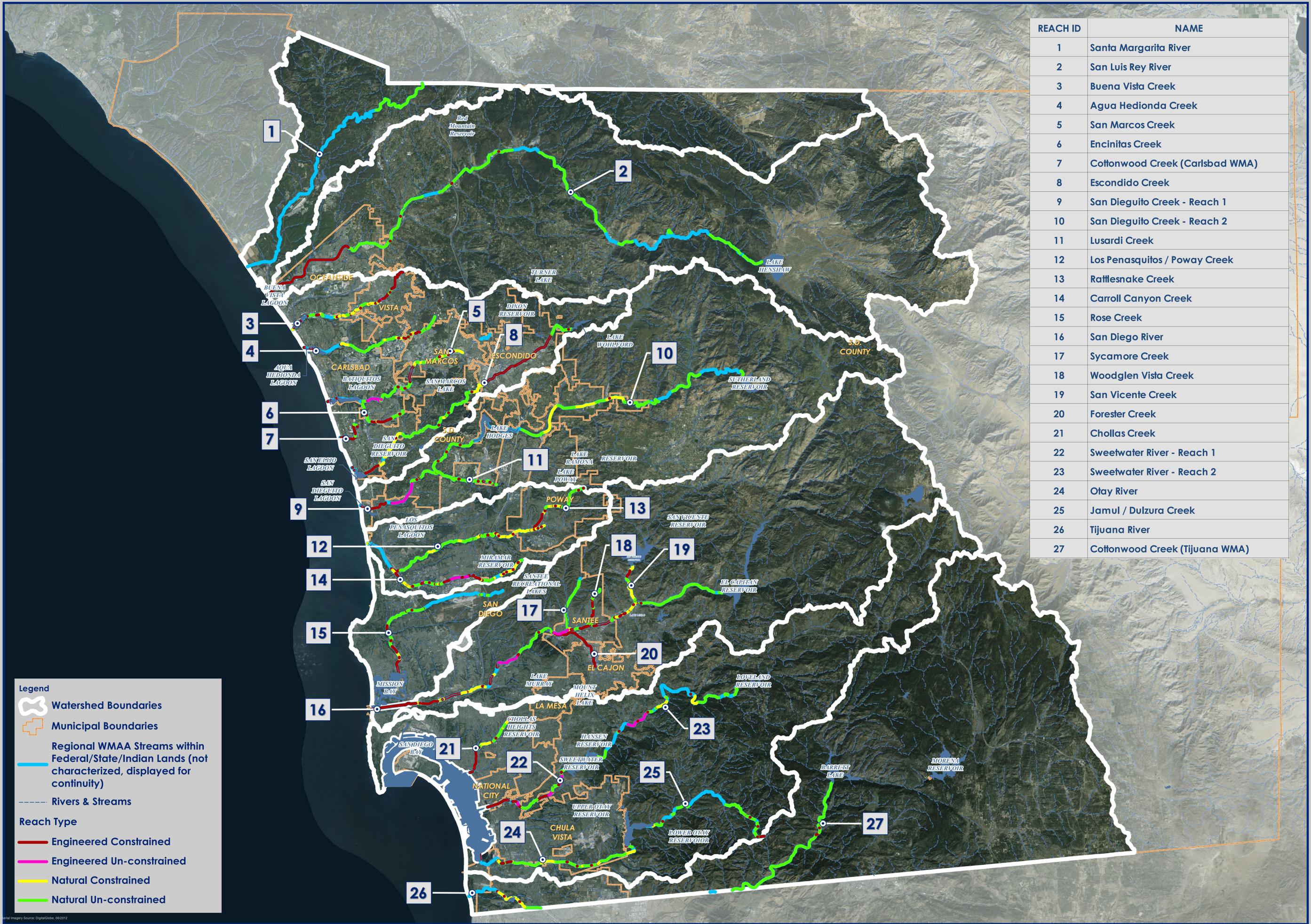
Exhibit Date: Sept. 8, 2014



Watershed Management Area Streams by Geologic Group

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014



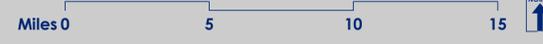
REACH ID	NAME
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Legend

- Watershed Boundaries
- Municipal Boundaries
- Regional WMAA Streams within Federal/State/Indian Lands (not characterized, displayed for continuity)
- Rivers & Streams

Reach Type

- Engineered Constrained
- Engineered Un-constrained
- Natural Constrained
- Natural Un-constrained



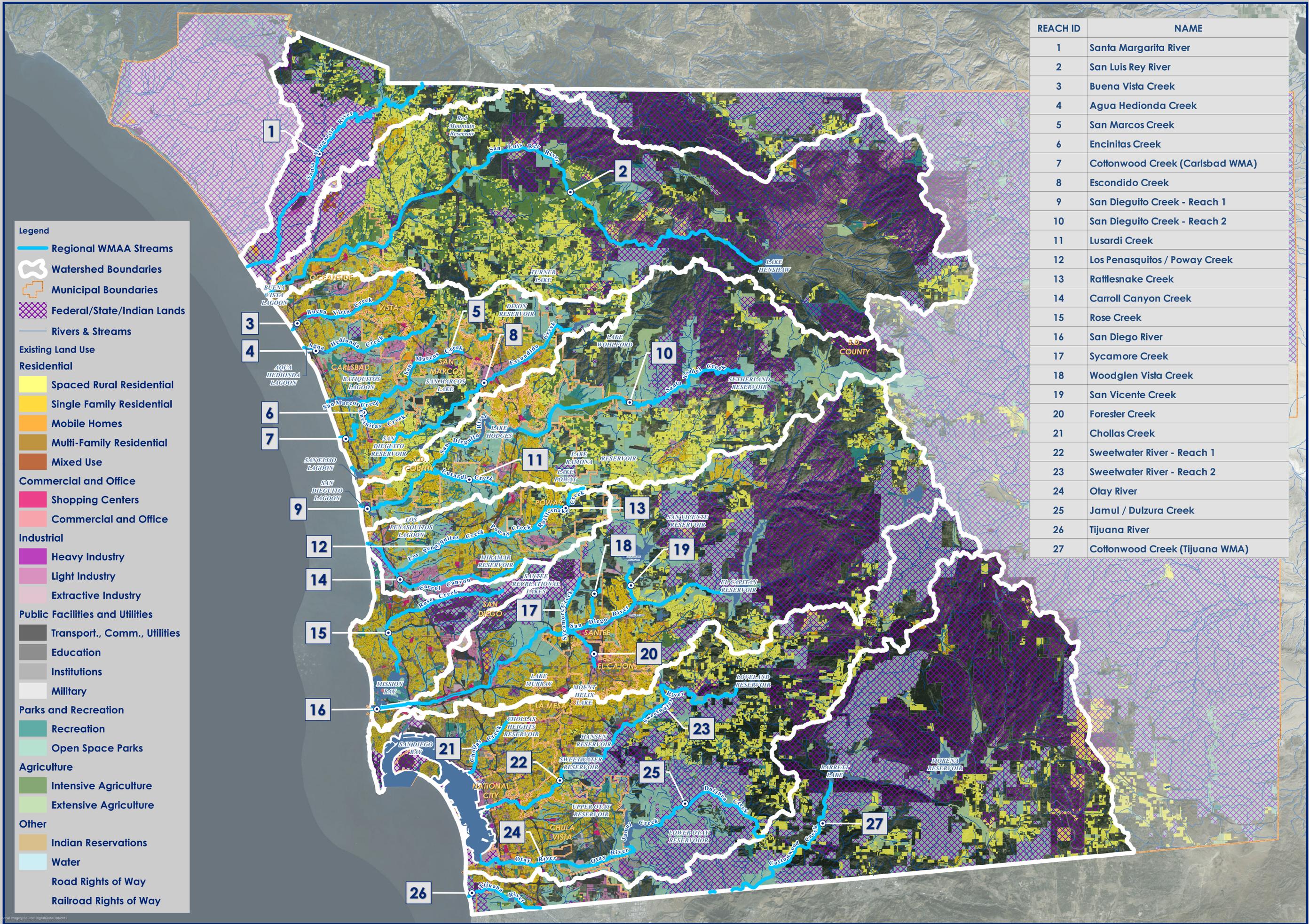
Watershed Management Area Streams by Reach Type

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014



ATTACHMENT A.3
LAND USES



REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
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23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Federal/State/Indian Lands
- Rivers & Streams

Existing Land Use

Residential

- Spaced Rural Residential
- Single Family Residential
- Mobile Homes
- Multi-Family Residential
- Mixed Use

Commercial and Office

- Shopping Centers
- Commercial and Office

Industrial

- Heavy Industry
- Light Industry
- Extractive Industry

Public Facilities and Utilities

- Transport., Comm., Utilities
- Education
- Institutions
- Military

Parks and Recreation

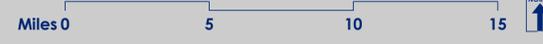
- Recreation
- Open Space Parks

Agriculture

- Intensive Agriculture
- Extensive Agriculture

Other

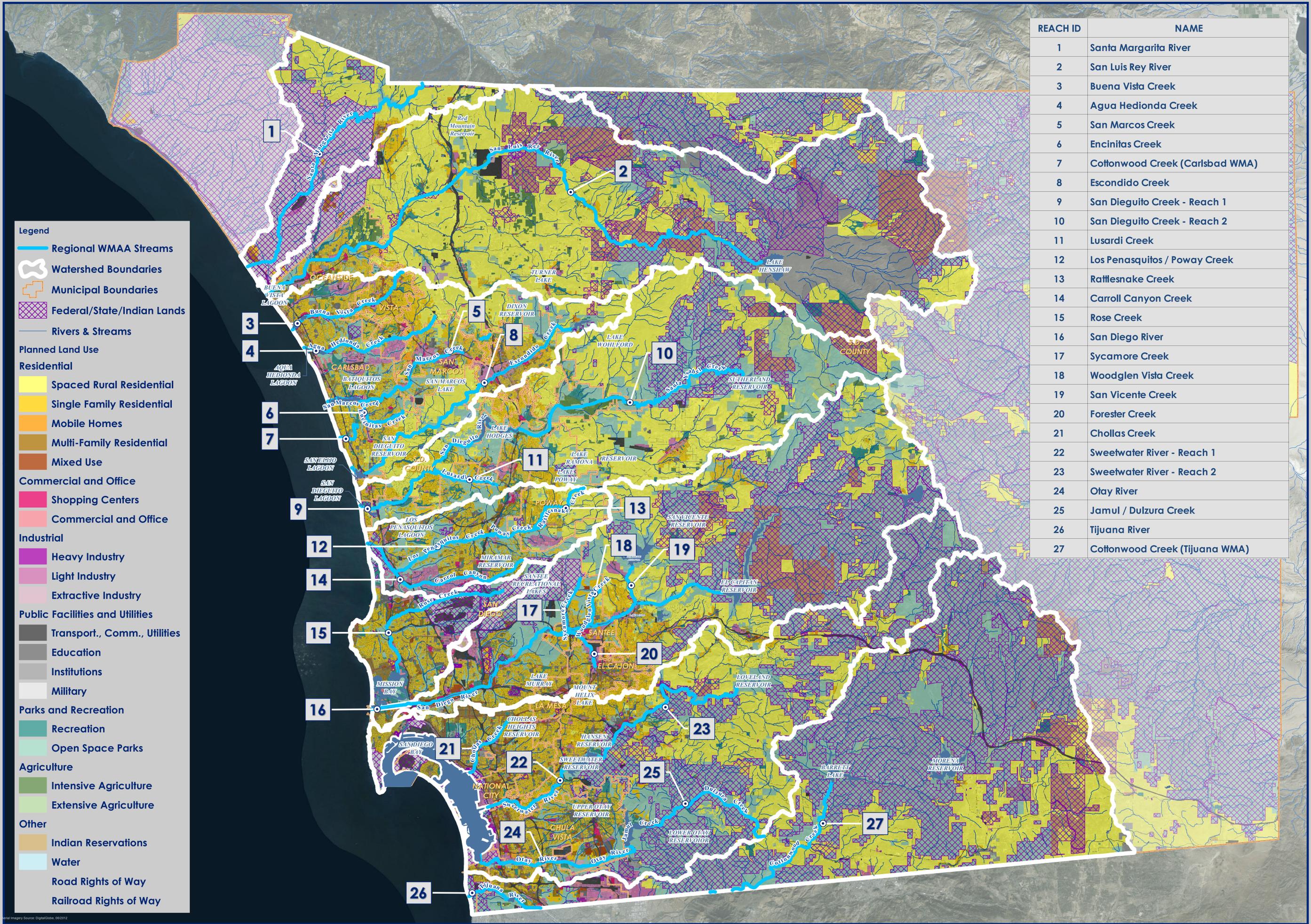
- Indian Reservations
- Water
- Road Rights of Way
- Railroad Rights of Way



Existing Land Use

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014



REACH ID	NAME
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Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Federal/State/Indian Lands
- Rivers & Streams

Planned Land Use

Residential

- Spaced Rural Residential
- Single Family Residential
- Mobile Homes
- Multi-Family Residential
- Mixed Use

Commercial and Office

- Shopping Centers
- Commercial and Office

Industrial

- Heavy Industry
- Light Industry
- Extractive Industry

Public Facilities and Utilities

- Transport., Comm., Utilities
- Education
- Institutions
- Military

Parks and Recreation

- Recreation
- Open Space Parks

Agriculture

- Intensive Agriculture
- Extensive Agriculture

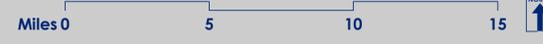
Other

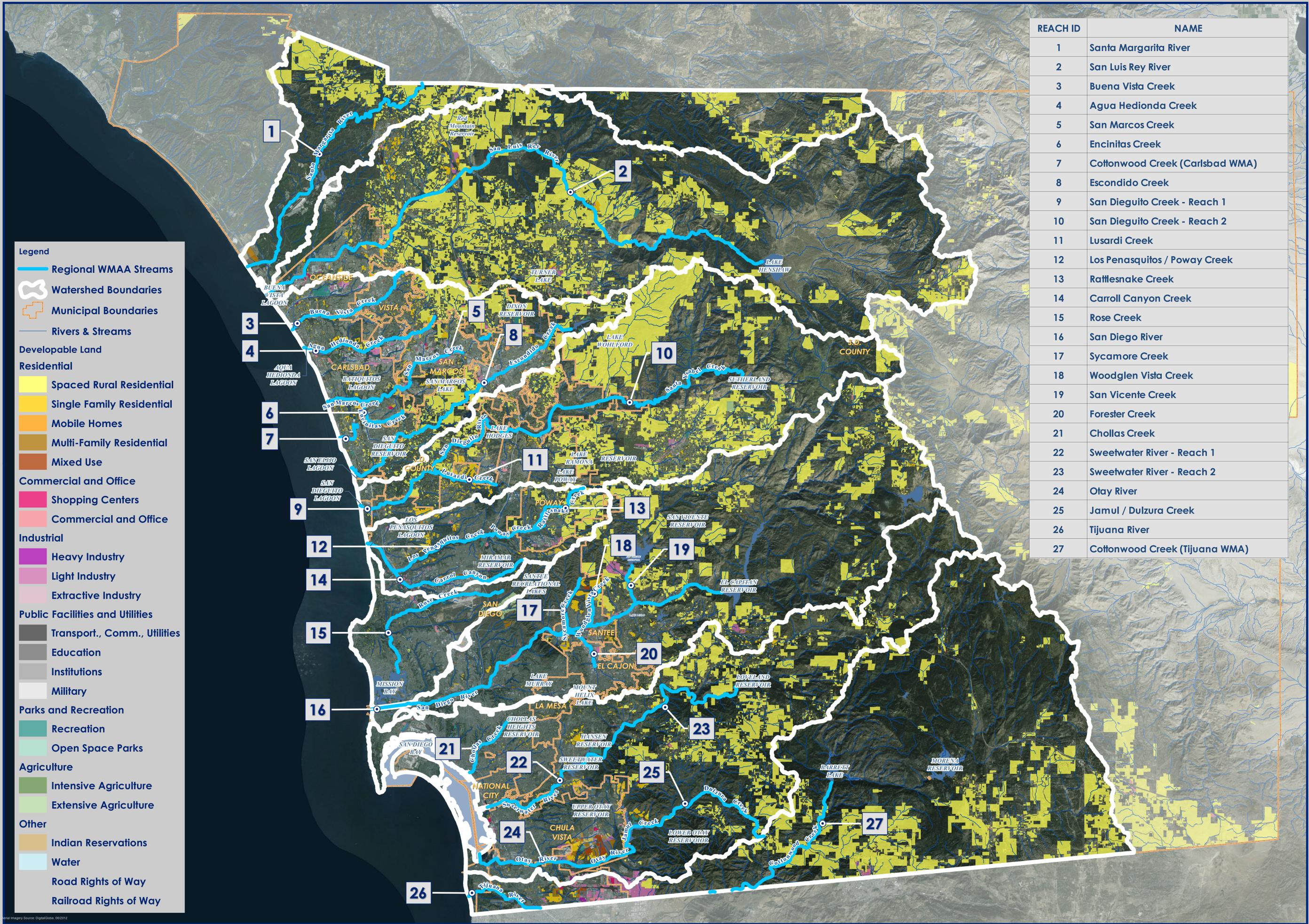
- Indian Reservations
- Water
- Road Rights of Way
- Railroad Rights of Way

Planned Land Use

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014





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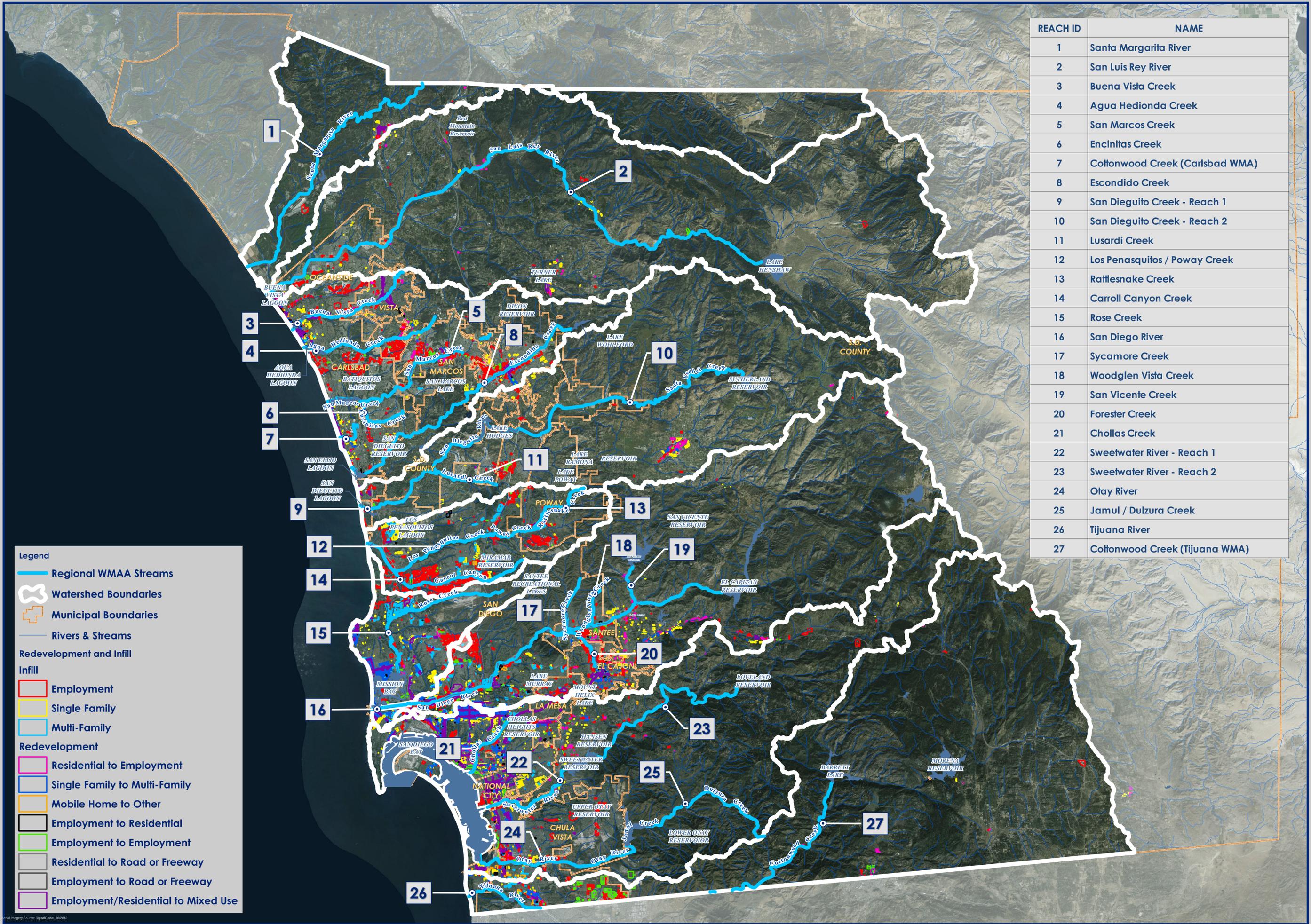
- Legend**
- Regional WMAA Streams
 - Watershed Boundaries
 - Municipal Boundaries
 - Rivers & Streams
- Developable Land**
- Spaced Rural Residential
 - Single Family Residential
 - Mobile Homes
 - Multi-Family Residential
 - Mixed Use
- Commercial and Office**
- Shopping Centers
 - Commercial and Office
- Industrial**
- Heavy Industry
 - Light Industry
 - Extractive Industry
- Public Facilities and Utilities**
- Transport., Comm., Utilities
 - Education
 - Institutions
 - Military
- Parks and Recreation**
- Recreation
 - Open Space Parks
- Agriculture**
- Intensive Agriculture
 - Extensive Agriculture
- Other**
- Indian Reservations
 - Water
 - Road Rights of Way
 - Railroad Rights of Way

Developable Land

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014

Miles 0 5 10 15



REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams

Redevelopment and Infill

Infill

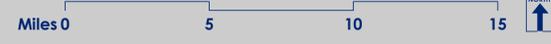
- Employment
- Single Family
- Multi-Family

Redevelopment

- Residential to Employment
- Single Family to Multi-Family
- Mobile Home to Other
- Employment to Residential
- Employment to Employment
- Residential to Road or Freeway
- Employment to Road or Freeway
- Employment/Residential to Mixed Use

Redevelopment and Infill Areas Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014



ATTACHMENT A.4
POTENTIAL COARSE SEDIMENT YIELD AREAS

A.4.1 Geology Grouping

Geologic grouping was based on the mapped geologic unit as determined by published geologic mapping information. The following describes the methodology utilized to determine bedrock or sedimentary characteristics, anticipated grain size, and suitability for infiltration. A complete list of the various geologic maps used in this evaluation is listed in Chapter 6.

Due to the various mapped scales of the published data and differing mapped unit names, the geologic units were initially compiled into similar categories where possible. For example, the Lindavista Formation is mapped as unit Ql on geologic maps at a scale of 1:24,000 but correlates to the same unit Qvop8 on geologic maps at a scale of 1:100,000. Following the compilation of geologic unit names, the units were differentiated between crystalline bedrock and sedimentary formations based on geologic characterization and material behavior. The Point Loma Formation for example, is a Cretaceous-age sandstone, but it was classified as a “coarse bedrock” unit due to its indurated and resistant nature.

For each site location, the predominant geologic units were then described as “coarse” or “fine” based on typical weathering characteristics of the bedrock units, or primary grain size of the sedimentary units. For example, granodiorite or tonalite crystalline rock typically weathers to a coarse material such as a silty sand and therefore was classified as “coarse,” compared to a gabbro which generally weathers to a sandy clay and was characterized as “fine.” Sedimentary formations can be more variable, such as the Mission Valley Formation. In this case, the Mission Valley Formation was characterized as “coarse” since the unit is predominantly comprised of sandstone even if it does contain localities of siltstone and claystone within the unit.

To further characterize the sedimentary formations, these units were evaluated for suitability of infiltration. Since no field investigations were performed for this evaluation to determine permeability, the differentiation between impermeable and permeable were based on the age of the geologic unit with the assumption that relatively younger sedimentary units of Pleistocene-age or younger (<1.6 mya) would be more susceptible to surface water infiltration. Geology grouping of different map units is presented in Table A.4.1

Table A.4.1 Geologic grouping for different map units

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
gr-m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
grMz	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Jcr	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Jhc	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Jsp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ka	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kbm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kbp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcc	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcm	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kcp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kd	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kdl	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgbf	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgd	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgdf	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgh	San Diego 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm1	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm2	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm3	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgm4	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgr	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kgu	San Diego 30' x 60'	Coarse	Bedrock	Impermeable	CB
Khg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ki	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kis	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kjd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
KJem	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
KJld	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kjv	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB

Regional WMAA Attachments

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Klb	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Klh	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Klp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Km	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmgp	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kmm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kpa	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kpv	El Cajon 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kqbd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Krm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Krr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kt	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ktr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kvc	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwm	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwp	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Kwsr	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
m	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Mzd	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzg	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzq	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Mzs	Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
sch	Jennings; CA	Coarse	Bedrock	Impermeable	CB
Kp	San Diego & Oceanside 30' x 60'	Coarse	Bedrock	Impermeable	CB
Ql	El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
QTf	El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Ec	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI
K	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI
Kccg	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Kcs	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Kl	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Ku	Jennings; CA	Coarse	Sedimentary	Impermeable	CSI

Regional WMAA Attachments

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Qvof	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop8a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop9a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmsc	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmss	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tp	San Diego & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tpm	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsc	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tscu	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsd	San Diego & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsdcg	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsdss	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsm	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tso	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tst	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tt	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tta	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tmv	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsi	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa11	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa12	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoa13	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvoc	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop1	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop10	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop10a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop11	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI

Regional WMAA Attachments

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Qvop11a	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop12	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop13	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop2	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop3	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop4	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop5	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop6	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop7	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop8	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qvop9	San Diego 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Tsa	Oceanside 30' x 60'	Coarse	Sedimentary	Impermeable	CSI
Qof	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qof1	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qof2	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Q	Jennings; CA	Coarse	Sedimentary	Permeable	CSP
Qa	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qd	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qf	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qmb	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qw	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qyf	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qt	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa1-2	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa2-6	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa5	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa6	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa7	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP

Regional WMAA Attachments

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
Qoc	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop1	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qc	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qu	El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qoa	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop2-4	San Diego 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop3	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop4	Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop6	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qop7	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qya	San Diego, Oceanside & El Cajon 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Qyc	San Diego & Oceanside 30' x 60'	Coarse	Sedimentary	Permeable	CSP
Mzu	San Diego & Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
gb	Jennings; CA	Fine	Bedrock	Impermeable	FB
JTRm	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kat	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kc	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgb	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
KJvs	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kmv	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Ksp	El Cajon 30' x 60'	Fine	Bedrock	Impermeable	FB
Kvsp	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kwmt	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Qv	Jennings; CA	Fine	Bedrock	Impermeable	FB
Tba	San Diego 30' x 60'	Fine	Bedrock	Impermeable	FB
Tda	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Tv	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Tvsr	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Kgdfg	Oceanside 30' x 60'	Fine	Bedrock	Impermeable	FB
Ta	San Diego 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tcs	Oceanside 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Td	San Diego & Oceanside	Fine	Sedimentary	Impermeable	FSI

Regional WMAA Attachments

Map Unit	Map Name	Anticipated Grain size of Weathered Material	Bedrock or Sedimentary	Impermeable/ Permeable	Geology Grouping
	30' x 60'				
Td+Tf	San Diego 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Qls	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tm	Oceanside 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tf	San Diego, Oceanside & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Tfr	El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
To	San Diego & El Cajon 30' x 60'	Fine	Sedimentary	Impermeable	FSI
Qpe	San Diego & Oceanside 30' x 60'	Fine	Sedimentary	Permeable	FSP
Mexico	San Diego 30' x 60'	NA	NA	Permeable	Other
Kuo	San Diego 30' x 60'	NA (Offshore)	NA	Permeable	Other
Teo	San Diego & Oceanside 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
Tmo	Oceanside 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
Qmo	San Diego 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
QTso	San Diego 30' x 60'	NA (Offshore)	Sedimentary	Permeable	Other
af	San Diego & Oceanside 30' x 60'	Variable, dependent on source material	Sedimentary		Other

A.4.2 Quantitative Analysis

Soil loss estimates for each Geomorphic Landscape Unit were estimated using the Revised Universal Soil Loss Equation (RUSLE; Renard et al. 1997) listed below:

$$A = R \times K \times LS \times C \times P$$

Where

A = estimated average soil loss in tons/acre/year

R = rainfall-runoff erosivity factor

K = soil erodibility factor

LS = slope length and steepness factor

C = cover-management factor

P = support practice factor; assumed 1 for this analysis

Regional datasets used to estimate the inputs required to estimate the soil loss from each GLU are listed in table below:

Dataset	Source	Download year	Description
RUSLE – R Factor	SWRCB	2014	Regional R factor map was downloaded from ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_R_Factor/
RUSLE – K Factor	SWRCB	2014	Regional K factor map was downloaded from ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_K_Factor/
RUSLE – LS Factor	SWRCB	2014	Regional LS factor map was downloaded from ftp://swrcb2a.waterboards.ca.gov/pub/swrcb/dwq/cgp/Risk/RUSLE/RUSLE_LS_Factor/
RUSLE – C Factor	USEPA	2014	Regional C factor map was downloaded from http://www.epa.gov/esd/land-sci/emap_west_browser/pages/wemap_mm_sl_rusle_c_qt.htm#mapnav

GIS analysis was used to calculate the area weighted estimate of R, K, LS and C factors using the regional datasets listed in the table above. For the developed land cover the C factor was then adjusted to 0 from the regional estimate to account for management actions implemented on developed sites (e.g. impervious surfaces). Soil loss estimates ranged from 0 to 15.2 tons/acre/year.

For evaluating the degree of relative risk to a stream solely arising from changes in sediment and/or water delivery SCCWRP Technical Report 605, 2010 states:

“The challenge in implementing this step is that presently we have insufficient basis to defensibly identify either low-risk or high-risk conditions using these metrics. For example, channels that are close to a threshold for geomorphic change may display significant morphological changes under nothing more than natural year-to-year variability in flow or sediment load.

- *Acknowledging this caveat, we nonetheless anticipate that changes of less than 10% in either driver are unlikely to instigate, on their own, significant channel changes. This value is a conservative estimate of the year-to-year variability in either discharge or sediment flux that can be accommodated by a channel system in a state of dynamic equilibrium. It does not “guarantee,” however, that channel change may not occur—either in response to yet modest alterations in water or sediment delivery, or because of other urbanization impacts (e.g., point discharge of runoff or the trapping of the upstream sediment flux; see Booth 1990) that are not represented with this analysis.*
- *In contrast, recognizing a condition of undisputed “high risk” must await broader collection of regionally relevant data. We note that >60% reductions in predicted sediment production have resulted in both minimal (McGonigle) and dramatic (Agua Hedionda) channel changes, indicating that “more data” may never provide absolute guidance. At present, we suggest using predicted watershed changes of 50% or more in either runoff (as indexed by change in impervious area) or sediment production as provisional criteria for requiring a more detailed evaluation of both the drivers and the resisting factors for channel change, regardless of other screening-level assessments. Clearly, however, only more experience with the application of such “thresholds,” and the actual channel conditions that accompany them, will provide a defensible basis for setting numeric standards.”*

The following criterion was developed using the suggestions listed above and then used to assign relative sediment production rating to each GLU:

- Low: Soil Loss < 5.6 tons/acre/year [GLUs that have a soil loss of 0 to 5.6 tons/acre/year produces around 10% of the total coarse sediment soil loss from the study area]
- Medium: 5.6 tons/acre/year < Soil Loss < 8.4 tons/acre/year
- High: > 8.4 tons/acre/year [GLUs that have a soil loss greater than 8.4 tons/acre/year produces around 42% of the total coarse sediment soil loss from the study area]

Results from the quantitative analysis are summarized in Table A.4.2.

Table A.4.2 Relative Sediment Production for different Geomorphic Landscape Units

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
CB-Agricultural/Grass-1	52883	0.20	4.67	0.14	50	6.5	Medium	No
CB-Agricultural/Grass-2	40633	0.21	5.19	0.14	56	8.3	Medium	No
CB-Agricultural/Grass-3	32617	0.22	6.04	0.14	57	10.6	High	Yes
CB-Agricultural/Grass-4	11066	0.23	7.38	0.14	57	13.5	High	Yes
CB-Developed-1	39746	0.22	3.77	0	49	0	Low	No
CB-Developed-2	32614	0.22	4.28	0	50	0	Low	No
CB-Developed-3	15841	0.22	4.86	0	49	0	Low	No
CB-Developed-4	1805	0.22	5.63	0	48	0	Low	No
CB-Forest-1	32231	0.20	6.38	0.14	39	6.8	Medium	No
CB-Forest-2	38507	0.20	7.20	0.13	45	8.8	High	Yes
CB-Forest-3	55303	0.20	8.14	0.13	48	10.6	High	Yes
CB-Forest-4	38217	0.20	9.95	0.14	50	13.6	High	Yes
CB-Other-1	1036	0.20	5.52	0.13	45	6.5	Medium	No
CB-Other-2	317	0.20	6.46	0.13	45	7.9	Medium	No
CB-Other-3	296	0.20	6.96	0.14	43	8.3	Medium	No
CB-Other-4	111	0.21	6.84	0.14	41	8.2	Medium	No
CB-Scrub/Shrub-1	88135	0.20	5.66	0.14	33	5.3	Low	No
CB-Scrub/Shrub-2	143694	0.20	6.51	0.14	37	6.8	Medium	No
CB-Scrub/Shrub-3	246703	0.21	7.33	0.14	41	8.4	Medium	No
CB-Scrub/Shrub-4	191150	0.21	8.28	0.14	42	9.8	High	Yes
CB-Unknown-1	1727	0.21	5.32	0.13	44	6.3	Medium	No
CB-Unknown-2	1935	0.21	5.95	0.13	44	7.1	Medium	No

Regional WMAA Attachments

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
CB-Unknown-3	1539	0.22	6.21	0.13	44	7.7	Medium	No
CB-Unknown-4	278	0.22	6.61	0.13	44	8.4	High	Yes
CSI-Agricultural/Grass-1	14609	0.34	2.72	0.14	39	4.8	Low	No
CSI-Agricultural/Grass-2	9059	0.37	3.61	0.14	47	8.7	High	Yes
CSI-Agricultural/Grass-3	10096	0.38	3.99	0.14	47	9.8	High	Yes
CSI-Agricultural/Grass-4	2498	0.37	4.33	0.14	47	10.5	High	Yes
CSI-Developed-1	82371	0.28	2.51	0	39	0	Low	No
CSI-Developed-2	22570	0.30	2.66	0	41	0	Low	No
CSI-Developed-3	13675	0.30	2.89	0	40	0	Low	No
CSI-Developed-4	3064	0.27	3.20	0	39	0	Low	No
CSI-Forest-1	449	0.27	4.26	0.13	43	6.6	Medium	No
CSI-Forest-2	611	0.25	5.11	0.13	44	7.5	Medium	No
CSI-Forest-3	716	0.29	4.43	0.13	44	7.4	Medium	No
CSI-Forest-4	348	0.30	4.49	0.13	43	7.6	Medium	No
CSI-Other-1	319	0.31	2.50	0.13	32	3.2	Low	No
CSI-Other-2	83	0.27	3.01	0.13	39	4.3	Low	No
CSI-Other-3	45	0.28	3.03	0.13	39	4.5	Low	No
CSI-Other-4	13	0.24	4.01	0.14	39	5.2	Low	No
CSI-Scrub/Shrub-1	9051	0.26	3.53	0.13	39	4.7	Low	No
CSI-Scrub/Shrub-2	10802	0.27	4.36	0.13	41	6.3	Medium	No
CSI-Scrub/Shrub-3	28220	0.26	4.82	0.13	41	6.7	Medium	No
CSI-Scrub/Shrub-4	20510	0.26	5.52	0.13	41	7.8	Medium	No
CSI-Unknown-1	5292	0.28	2.38	0.13	36	3.1	Low	No

Regional WMAA Attachments

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
CSI-Unknown-2	2074	0.29	2.98	0.13	40	4.5	Low	No
CSI-Unknown-3	2171	0.27	3.04	0.13	39	4.2	Low	No
CSI-Unknown-4	676	0.26	3.04	0.13	38	3.8	Low	No
CSP-Agricultural/Grass-1	59327	0.22	3.01	0.14	44	4.0	Low	No
CSP-Agricultural/Grass-2	8426	0.23	3.81	0.14	42	5.2	Low	No
CSP-Agricultural/Grass-3	2377	0.24	4.05	0.14	41	5.6	Low	No
CSP-Agricultural/Grass-4	291	0.22	6.28	0.14	52	10.1	High	Yes
CSP-Developed-1	85283	0.27	2.10	0	42	0	Low	No
CSP-Developed-2	7513	0.26	2.77	0	42	0	Low	No
CSP-Developed-3	2317	0.27	2.70	0	40	0	Low	No
CSP-Developed-4	272	0.27	2.76	0	38	0	Low	No
CSP-Forest-1	14738	0.22	4.52	0.14	44	6.0	Medium	No
CSP-Forest-2	3737	0.22	5.99	0.14	45	8.2	Medium	No
CSP-Forest-3	1858	0.21	6.42	0.14	45	8.5	High	Yes
CSP-Forest-4	484	0.21	7.62	0.14	48	10.2	High	Yes
CSP-Other-1	7404	0.23	2.61	0.14	39	3.2	Low	No
CSP-Other-2	343	0.24	3.68	0.13	40	4.8	Low	No
CSP-Other-3	126	0.24	3.76	0.13	40	4.9	Low	No
CSP-Other-4	17	0.24	4.19	0.13	39	5.3	Low	No
CSP-Scrub/Shrub-1	22583	0.23	3.75	0.14	41	4.8	Low	No
CSP-Scrub/Shrub-2	8938	0.24	5.63	0.14	40	7.1	Medium	No
CSP-Scrub/Shrub-3	7186	0.23	6.15	0.13	39	7.5	Medium	No
CSP-Scrub/Shrub-4	2609	0.22	7.16	0.14	43	9.3	High	Yes

Regional WMAA Attachments

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
CSP-Unknown-1	6186	0.25	2.63	0.13	40	3.4	Low	No
CSP-Unknown-2	744	0.27	3.49	0.13	39	4.8	Low	No
CSP-Unknown-3	350	0.28	3.32	0.13	38	4.5	Low	No
CSP-Unknown-4	78	0.28	3.26	0.13	40	4.5	Low	No
FB-Agricultural/Grass-1	6103	0.25	5.49	0.14	49	9.2	High	No
FB-Agricultural/Grass-2	7205	0.25	5.87	0.14	51	10.1	High	No
FB-Agricultural/Grass-3	6730	0.24	6.43	0.14	53	11.3	High	No
FB-Agricultural/Grass-4	2586	0.22	8.62	0.14	57	15.2	High	No
FB-Developed-1	10116	0.28	3.94	0	46	0	Low	No
FB-Developed-2	9075	0.28	4.41	0	45	0	Low	No
FB-Developed-3	5499	0.27	4.72	0	44	0	Low	No
FB-Developed-4	785	0.27	5.08	0	43	0	Low	No
FB-Forest-1	3780	0.21	7.24	0.13	39	8.0	Medium	No
FB-Forest-2	7059	0.21	7.53	0.13	43	8.8	High	No
FB-Forest-3	13753	0.22	8.02	0.13	43	9.7	High	No
FB-Forest-4	8899	0.26	9.63	0.13	35	11.5	High	No
FB-Other-1	172	0.26	5.72	0.13	44	8.6	High	No
FB-Other-2	75	0.26	5.97	0.13	38	7.7	Medium	No
FB-Other-3	76	0.28	6.27	0.13	34	7.6	Medium	No
FB-Other-4	36	0.31	6.70	0.13	33	8.6	High	No
FB-Scrub/Shrub-1	10297	0.24	6.94	0.14	36	8.3	Medium	No
FB-Scrub/Shrub-2	25150	0.25	7.24	0.14	38	9.0	High	No
FB-Scrub/Shrub-3	70895	0.25	7.89	0.13	38	10.0	High	No

Regional WMAA Attachments

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
FB-Scrub/Shrub-4	70679	0.26	9.05	0.14	39	12.1	High	No
FB-Unknown-1	654	0.30	5.33	0.13	37	7.6	Medium	No
FB-Unknown-2	829	0.29	5.26	0.13	40	7.9	Medium	No
FB-Unknown-3	1062	0.29	5.54	0.13	39	8.2	Medium	No
FB-Unknown-4	299	0.28	6.02	0.13	38	8.4	High	No
FSI-Agricultural/Grass-1	8462	0.32	3.91	0.13	24	3.9	Low	No
FSI-Agricultural/Grass-2	4979	0.33	4.29	0.13	31	5.7	Medium	No
FSI-Agricultural/Grass-3	4808	0.34	4.26	0.13	34	6.3	Medium	No
FSI-Agricultural/Grass-4	1055	0.35	4.11	0.13	36	6.7	Medium	No
FSI-Developed-1	9953	0.29	3.09	0	34	0	Low	No
FSI-Developed-2	4972	0.31	3.22	0	37	0	Low	No
FSI-Developed-3	3350	0.29	3.30	0	36	0	Low	No
FSI-Developed-4	763	0.28	3.31	0	37	0	Low	No
FSI-Forest-1	186	0.33	4.62	0.13	37	7.2	Medium	No
FSI-Forest-2	217	0.35	4.47	0.13	39	7.9	Medium	No
FSI-Forest-3	262	0.37	4.71	0.13	40	9.2	High	No
FSI-Forest-4	111	0.36	4.73	0.13	40	9.2	High	No
FSI-Other-1	266	0.31	3.11	0.13	24	2.9	Low	No
FSI-Other-2	81	0.30	3.29	0.13	25	3.1	Low	No
FSI-Other-3	56	0.31	3.04	0.13	27	3.2	Low	No
FSI-Other-4	15	0.29	3.57	0.13	33	4.4	Low	No
FSI-Scrub/Shrub-1	2241	0.27	4.46	0.13	29	4.5	Low	No
FSI-Scrub/Shrub-2	3911	0.28	4.96	0.13	31	5.7	Medium	No

Regional WMAA Attachments

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
FSI-Scrub/Shrub-3	7590	0.29	5.05	0.13	34	6.3	Medium	No
FSI-Scrub/Shrub-4	3502	0.30	5.14	0.13	37	7.5	Medium	No
FSI-Unknown-1	1117	0.29	2.83	0.13	27	3.0	Low	No
FSI-Unknown-2	780	0.30	3.44	0.13	32	4.3	Low	No
FSI-Unknown-3	855	0.29	3.41	0.13	31	4.0	Low	No
FSI-Unknown-4	285	0.28	3.21	0.13	32	3.7	Low	No
FSP-Agricultural/Grass-1	13	0.22	2.22	0.13	40	2.5	Low	No
FSP-Agricultural/Grass-2	3	0.22	2.59	0.13	40	3.0	Low	No
FSP-Agricultural/Grass-3	2	0.22	2.69	0.13	40	3.2	Low	No
FSP-Agricultural/Grass-4	0	0.20	2.94	0.12	40	2.9	Low	No
FSP-Developed-1	180	0.26	2.85	0	40	0	Low	No
FSP-Developed-2	13	0.25	2.69	0	40	0	Low	No
FSP-Developed-3	8	0.21	2.25	0	40	0	Low	No
FSP-Developed-4	0	0.21	2.29	0	40	0	Low	No
FSP-Forest-1	8	0.22	2.29	0.14	40	2.9	Low	No
FSP-Forest-2	5	0.20	2.22	0.14	40	2.5	Low	No
FSP-Forest-3	0	0.20	2.22	0.14	40	2.5	Low	No
FSP-Other-1	1307	0.20	2.38	0.14	40	2.7	Low	No
FSP-Other-2	34	0.21	2.36	0.14	40	2.7	Low	No
FSP-Other-3	8	0.22	2.56	0.13	40	3.0	Low	No
FSP-Other-4	0	0.43	4.35	0.12	40	9.3	High	No
FSP-Scrub/Shrub-1	147	0.23	2.68	0.14	40	3.3	Low	No
FSP-Scrub/Shrub-2	18	0.23	2.55	0.14	40	3.3	Low	No

Regional WMAA Attachments

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
FSP-Scrub/Shrub-3	4	0.20	2.23	0.14	40	2.6	Low	No
FSP-Scrub/Shrub-4	0	0.20	1.70	0.12	40	1.7	Low	No
FSP-Unknown-1	40	0.20	1.87	0.13	40	1.9	Low	No
FSP-Unknown-2	5	0.20	1.99	0.12	40	2.0	Low	No
FSP-Unknown-3	1	0.20	2.39	0.12	40	2.4	Low	No
O-Agricultural/Grass-1	2433	0.20	2.93	0.14	34	2.8	Low	No
O-Agricultural/Grass-2	112	0.21	3.44	0.14	32	3.2	Low	No
O-Agricultural/Grass-3	30	0.23	3.89	0.13	32	3.8	Low	No
O-Agricultural/Grass-4	1	0.26	6.47	0.13	37	7.9	Medium	No
O-Developed-1	8327	0.27	1.37	0	39	0	Low	No
O-Developed-2	474	0.25	2.12	0	40	0	Low	No
O-Developed-3	157	0.26	3.07	0	41	0	Low	No
O-Developed-4	26	0.24	3.89	0	41	0	Low	No
O-Forest-1	235	0.22	6.15	0.13	43	7.6	Medium	No
O-Forest-2	67	0.21	5.07	0.13	45	6.6	Medium	No
O-Forest-3	45	0.21	5.43	0.13	47	7.3	Medium	No
O-Forest-4	20	0.20	5.95	0.13	59	9.0	High	No
O-Other-1	9362	0.25	3.86	0.13	36	4.3	Low	No
O-Other-2	344	0.24	3.32	0.13	35	3.5	Low	No
O-Other-3	120	0.23	4.86	0.13	35	5.0	Low	No
O-Other-4	37	0.22	5.64	0.13	39	6.6	Medium	No
O-Scrub/Shrub-1	688	0.22	4.83	0.13	40	5.7	Medium	No
O-Scrub/Shrub-2	224	0.22	5.80	0.13	36	6.3	Medium	No

Geomorphic Landscape Unit (GLU)	Area (acres)	K	LS	C	R	A	Relative Sediment Production	Critical Coarse Sediment
O-Scrub/Shrub-3	209	0.22	6.47	0.13	41	7.5	Medium	No
O-Scrub/Shrub-4	96	0.22	6.62	0.13	44	8.2	Medium	No
O-Unknown-1	1236	0.28	1.60	0.12	26	1.5	Low	No
O-Unknown-2	62	0.27	1.48	0.13	36	1.8	Low	No
O-Unknown-3	15	0.29	3.52	0.13	38	4.9	Low	No
O-Unknown-4	7	0.34	3.87	0.12	40	6.6	Medium	No

GLU Nomenclature: Geology – Land Cover – Slope Category

Geology Categories:

- CB Coarse Bedrock
- CSI Coarse Sedimentary Impermeable
- CSP Coarse Sedimentary Permeable
- FB Fine Bedrock
- FSI Fine Sedimentary Impermeable
- FSP Fine Sedimentary Permeable
- O Other

Slope Categories:

- 1 0%-10%
- 2 10% - 20%
- 3 20% - 40%
- 4 > 40%

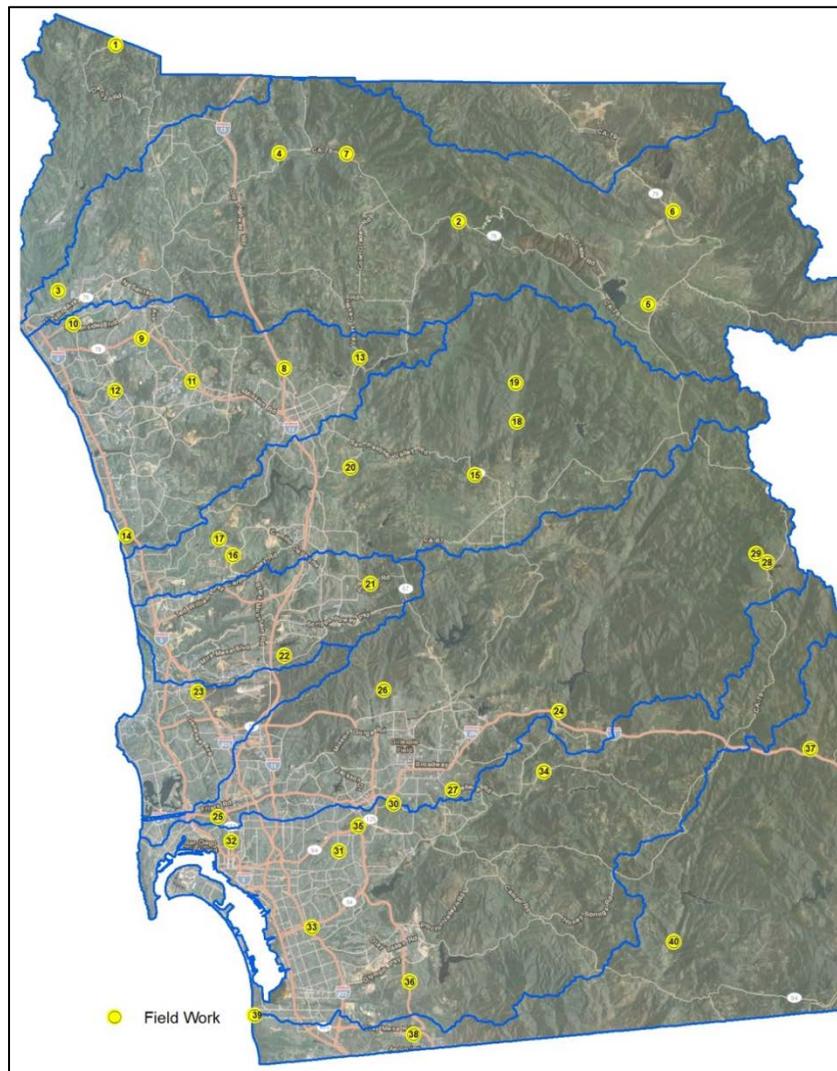
A4.3 Field Assessment

Site Selection:

Forty locations were selected from the study region for field assessment. Sites were selected such that they are accessible by existing road network based on review of satellite imagery and are uniformly distributed considering the following criteria:

- Geologic grouping
- Land cover
- Slope category
- WMA
- Jurisdiction

Yellow circles in the figure below shows the 40 locations for which field assessment was performed.



Pre-Field Activities

Prior to conducting field activities, the consultant team reviewed available published geologic information at each site location and prepared satellite imagery of each site using Google Earth™. Pre-field activities consisted of evaluating site access at each location using aerial imagery and logistics were coordinated based on regional site location to maximize field efficiency.

Site Reconnaissance

Site reconnaissance was performed at forty locations between 22 January and 7 February 2014 by a team of geologists. The reconnaissance consisted of:

- Visual soil classification,
- Assessing existing vegetative cover (0-100%),
- Qualitative assignment of existing sediment production (low, medium, and high) [based on existing vegetative cover],
- Qualitative assignment of potential sediment production (low, medium, and high)[assuming there is 0% vegetative cover], and
- Identifying existing erosional features.

Descriptions and visual classifications of the surficial materials were based on the Unified Soil Classification System (USCS). Underlying geologic units were confirmed where exposed formations were observed within the individual site limits.

SITE AND GEOLOGIC CONDITIONS

Our knowledge of the site conditions has been developed from a review of available geologic literature, previous geologic and geotechnical investigations by the consultant team in the study region, professional experience, site reconnaissance, and field investigations performed for this study.

Surface Conditions

Site locations were sited in open space with the exception of sites ID-27, -30, and -31 which were situated within developed areas with paved streets and sidewalks. The surface conditions at the site locations were characterized by sloping terrain varying from relatively flat (< 5%) to very steep slopes (> 40%). At the time of our reconnaissance the natural hillsides along the areas of interest were covered by varying degrees of moderate to dense growth scrub brush, low grasses, and scattered trees.

Existing erosional and geomorphic features at each site location were identified where possible. The observed erosional features included notable drainages, rilling, scour, and sediment accumulation. Observed geomorphic features included areas of minor slope instability and surficial slumping. Several sources of ground disturbance were identified during the site reconnaissance included active grading operations and bioturbation.

An evaluation of the existing and potential sediment production for each site was determined based on surface conditions. Sediment production was assigned as “high, medium, or low” based on the existing conditions and consultant team’s professional experience.

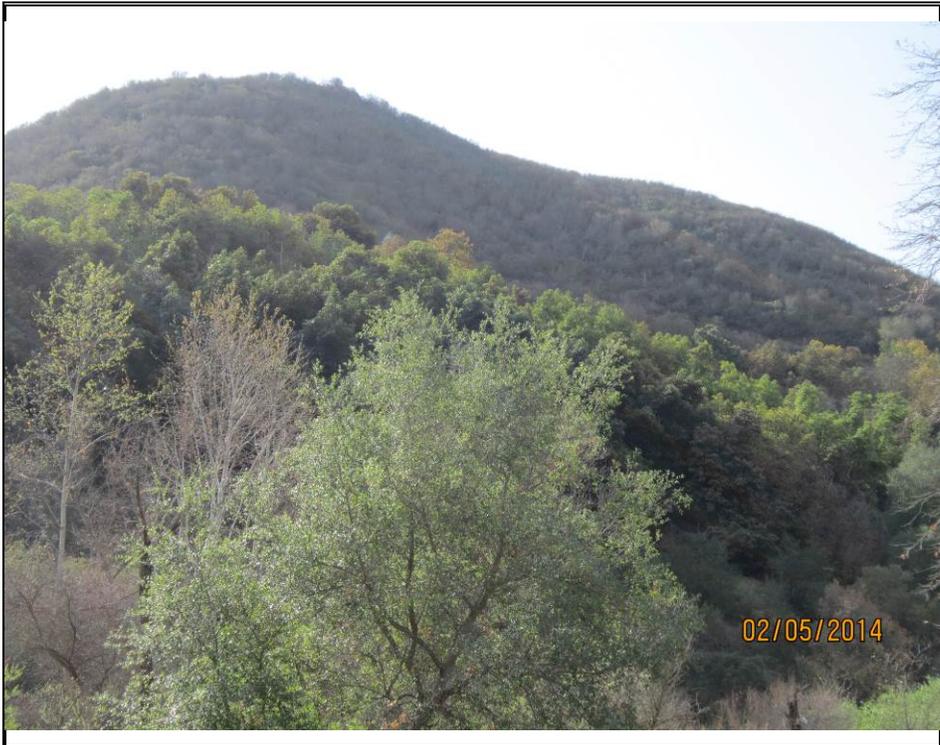
Surficial Deposits

Surficial deposits, including topsoil, alluvium, colluvium, slopewash, and residual soils are present in portions of the study area within the natural drainages and mantling the slope areas. The composition and grain size of these materials are variable depending on the age, parent sources, and mode of deposition.

Geologic Conditions

Our knowledge of the subsurface conditions at the site locations is based on a review of available published geologic information, professional experience, site reconnaissance, previous explorations and geotechnical investigations performed by the consultant team in the study region.

Field Assessment Photo Log

	<p>Field Visit ID-1 GLU: CB-Scrub/Shrub-4</p> <p>View: Looking southwest</p> <p>Existing sediment production: Med</p> <p>Potential sediment production: High</p> <p>Existing veg. cover: 90%</p>
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	<p>Field Visit ID-2 GLU: CB-Forest-4</p> <p>View: Looking north</p> <p>Existing sediment production: Med</p> <p>Potential sediment production: High</p> <p>Existing veg. cover: 95%</p>
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Field Visit ID-3

**GLU: CSI-Agricultural/
Grass-3**

View: Looking southwest

Existing sediment
production: Low to Med

Potential sediment
production:
Med to High

Existing veg. cover:
95-100%



Field Visit ID-4

GLU: CSI-Scrub/Shrub-2

View: Looking north

Existing sediment
production: Med

Potential sediment
production: High

Existing veg. cover: 70%



Field Visit ID-5

**GLU: CSP-Agricultural/
Grass-1**

View: Looking southwest

Existing sediment
production: Low to Med

Potential sediment
production: Med

Existing veg. cover: 90%



Field Visit ID-6

**GLU: CSP-Agricultural/
Grass-3**

View: Looking east

Existing sediment
production: Low to Med

Potential sediment
production:
Low to Med

Existing veg. cover:
Southeast slope ~50%
Northeast slope ~70%



Field Visit ID-7

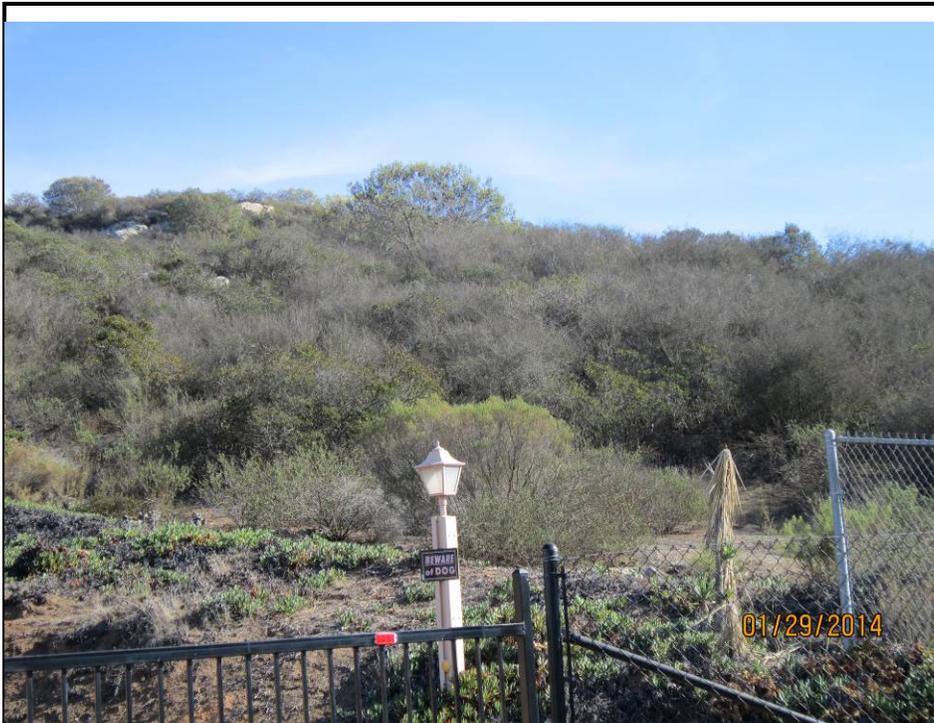
GLU: CSP-Forest-3

View: Looking east

Existing sediment
production: Med to High

Potential sediment
production: High

Existing veg. cover: 75-80%



Field Visit ID-8

GLU: CB-Scrub/Shrub-3

View: Looking southeast

Existing sediment
production: Low to Med

Potential sediment
production:
Med to High

Existing veg. cover: 90-95%



Field Visit ID-9

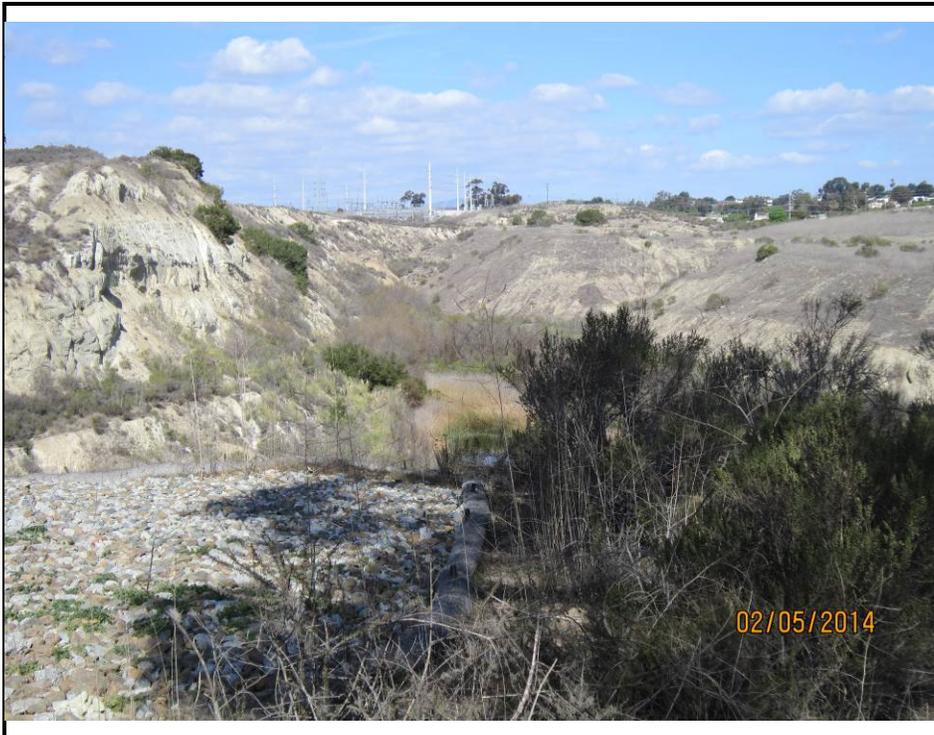
**GLU: CB-Agricultural/
Grass-2**

View: Looking northwest

Existing sediment
production: Low to Med

Potential sediment
production: Med

Existing veg. cover: 70%



Field Visit ID-10

GLU: CSI-Unknown-2

View: Looking north

Existing sediment
production: Med to High

Potential sediment
production: High

Existing veg. cover: 75%



Field Visit ID-11

**GLU: CSI-Agricultural/
Grass-2**

View: Looking east

Existing sediment
production: Low

Potential sediment
production: Med

Existing veg. cover: 85%



Field Visit ID-12

GLU: CSP-Unknown-2

View: Looking southwest

Existing sediment
production: Low

Potential sediment
production:

Low to Med

Existing veg. cover: 50%



Field Visit ID-13

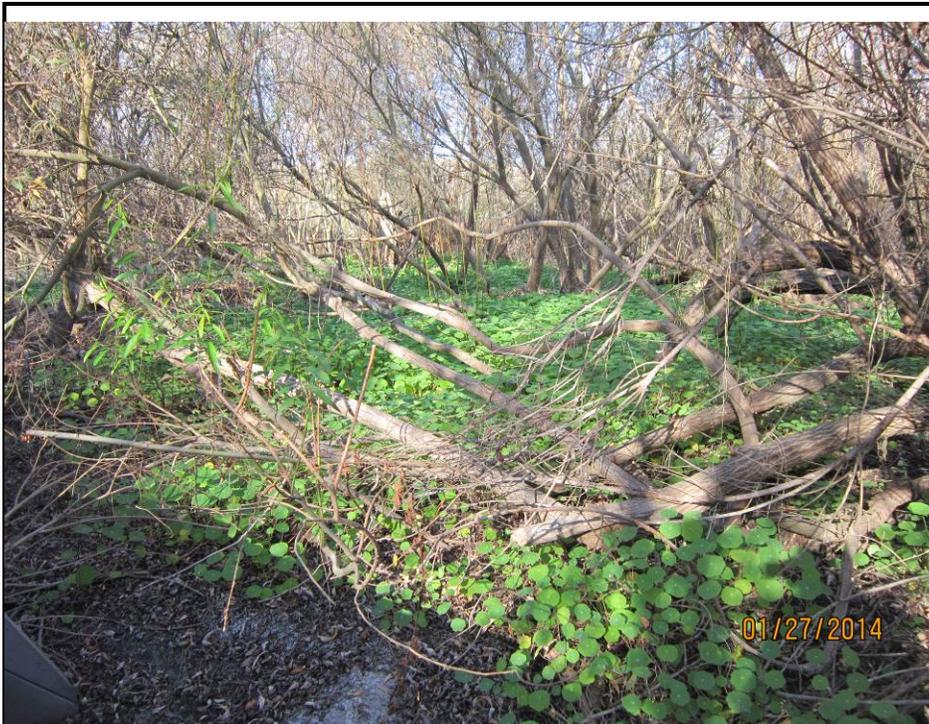
GLU: CSP-Scrub/Shrub-2

View: Looking southeast

Existing sediment
production: Med

Potential sediment
production:
Med to High

Existing veg. cover: 80-85%



Field Visit ID-14

GLU: FSP-Scrub/Shrub-1

View: Looking northeast

Existing sediment
production: Low

Potential sediment
production:
Low to Med

Existing veg. cover:
95-100%



Field Visit ID-15

**GLU: CB-Agricultural/
Grass-4**

View: Looking west

Existing sediment
production: Med

Potential sediment
production: High

Existing veg. cover: 95%



Field Visit ID-16

**GLU: CB-Agricultural/
Grass-3**

View: Looking south

Existing sediment
production: High*

Potential sediment
production: High

Existing veg. cover: 90-95%

* Area was burned in 2014
fires after the field
assessment so existing
sediment production was
adjusted to High (based on
potential sediment
production) from Medium



Field Visit ID-17

GLU: CSI-Scrub/Shrub-4

View: Looking west

Existing sediment
production: Med

Potential sediment
production: High

Existing veg. cover: 95%



Field Visit ID-18

GLU: CSP-Forest-1

View: Looking southwest

Existing sediment
production: Low to Med

Potential sediment
production: Med

Existing veg. cover: 80%



Field Visit ID-19

GLU: CSP-Scrub/Shrub-3

View: Looking southwest

Existing sediment
production: Low to Med

Potential sediment
production:
Med to High

Existing veg. cover: 60%



Field Visit ID-20

GLU: CSP-Unknown-1

View: Looking southeast

Existing sediment
production: Low

Potential sediment
production: Med

Existing veg. cover: 95%



Field Visit ID-21

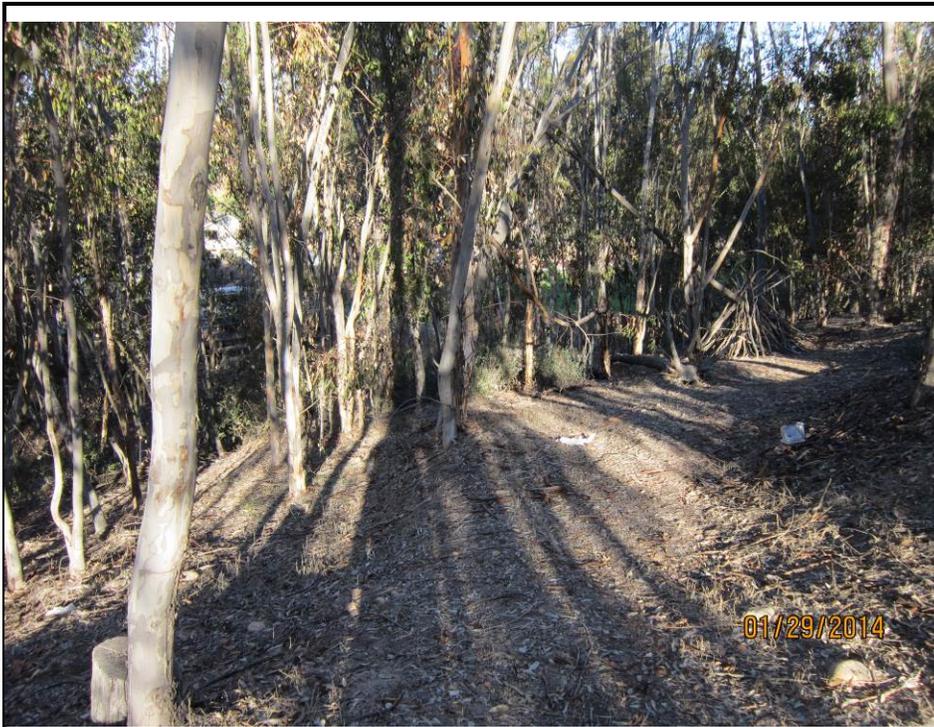
GLU: CB-Unknown-3

View: Looking northwest

Existing sediment
production: Low to Med

Potential sediment
production:
Med to High

Existing veg. cover: 50-60%



Field Visit ID-22

GLU: CSI-Forest-3

View: Looking east

Existing sediment
production: Low

Potential sediment
production: Med

Existing veg. cover: 60%



Field Visit ID-23

GLU: CSI-Scrub/Shrub-1

View: Looking north

Existing sediment
production: Low

Potential sediment
production: Low

Existing veg. cover: 80%



Field Visit ID-24

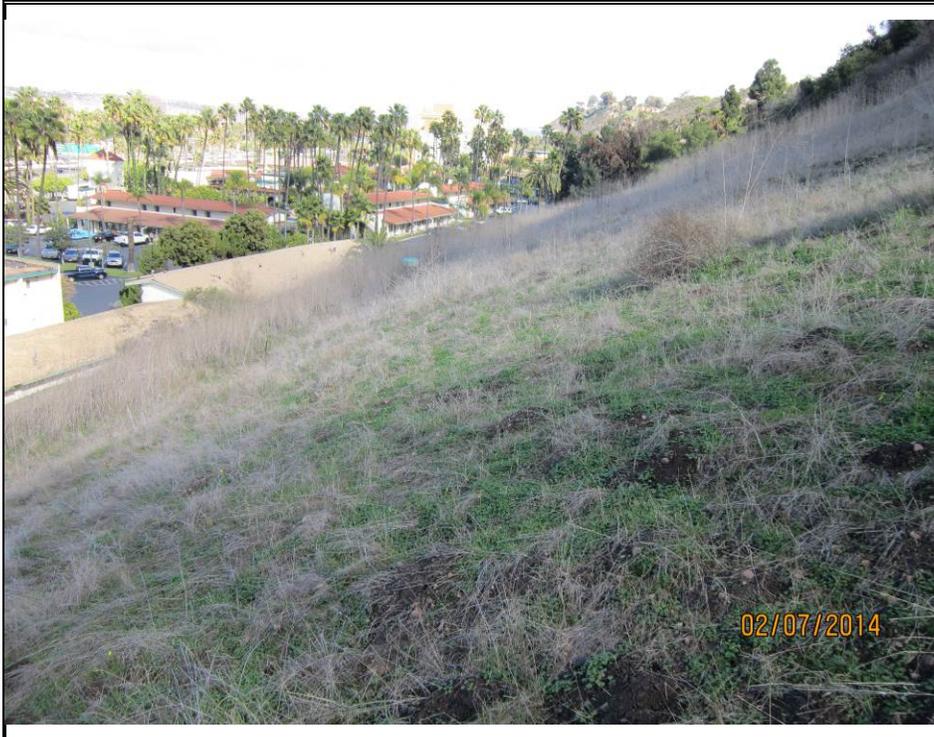
GLU: CB-Unknown-4

View: Looking northeast

Existing sediment
production: Low to Med

Potential sediment
production: High

Existing veg. cover: 80%



Field Visit ID-25

**GLU: CSI-Agricultural/
Grass-4**

View: Looking east

Existing sediment
production: Low

Potential sediment
production: Med-High

Existing veg. cover: 95%



Field Visit ID-26

GLU: CSI-Scrub/Shrub-3

View: Looking east

Existing sediment
production: Low

Potential sediment
production: Med

Existing veg. cover: 100%



Field Visit ID-27

GLU: CSP-Developed-2

View: Looking north

Existing sediment
production: Low

Potential sediment
production: Low

Existing veg. cover: 30-35%



Field Visit ID-28

**GLU: CSP-Agricultural/
Grass-2**

View: Looking north

Existing sediment
production: Low

Potential sediment
production: Med

Existing veg. cover: 90-95%



Field Visit ID-29

GLU: FB-Forest-3

View: Looking northwest

Existing sediment
production: Med

Potential sediment
production: High

Existing veg. cover: 80-85%



Field Visit ID-30

GLU: CB-Developed-4

View: Looking northeast

Existing sediment
production: Low

Potential sediment
production: Med

Existing veg. cover: 70%



Field Visit ID-31

GLU: CSI-Developed-3

View: Looking north

Existing sediment
production: Low

Potential sediment
production: Low

Existing veg. cover: 30-35%



Field Visit ID-32

GLU: CSI-Unknown-3

View: Looking west

Existing sediment
production: Low to Med

Potential sediment
production: Med

Existing veg. cover: 70-75%



Field Visit ID-33
GLU: CSP-Scrub/Shrub-1

View: Looking northeast

Existing sediment
production: Low to Med

Potential sediment
production:
Med to High

Existing veg. cover: 70%



Field Visit ID-34
GLU: CSP-Developed-2

View: Looking south

Existing sediment
production: Low

Potential sediment
production: Low

Existing veg. cover: 95%



Field Visit ID-35

GLU: FB-Scrub/Shrub-3

View: Looking northeast

Existing sediment
production: Low

Potential sediment
production: Med

Existing veg. cover: 90-95%



Field Visit ID-36

**GLU: FSI-Agricultural/
Grass-2**

View: Looking northeast

Existing sediment
production: Low

Potential sediment
production: Med

Existing veg. cover: 95%



Field Visit ID-37

GLU: CB-Forest-3

View: Looking southeast

Existing sediment
production: Med-High

Potential sediment
production: High

Existing veg. cover: 75-80%



Field Visit ID-38

**GLU: CSI-Agricultural/
Grass-1**

View: Looking northeast

Existing sediment
production: Low

Potential sediment
production: Med

Existing veg. cover: 85%



Field Visit ID-39

GLU: CSP-Developed-1

View: Looking west

Existing sediment
production: Low

Potential sediment
production: Low

Existing veg. cover: 30-35%



Field Visit ID-40

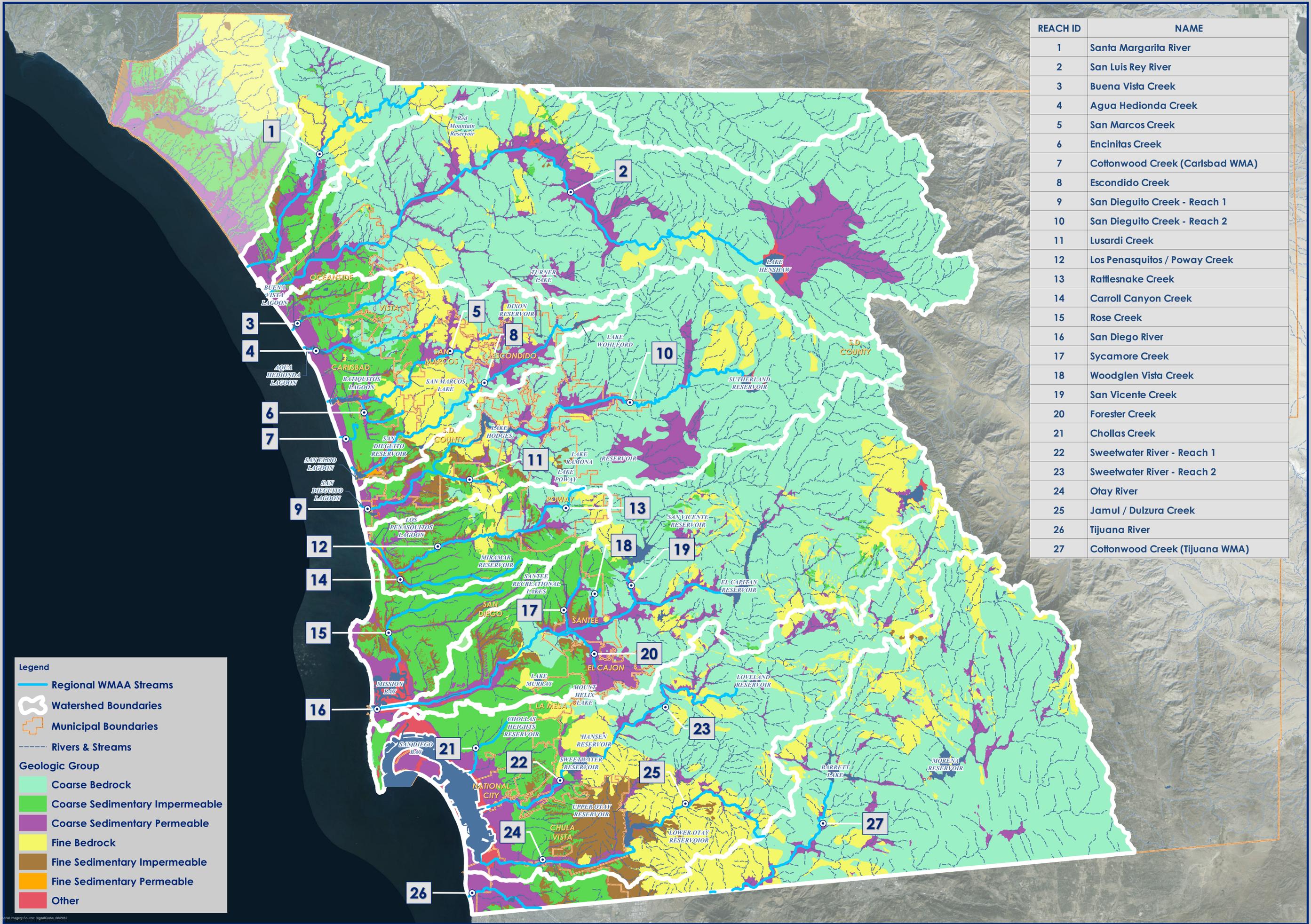
GLU: CSP-Scrub/Shrub-4

View: Looking south

Existing sediment
production: Med

Potential sediment
production: High

Existing veg. cover: 90-95%



REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams

Geologic Group

- Coarse Bedrock
- Coarse Sedimentary Impermeable
- Coarse Sedimentary Permeable
- Fine Bedrock
- Fine Sedimentary Impermeable
- Fine Sedimentary Permeable
- Other

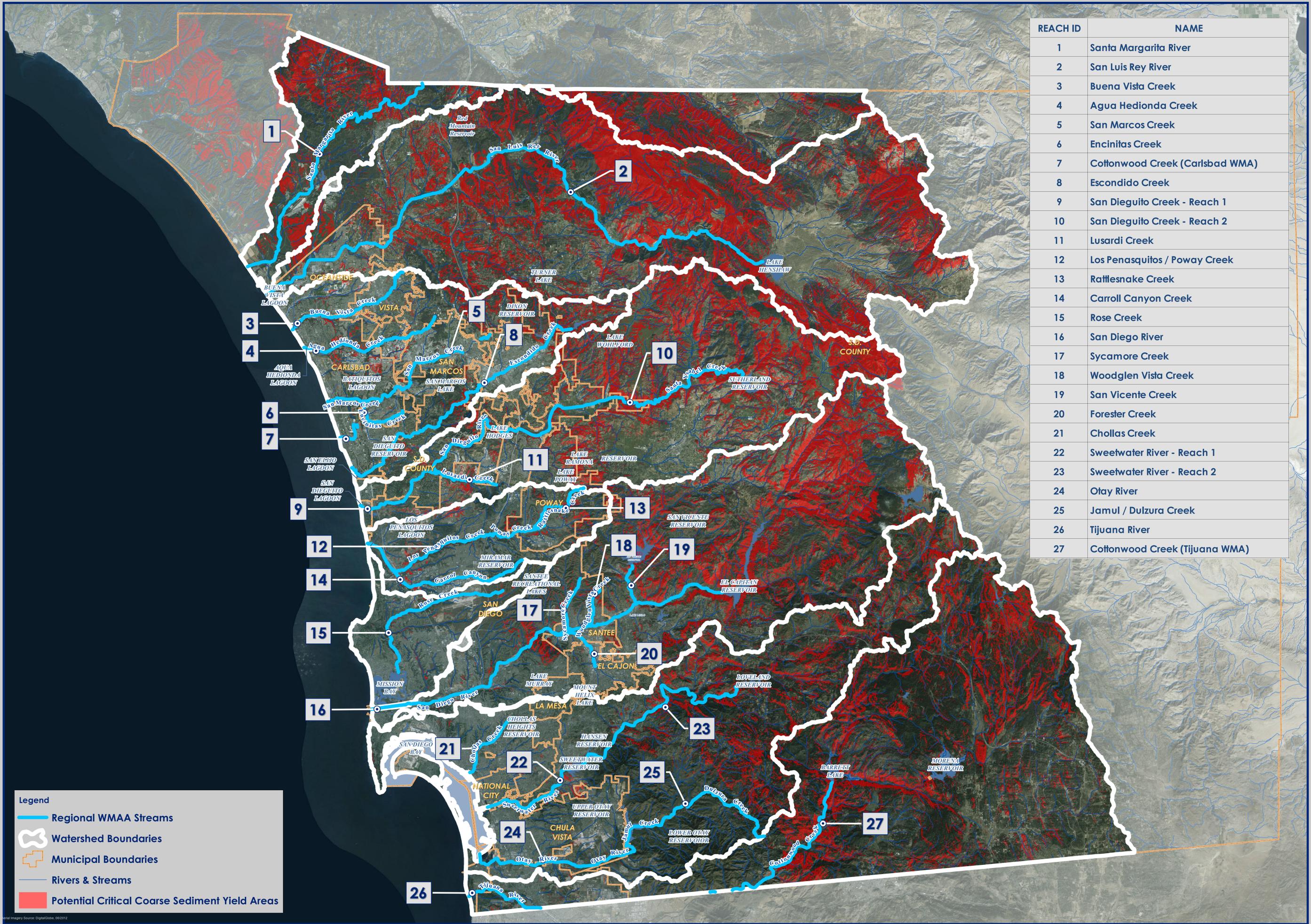
Miles 0 5 10 15

Geologic Groups

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014





REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
15	Rose Creek
16	San Diego River
17	Sycamore Creek
18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

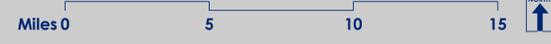
Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams
- Potential Critical Coarse Sediment Yield Areas

Potential Critical Coarse Sediment Yield Areas

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014



ATTACHMENT A.5
PHYSICAL STRUCTURES

A.5 Physical Structures

The desktop-level analysis to identify existing physical structures within the nine watershed management areas within the San Diego region utilized the following GIS data sources:

- ESRI ArcMap, Google Earth, and Google Maps products
- Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) Flood Profiles and FEMA Flood Insurance Rate Map (FIRM)
- National Flood Hazard Layer (NFHL)
- Municipal master drainage plans (as provided)
- San Diego Geographic Information Source (SanGIS) Municipal Boundaries and Hydrologic Basins
- United States Geological Survey (USGS) National Hydrography Dataset (NHD) California data
- Stream data generated as indicated in Section 2.2

The following documents the process used to identify the physical structures along the reaches and the resulting GIS data:

- The process began by importing the data sources indicated above into a single ArcMap document that served as a master map file from which all further analysis proceeded.
- The data were screened and selected for inclusion as appropriate to the project scope.
- Point features were placed along river reach line segments to coincide with visually identified structures, utilizing different feature symbols according to the type of infrastructure.
- In the case of levees, the point was placed at the downstream-most end of the FEMA NFHL Shapefile. All point features generated in this task appear in the GIS shapefile.
- Municipal boundaries intersecting river reaches were identified to identify the applicable municipal drainage plan data.
- Point feature attributes and associated information for Physical Structures GIS shapefile is indicated in Table A.5.1 below.

Table A.5.1: Structure Identification Point Feature Attribute Development and Information

Attribute	Description
Struct_ID	The Structure ID field provides a six-digit identification number based upon the structure's specific location within a watershed. The first three digits in the code reflect the structure's Hydrologic Unit (HU) Basin number (ranging between 902-911 for Region 9, as defined in the Water Quality Control Plan for the San Diego Basin). The subsequent three digits reflect the structure's location along the reach, ascending along the channel from the headwaters to tailwaters (ranging between 001-999, beginning at the confluence and increasing in the upstream direction).

Attribute	Description
WMA	The Watershed Management Area field provides the name of the watershed in which the structure exists. The WMA corresponds with the HU identified in the first three digits in the Struct_ID (e.g., 911, Tijuana Watershed).
Channel_ID	The Channel ID field provides the name of the channel in which the structure exists.
Struct_Typ	The Structure Type field classifies known structures as one of the following types: Bridge, Culvert, Dam, Energy Dissipater, Flood Management Basin, Flood Wall, Grade Control, Levee, Pipeline, Weir.
Struct_Dtl	The Structure Detail field provides known quantitative information for multi-section culverts.
Struct_Mtl	The Structure Material field provides known qualitative information for structure material composition.
Struct_Shp	The Structure Shape field provides known geometric information for culvert shapes, and is classified as one of the following types: Arch, Box, Pipe.
Jurisd_ID	The Jurisdiction ID field, when applicable, provides the known separate structure identification number developed and utilized by the jurisdiction or entity responsible for creating and distributing the coinciding structure Shapefile data used for this analysis. This number was copied from the coinciding external Shapefile data attribute field best representing a unique jurisdiction or entity-based identification number (external Shapefile data received from regional WMAA data call; for jurisdictional information, see "Other" attribute field). Coinciding external Shapefile data was used to determine various structure attributes.
Plan_ID	The Plan ID field, when applicable, provides the known structure plan number corresponding with the Jurisdiction ID. This number was copied from the coinciding external Shapefile data attribute field best representing a unique plan number received from the regional WMAA data call (external Shapefile data received from regional WMAA data call; for jurisdictional information, see "Other" field). Coinciding external Shapefile data was used to determine various structure attributes.
Diameter	The Diameter field, when applicable, provides the known diameter (in US feet) for culverts.
Length	The Length field, when applicable, provides the known length (in US feet) for select structure types. When lengths were determined using FEMA FIS Flood Profiles, the scaled horizontal distances along the indicated roadway or channel slope were used.
Width	The Width field, when applicable, provides the known width (in US feet) for select structure types.
Height	The Height field, when applicable, provides the known height (in US feet) for select structure types. When heights were determined using FEMA FIS Flood Profiles, the scaled vertical distances from channel bed to indicated roadway bottom were used.
US_Invert	The Upstream Invert field, when applicable, provides the known upstream invert elevation (in US feet) for select structure types.
DS_Invert	The Downstream Invert field, when applicable, provides the known downstream invert elevation (in US feet) for select structure types.

Attribute	Description
RD_EL_NAVD	The Roadway Elevation (NAVD) field, when applicable, provides the known roadway elevation (in US feet, NAVD) for select structure types. When roadway elevations were determined using FEMA FIS Flood Profiles, the horizontal projection onto the vertical grid scales were used.
Loc_Descr	The Location Description field, when applicable, provides information for structures crossing a known roadway. In nearly all cases, Google Earth imagery was used to determine the roadway name.
Other	The Other field is used to convey any information not present within the preceding fields. Typically, "other" information includes jurisdictional, plan, and supplemental dimensions for a given structure.

Example Structure Identification

The following example demonstrates the structure identification process for a discrete structure (ID 907029) along the San Diego River. The San Diego River is located in the San Diego River watershed (WMA 907). Scanning the river from lower to higher reached, a new point feature was placed at the road crossing over the San Diego River as indicated in Figure A.5.1. Select attributes of this particular structure were available from the FEMA NFHL as displayed in the highlighted boxes in Figure A.5.1. Additional attributes such as the culvert height, length, roadway elevation, and name were also determined from the FIS Flood Profile as indicated in Figure A.5.2. Satellite imagery (e.g., Google) was used to verify the existence of structure. In this case, the most current Google Map data indicated that the culvert still exists and that the roadway name has been changed to Qualcomm Way. When structures could not be verified with satellite imagery, the structure identification was based solely upon the information provided or readily available and was not physically verified in the field. Figure A.5.3 displays an example of imagery used to identify structures.

Figure A.5.1: Typical ArcMap Window

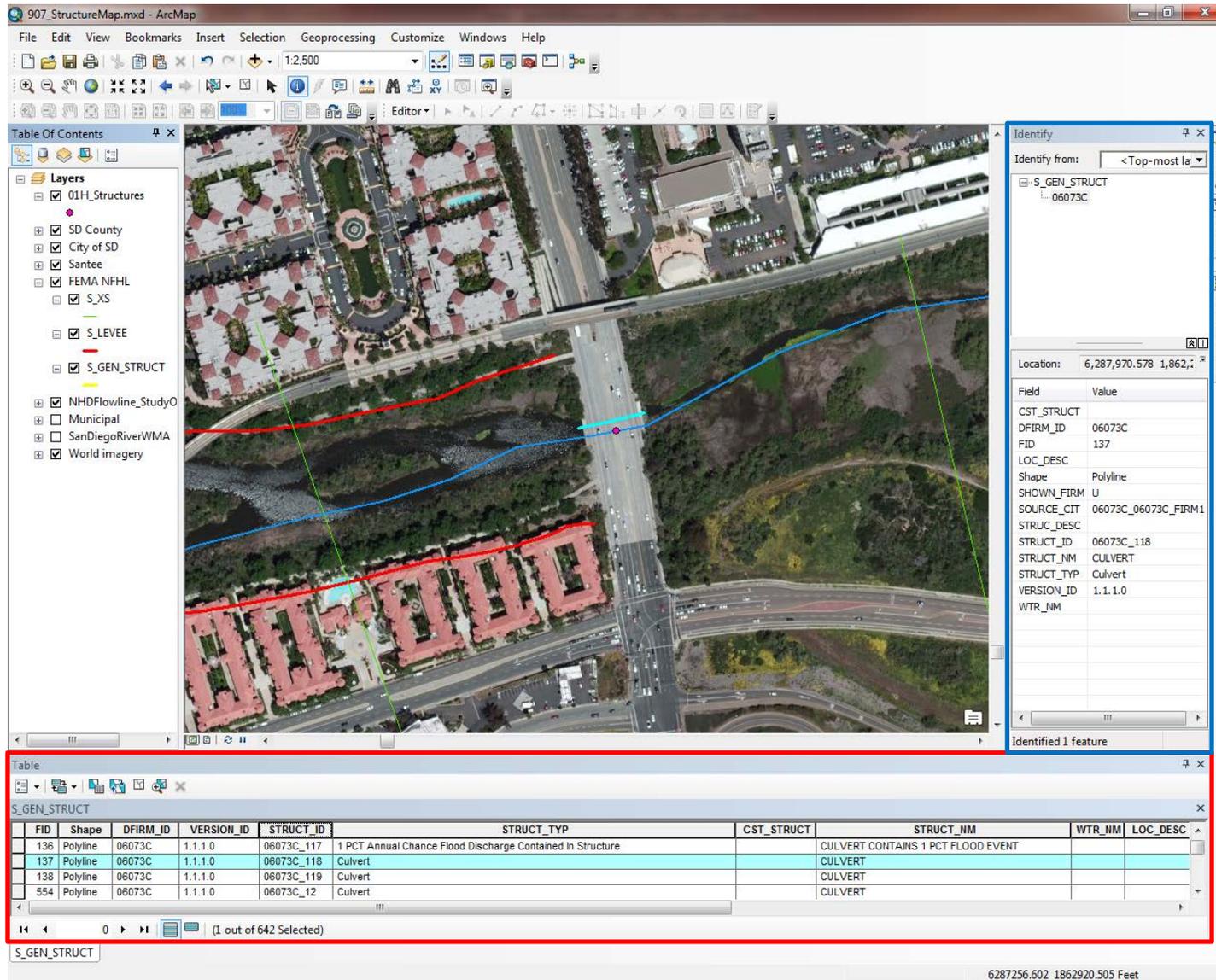
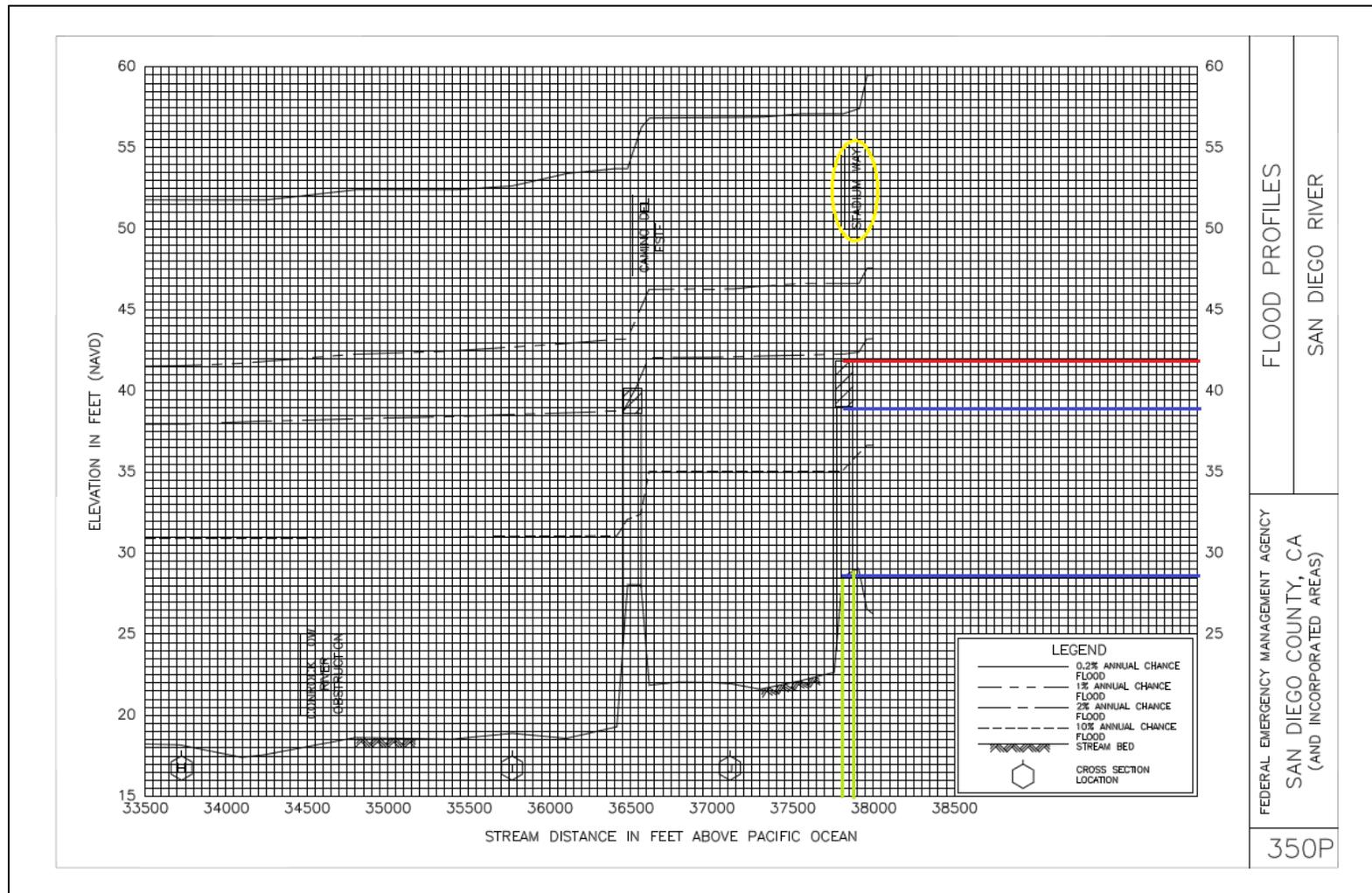


Figure A.5.2: Typical FEMA FIS Flood Profile



Legend: roadway elevation (red), roadway name (yellow), culvert height (blue), culvert width (green)

Figure A.5.3: Google Map Imagery for Structure Identification



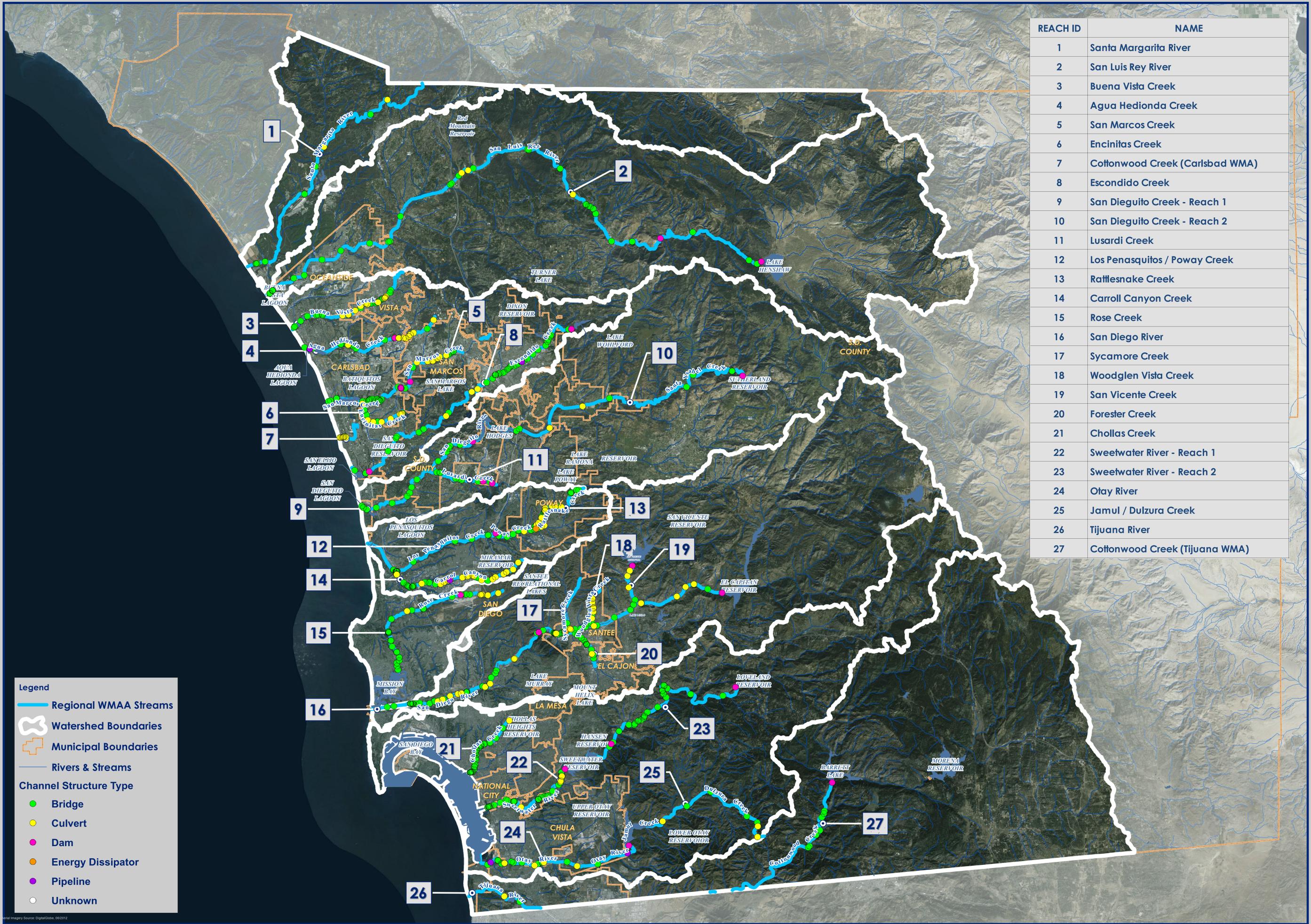
The following bridge structure dimensional attributes were included in the point feature attributes:

- length 110 feet
- height 10 feet
- roadway elevation 41.9 feet

The attribute table associated with the identified structure included in the GIS shapefile is indicated in Table A.5.2.

Table A.5.2: Structure 907029 Attribute Table

Attribute	Description
Struct_ID	907029
WMA	San Diego
Channel_ID	San Diego River
Struct_Typ	Culvert
Struct_Dtl	
Struct_Mtl	
Struct_Shp	
Jurisd_ID	06073C_118
Plan_ID	06073C_06073C_FIRM1
Diameter	0
Length	110
Width	0
Height	10
US_Invert	0
DS_Invert	0
RD_EL_NAVD	41.9
Loc_Descr	Qualcomm Way
Other	Info from FEMA NFHL shapefile data/FIS FP V.9-350P



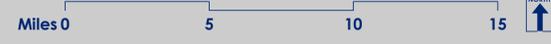
REACH ID	NAME
1	Santa Margarita River
2	San Luis Rey River
3	Buena Vista Creek
4	Agua Hedionda Creek
5	San Marcos Creek
6	Encinitas Creek
7	Cottonwood Creek (Carlsbad WMA)
8	Escondido Creek
9	San Dieguito Creek - Reach 1
10	San Dieguito Creek - Reach 2
11	Lusardi Creek
12	Los Penasquitos / Poway Creek
13	Rattlesnake Creek
14	Carroll Canyon Creek
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18	Woodglen Vista Creek
19	San Vicente Creek
20	Forester Creek
21	Chollas Creek
22	Sweetwater River - Reach 1
23	Sweetwater River - Reach 2
24	Otay River
25	Jamul / Dulzura Creek
26	Tijuana River
27	Cottonwood Creek (Tijuana WMA)

Legend

- Regional WMAA Streams
- Watershed Boundaries
- Municipal Boundaries
- Rivers & Streams

Channel Structure Type

- Bridge
- Culvert
- Dam
- Energy Dissipator
- Pipeline
- Unknown



Watershed Management Area Streams with Channel Structures

Regional San Diego County Watersheds

Exhibit Date: Sept. 8, 2014



ATTACHMENT B
HYDROMODIFICATION MANAGEMENT
APPLICABILITY/EXEMPTIONS

ATTACHMENT B.1
ADDITIONAL ANALYSIS FOR HYDROMODIFICATION
MANAGEMENT EXEMPTIONS

ATTACHMENT B.1.1
EXEMPT RIVER REACHES

B.1.1 Exempt River Reaches

B.1.1.1 Approach for Exempt River Reach Analysis

The approach selected in this cumulative hydromodification impacts study accounts for: (1) hydrology, (2) channel geometry, (3) bed and bank material, and (4) sediment supply. The selected approach compares long-term changes in sediment transport capacity, or in-stream work, and sediment supply for the existing and future development conditions. The ratio of future/existing condition transport capacity, or work, is termed Erosion Potential (Ep). The ratio of future/existing condition bed sediment supply is termed Sediment Supply Potential (Sp). To calculate Ep, the hydrology, channel geometry, and bed/bank materials are characterized for the existing and future conditions. To calculate Sp, the sediment supply factor is characterized for the existing and future conditions.

The findings in this study propose exemption for a given river reach if the analysis satisfies the following criteria:

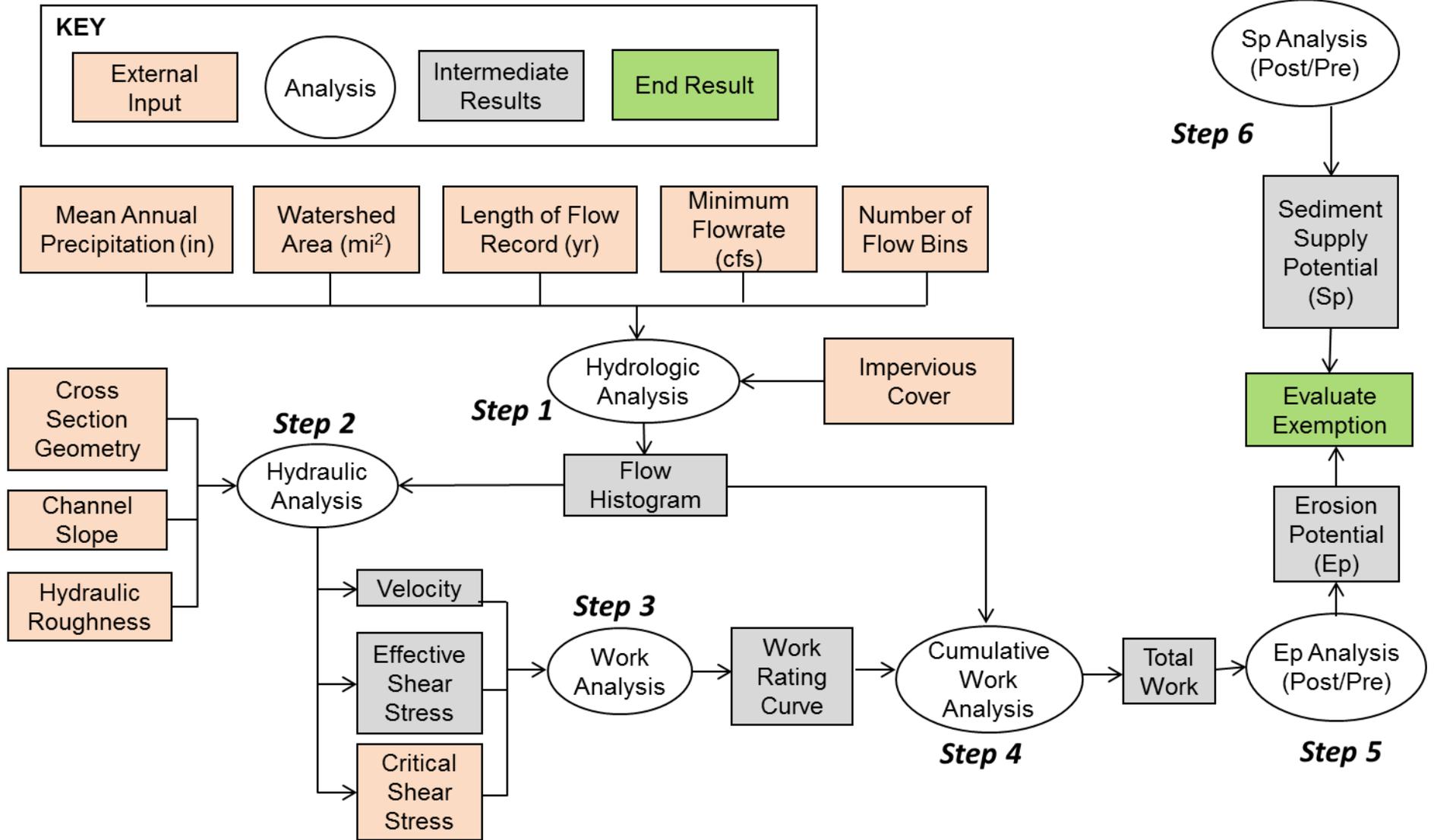
- $Ep < 1.05$ when $d_{50} < 16$ mm or $Ep < 1.20$ when $d_{50} > 16$ mm, and;
- $Sp > 0.90$

The following bullet points provide basis for the criteria listed above:

- For Ep
 - According to the Journal of Hydrology article titled Channel Enlargement in Semiarid Suburbanizing Watersheds: A Southern California Case Study (Hawley and Bledsoe, 2013): “*The threshold corresponding to the presence/absence of headcutting varied based on substrate type, and was roughly quantified as a sediment-transport ratio greater than ~1.20 in systems with a median grain size > 16mm, and [Ep] ~ 1.05 when $d_{50} < 16$ mm*”
- For Sp
 - Soar and Thorne (2001) indicate that a greater than 10% reduction in sediment supply can have potentially significant effects on stream stability.
 - SCCWRP Technical Report 605, 2010 states that changes of less than 10% in either driver (Water delivery and sediment are the drivers in this report) are unlikely to instigate, on their own, significant channel changes.

The flow chart summarizing the analysis procedure is presented below.

Flowchart for Exempt River Reach Analysis



B.1.1.2 Selection of Inputs for Exempt River Reach Analysis

The following steps were implemented for each river reach:

- Step 1 – Hydrologic Analysis:
 - Due to limited flow data, a flow duration equation developed for Southern California (Hawley and Bledsoe, 2011) was used to estimate existing and future flow histograms for each watershed.
 - The change in impervious cover between existing and future development conditions was estimated using the developable land use layer from Section 2.3.
 - A desktop-level GIS exercise was performed to manually assign land use classifications if the parcel in the developable land use layer directly discharges into the analyzed reach. Results are summarized in Section B.1.13.
 - Assumptions for percent imperviousness for each land use type were based on the information provided in the San Diego County Imperviousness Study (County of San Diego, 2010).
 - The table below presents the input parameters used to construct flow histograms, as well as the estimated channel slope at the critical cross section.

Exempt River Reach	Area (sq. miles)	Mean Annual Precipitation (in)	Length of Daily Flow Record (Years)	Channel Slope (ft/ft)
San Diego River	173	14.5	30	0.0012
Otay River – West of Interstate 805	46	12	30	0.0026
San Dieguito River	45	14	30	0.0012
San Luis Rey River	353	20	30	0.0019
Sweetwater River	72	12	30	0.0033

- Step 2 – Hydraulic Analysis: The reach type classification from Section 2.2 was used to identify the critical cross section along the reach for Ep analysis. A critical flow rate of $0.5Q_2$ was assigned to estimate the critical shear stress for the analyzed cross section. Flow rates below $0.5Q_2$ were assumed to perform no work on the reach.
- Step 3 – Work Analysis: The simplified effective work equation shown below is used to calculate the work done for each flow bin.

$$W = (\tau - \tau_c)^{1.5}V$$

Where

- W = Work (dimensionless)
- τ = effective Shear Stress [lb/ft²]
- τ_c = Critical Shear Stress [lb/ft²]
- V = Flow Velocity [ft/s]

- Step 4 – Cumulative Work Analysis: Cumulative work is a measure of the long-term total work or sediment transport capacity performed at a given stream location. Cumulative work incorporates both discharge magnitude and flow duration distributions for the full range of simulated flow rates. Cumulative work is calculated by multiplying work and

duration for each bin. Total work is calculated through summation of work from all flow bins.

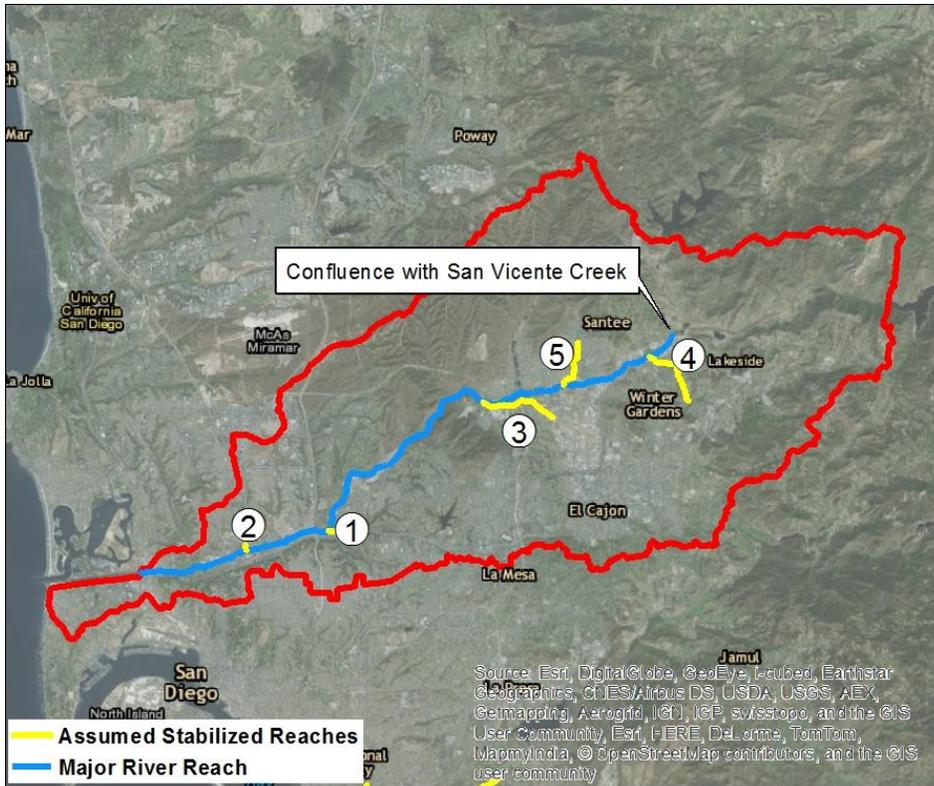
- Step 5 – Ep Analysis: Ep is calculated by dividing the total work of the future condition by that of the existing condition. The existing river reaches analyzed appear relatively stable and have not experienced excessive geomorphic instability due to the alteration of the drainage areas. Given the stable condition of the existing channels, the existing condition was used as the baseline condition instead of natural. Results from the Ep analysis are presented in Section B.1.1.3.
- Step 6 – Sp Analysis: Coarse Sediment Supply Potential for each watershed was estimated using the quantitative results from Section 2.4. First, the watershed coarse sediment soil loss was estimated for all GLUs producing coarse sediment. Then, the future-condition coarse sediment soil loss was estimated by subtracting the approximate exempt parcel soil loss from the existing soil loss. Sp is ultimately calculated by dividing the future coarse sediment soil loss by the existing coarse sediment soil loss. Results from Sp analysis are presented in Section B.1.1.3.

Steps 1 to 5 were performed in Excel and Steps 1 and 6 were executed in GIS. Ep estimates for the exempt river reaches are included in this attachment.

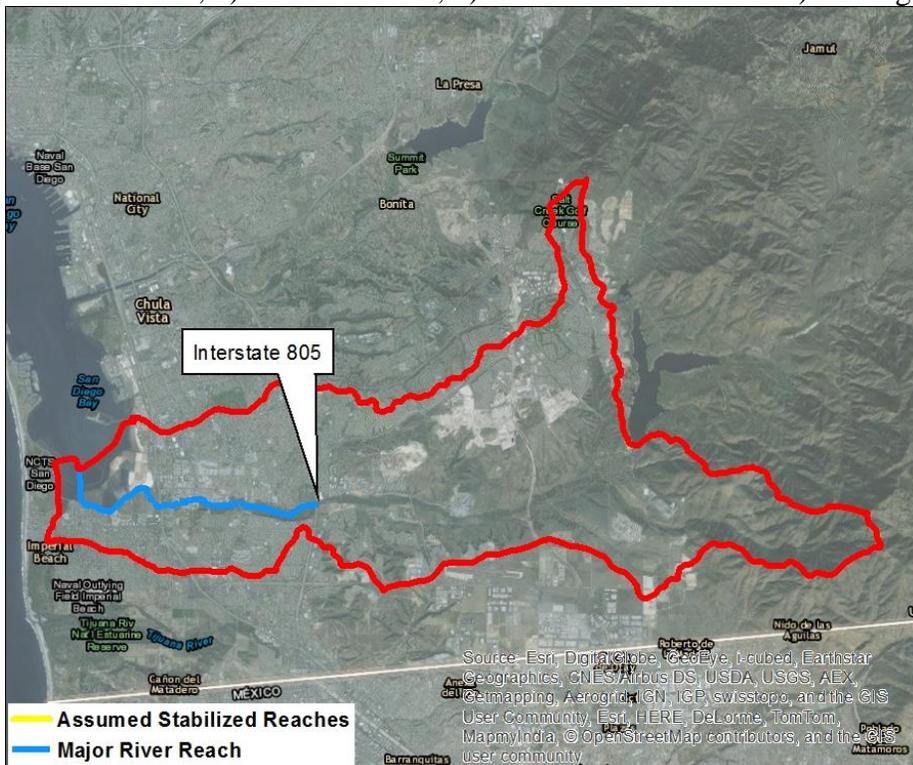
Exempt river reach extents are shown in the figures below. Figures also indicate the tributaries assumed to be stable for performing the erosion potential analysis as a conservative approach to approximate potential HMP exempt flows that may enter the river reach being analyzed.

For a PDP draining to one of the assumed stable tributaries shown in the following exempt reach figures, the PDP applicant shall verify and document that the assumed stable tributary is a stabilized conveyance system by using the methodology presented in section 4.1.2 prior to claiming exemption from hydromodification management requirements.

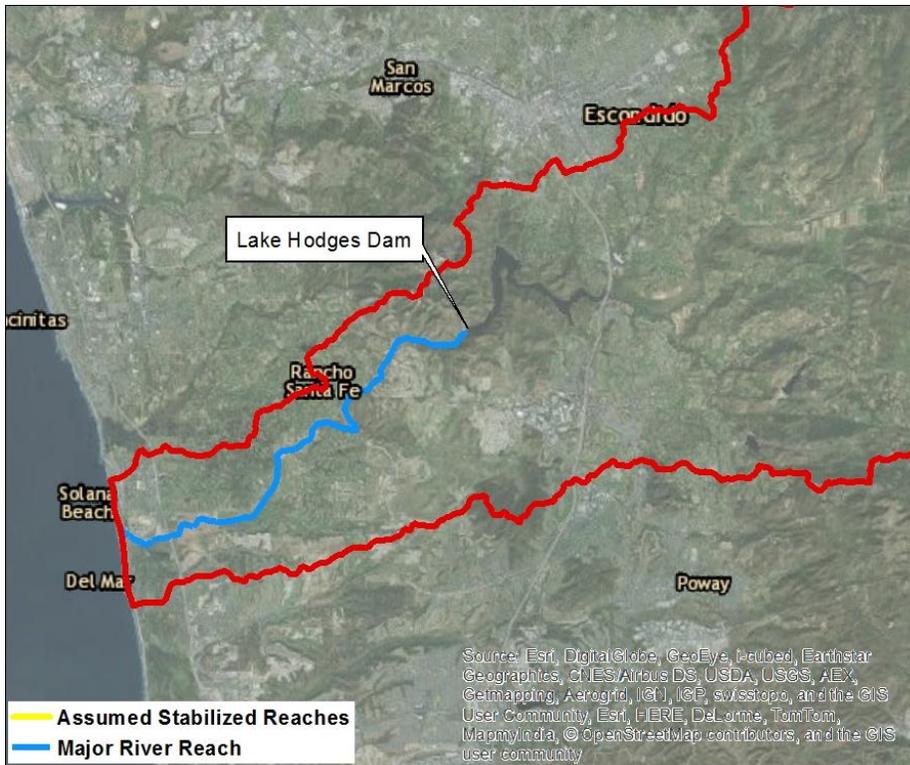
For a PDP draining to a tributary not shown in the figures below to be considered for exemption, a stability analysis using the section 4.1.2 methodology is to be conducted for the given tributary. If the stability analysis determines the tributary is stable, then the exempt river reach analysis indicated in section 4.1.1 shall be performed by adding the additional stabilized tributary to the current list of tributaries shown in the figures below to confirm that the reach satisfies the Ep and Sp criteria.



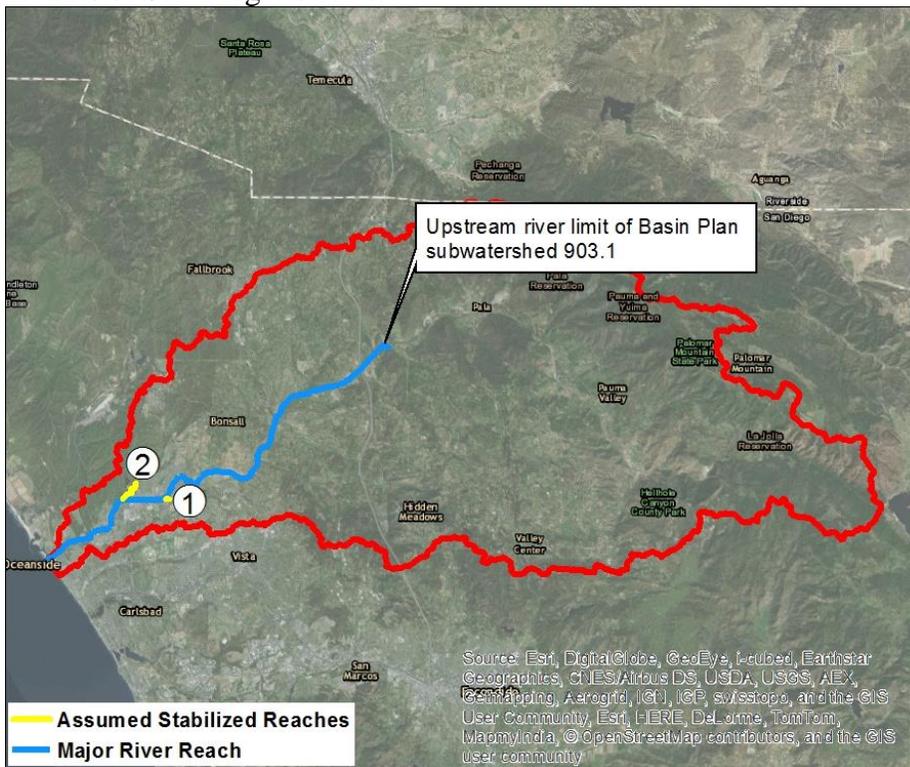
Extents of San Diego River and extents of assumed Stabilized Reaches: 1) Alvarado Creek; 2) Civita Channel; 3) Forester Creek; 4) Los Coches Creek and 5) Woodglen Vista Creek



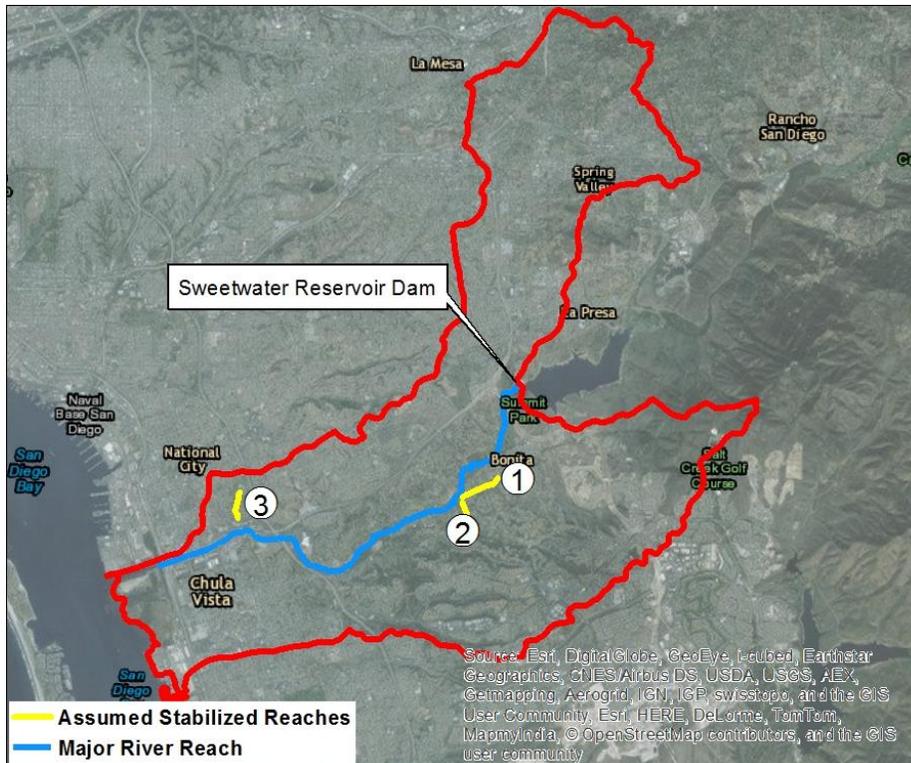
Extents of Otay River



Extents of San Diego River



Extents of San Luis Rey River and extents of assumed Stabilized Reaches: 1) Frazee Road Channel and 2) Pilgrim Creek



Extents of Sweetwater River and extents of assumed Stabilized Reaches: 1) Sunnyside Channel; 2) Long Canyon Channel; and 3) National City Gold Course Channel

The table below presents the summary of the developable land in each of the five watersheds with the exempt river reach and the estimated developable area that will be exempted from hydromodification management area requirements if the exempt river reach exemption is reinstated. This area will still be subject to the pollutant control requirements from the regional MS4 permit.

Exempt River Reach	Developable Land		
	Total (acres)	Area exempt (acres)	Exempt (%)
Otay River – West of Interstate 805	4,310	68	2%
San Diego River	13,667	1,196	9%
San Dieguito River	4,653	1,054	23%
San Luis Rey River	77,418	4,223	5%
Sweetwater River	1,332	255	19%

B.1.1.3 Results from Exempt River Reach Analysis

Results from Erosion potential analysis are presented below:

Exempt River Reach	Area (acres)	Impervious Area (acres) [%]			Ep (Post/Pre) [Criteria<1.05]
		Pre	Post	Increase	
Otay River – West of Interstate 805	29,571	9,428[31.8]	9,473[32.0]	45[0.2]	1.01
San Diego River	111,006	32,106[28.9]	32,777[29.5]	671 [0.6]	1.03
San Dieguito River	28,701	6,008[20.9]	6,042[21.0]	34[0.1]	1.01
San Luis Rey River	225,768	26,216[11.6]	26,803[11.9]	587[0.3]	1.01
Sweetwater River	26,596	10,566[39.7]	10,663[40.1]	97[0.4]	1.03

Results from coarse sediment supply potential analysis are presented below:

Exempt River Reach	Soil Loss (tons/yr.)			Sp (Post/Pre) [Criteria>0.90]
	Pre	Exempt Parcels	Post [Pre – Exempt Parcels]	
Otay River – West of Interstate 805	24,402	38	24,364	1.00
San Diego River	354,619	2,575	352,044	0.99
San Dieguito River	53,549	3,582	49,967	0.93
San Luis Rey River	1,503,964	27,072	1,476,892	0.98
Sweetwater River	16,672	601	16,071	0.96

Based on the results from the analysis it is recommended that exemption be reinstated for Otay River west of Interstate 805, San Diego River, San Dieguito River, San Luis Rey River and Sweetwater River.

Erosion Potential Analysis for Otay River - West of I805

Erosion Potential (Ep) **1.01**

Channel Slope	0.0026	ft/ft
Estimated Q ₂	133	cfs
0.5Q ₂	66.5	cfs
Critical Shear	0.135	lb/sq. ft
γ	62.4	lb/ft ³

			Existing Condition	Future Condition
Tributary Area	A	sq mi	46	46
Mean Annual Precip	MAP	in/yr	12.0	12.0
Length of Daily Flow Record	Yr	yr	30	30
Imperviousness	Impav	mi ² /mi ²	0.3188	0.3203
Maximum Flow of Record	Q _{max}	cfs	1236.9	1236.9
Minimum Flow of Record	Q _{min}	cfs	0.01	0.01
10-year peak flow	Q ₁₀	cfs	3405.1	3405.1
Coefficient of DDF	day1	days & cfs	14796.19	15110.20
Exponent of DDF	day2	days & cfs	-0.91	-0.91
Number of Bins	N _B	--	25	25
Bin Size	H _{B-log}	--	0.489	0.489

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
<i>B</i>	<i>B_{lwr-log (cfs)}</i>	<i>B_{upr-log (cfs)}</i>	<i>Q (cfs)</i>	<i>R (ft)</i>	<i>v (ft/s)</i>	<i>τ (psf)</i>	<i>W</i>		<i>W*duration</i>		<i>W*duration</i>
1	0.006	0.010	0.01	0.03	0.18	0.005	0.000	1169806	0.00	1205056	0.00
2	0.010	0.016	0.01	0.03	0.18	0.005	0.000	751154	0.00	773107	0.00
3	0.016	0.027	0.02	0.04	0.22	0.006	0.000	482330	0.00	495989	0.00
4	0.027	0.043	0.03	0.05	0.24	0.008	0.000	309713	0.00	318204	0.00
5	0.043	0.071	0.06	0.06	0.29	0.010	0.000	198872	0.00	204144	0.00
6	0.071	0.115	0.09	0.07	0.32	0.011	0.000	127699	0.00	130970	0.00
7	0.115	0.188	0.15	0.08	0.36	0.013	0.000	81998	0.00	84024	0.00
8	0.188	0.306	0.25	0.10	0.41	0.016	0.000	52653	0.00	53906	0.00
9	0.306	0.498	0.40	0.12	0.46	0.019	0.000	33809	0.00	34583	0.00
10	0.498	0.812	0.66	0.14	0.52	0.023	0.000	21709	0.00	22187	0.00
11	0.812	1.324	1.07	0.17	0.59	0.028	0.000	13940	0.00	14234	0.00
12	1.324	2.158	1.74	0.21	0.66	0.034	0.000	8951	0.00	9132	0.00
13	2.158	3.517	2.84	0.25	0.75	0.041	0.000	5748	0.00	5859	0.00
14	3.517	5.733	4.62	0.30	0.85	0.049	0.000	3691	0.00	3759	0.00
15	5.733	9.344	7.54	0.36	0.96	0.058	0.000	2370	0.00	2411	0.00
16	9.344	15.230	12.29	0.43	1.08	0.070	0.000	1522	0.00	1547	0.00
17	15.230	24.825	20.03	0.52	1.22	0.084	0.000	977	0.00	992	0.00
18	24.825	40.465	32.64	0.62	1.38	0.101	0.000	627	0.00	637	0.00
19	40.465	65.956	53.21	0.75	1.56	0.122	0.000	403	0.00	409	0.00
20	65.956	107.507	86.73	0.94	1.82	0.153	0.004	259	1.12	262	1.14
21	107.507	175.233	141.37	1.18	2.11	0.191	0.029	166	4.74	168	4.80
22	175.233	285.626	230.43	1.46	2.44	0.237	0.080	107	8.50	108	8.60
23	285.626	465.563	375.59	1.80	2.81	0.292	0.175	68	12.02	69	12.14
24	465.563	758.856	612.21	2.15	3.16	0.349	0.313	44	13.77	44	13.90
25	758.856	1236.916	997.89	2.57	3.56	0.417	0.534	28	15.08	28	15.21

Erosion Potential Analysis for San Diego River

Erosion Potential (Ep) **1.03**

Channel Slope	0.0012	ft/ft
Estimated Q₂	436	cfs
0.5Q₂	218	cfs
Critical Shear	0.109	lb/sq. ft
γ	62.4	lb/ft ³

			Existing Condition	Future Condition
Tributary Area	A	sq mi	173	173
Mean Annual Precip	MAP	in/yr	14.5	14.5
Length of Daily Flow Record	Yr	yr	30	30
Imperviousness	Impav	mi ² /mi ²	0.2892	0.2953
Maximum Flow of Record	Q _{max}	cfs	6336.8	6336.8
Minimum Flow of Record	Q _{min}	cfs	0.01	0.01
10-year peak flow	Q ₁₀	cfs	12411.4	12411.4
Coefficient of DDF	day1	days & cfs	48535.40	52754.33
Exponent of DDF	day2	days & cfs	-0.88	-0.88
Number of Bins	N _B	--	25	25
Bin Size	H _{B-log}	--	0.557	0.557

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
<i>B</i>	<i>B_{lwr-log (cfs)}</i>	<i>B_{upr-log (cfs)}</i>	<i>Q (cfs)</i>	<i>R (ft)</i>	<i>v (ft/s)</i>	<i>τ (psf)</i>	<i>W</i>		<i>W*duration</i>		<i>W*duration</i>
1	0.006	0.010	0.01	0.00	0.02	0.000	0.000	3404271	0.00	3830691	0.00
2	0.010	0.017	0.01	0.00	0.02	0.000	0.000	2089074	0.00	2341409	0.00
3	0.017	0.030	0.02	0.00	0.03	0.000	0.000	1281986	0.00	1431125	0.00
4	0.030	0.053	0.04	0.01	0.04	0.001	0.000	786707	0.00	874737	0.00
5	0.053	0.093	0.07	0.01	0.05	0.001	0.000	482773	0.00	534660	0.00
6	0.093	0.162	0.13	0.01	0.07	0.001	0.000	296259	0.00	326797	0.00
7	0.162	0.282	0.22	0.02	0.08	0.001	0.000	181803	0.00	199746	0.00
8	0.282	0.492	0.39	0.02	0.10	0.001	0.000	111566	0.00	122090	0.00
9	0.492	0.859	0.68	0.03	0.13	0.002	0.000	68464	0.00	74624	0.00
10	0.859	1.499	1.18	0.04	0.16	0.003	0.000	42014	0.00	45612	0.00
11	1.499	2.615	2.06	0.06	0.20	0.004	0.000	25782	0.00	27879	0.00
12	2.615	4.562	3.59	0.09	0.25	0.007	0.000	15822	0.00	17040	0.00
13	4.562	7.960	6.26	0.12	0.31	0.009	0.000	9709	0.00	10415	0.00
14	7.960	13.889	10.92	0.17	0.39	0.013	0.000	5958	0.00	6366	0.00
15	13.889	24.234	19.06	0.23	0.49	0.017	0.000	3656	0.00	3891	0.00
16	24.234	42.283	33.26	0.33	0.61	0.025	0.000	2244	0.00	2378	0.00
17	42.283	73.776	58.03	0.45	0.76	0.034	0.000	1377	0.00	1454	0.00
18	73.776	128.724	101.25	0.63	0.94	0.047	0.000	845	0.00	889	0.00
19	128.724	224.597	176.66	0.87	1.17	0.065	0.000	519	0.00	543	0.00
20	224.597	391.875	308.24	1.20	1.45	0.090	0.000	318	0.00	332	0.00
21	391.875	683.742	537.81	1.65	1.80	0.124	0.003	195	0.60	203	0.62
22	683.742	1192.991	938.37	2.25	2.21	0.168	0.032	120	3.81	124	3.94
23	1192.991	2081.525	1637.26	3.00	2.68	0.225	0.105	74	7.72	76	7.96
24	2081.525	3631.836	2856.68	3.80	3.13	0.285	0.230	45	10.36	46	10.64
25	3631.836	6336.812	4984.32	4.06	3.28	0.304	0.282	28	7.80	28	7.98

Erosion Potential Analysis for San Dieguito River

Erosion Potential (Ep) **1.01**

Channel Slope	0.0012	ft/ft
Estimated Q ₂	156	cfs
0.5Q ₂	78	cfs
Critical Shear	0.044	lb/sq. ft
γ	62.4	lb/ft ³

			Existing Condition	Future Condition
Tributary Area	A	sq mi	45	45
Mean Annual Precip	MAP	in/yr	14.0	14.0
Length of Daily Flow Record	Yr	yr	30	30
Imperviousness	Impav	mi ² /mi ²	0.209	0.211
Maximum Flow of Record	Q _{max}	cfs	1583.0	1583.0
Minimum Flow of Record	Q _{min}	cfs	0.01	0.01
10-year peak flow	Q ₁₀	cfs	3734.4	3734.4
Coefficient of DDF	day1	days & cfs	5669.51	5762.95
Exponent of DDF	day2	days & cfs	-0.84	-0.84
Number of Bins	N _B	--	25	25
Bin Size	H _{B-log}	--	0.499	0.499

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
<i>B</i>	<i>B_{lwr-log (cfs)}</i>	<i>B_{upr-log (cfs)}</i>	<i>Q (cfs)</i>	<i>R (ft)</i>	<i>v (ft/s)</i>	<i>τ (psf)</i>	<i>W</i>		<i>W*duration</i>		<i>W*duration</i>
1	0.006	0.010	0.01	0.01	0.07	0.001	0.000	322675	0.00	330221	0.00
2	0.010	0.016	0.01	0.01	0.07	0.001	0.000	212448	0.00	217264	0.00
3	0.016	0.027	0.02	0.02	0.09	0.001	0.000	139875	0.00	142946	0.00
4	0.027	0.045	0.04	0.01	0.10	0.001	0.000	92093	0.00	94049	0.00
5	0.045	0.074	0.06	0.03	0.11	0.002	0.000	60634	0.00	61878	0.00
6	0.074	0.121	0.10	0.03	0.13	0.002	0.000	39921	0.00	40712	0.00
7	0.121	0.199	0.16	0.04	0.14	0.003	0.000	26284	0.00	26786	0.00
8	0.199	0.328	0.26	0.05	0.16	0.004	0.000	17305	0.00	17623	0.00
9	0.328	0.541	0.43	0.05	0.19	0.004	0.000	11394	0.00	11595	0.00
10	0.541	0.891	0.72	0.07	0.21	0.005	0.000	7502	0.00	7629	0.00
11	0.891	1.467	1.18	0.08	0.25	0.006	0.000	4939	0.00	5019	0.00
12	1.467	2.416	1.94	0.11	0.29	0.008	0.000	3252	0.00	3302	0.00
13	2.416	3.979	3.20	0.13	0.34	0.010	0.000	2141	0.00	2173	0.00
14	3.979	6.552	5.27	0.17	0.40	0.013	0.000	1410	0.00	1430	0.00
15	6.552	10.790	8.67	0.21	0.46	0.016	0.000	928	0.00	941	0.00
16	10.790	17.769	14.28	0.26	0.53	0.019	0.000	611	0.00	619	0.00
17	17.769	29.263	23.52	0.34	0.62	0.025	0.000	402	0.00	407	0.00
18	29.263	48.191	38.73	0.43	0.73	0.032	0.000	265	0.00	268	0.00
19	48.191	79.361	63.78	0.54	0.85	0.040	0.000	174	0.00	176	0.00
20	79.361	130.694	105.03	0.68	1.00	0.051	0.001	115	0.06	116	0.06
21	130.694	215.228	172.96	0.86	1.16	0.064	0.003	76	0.25	76	0.25
22	215.228	354.441	284.83	1.08	1.35	0.081	0.009	50	0.47	50	0.48
23	354.441	583.699	469.07	1.34	1.57	0.100	0.021	33	0.68	33	0.69
24	583.699	961.245	772.47	1.65	1.80	0.124	0.040	22	0.87	22	0.87
25	961.245	1582.993	1272.12	1.98	2.03	0.148	0.068	14	0.97	14	0.97

Erosion Potential Analysis for San Luis Rey River

Erosion Potential (Ep) **1.01**

Channel Slope	0.0019	ft/ft
Estimated Q ₂	1225	cfs
0.5Q ₂	612.5	cfs
Critical Shear	0.077	lb/sq. ft
Y	62.4	lb/ft ³

			Existing Condition	Future Condition
Tributary Area	A	sq mi	353	353
Mean Annual Precip	MAP	in/yr	20.0	20.0
Length of Daily Flow Record	Yr	yr	30	30
Imperviousness	Impav	mi ² /mi ²	0.1161	0.1187
Maximum Flow of Record	Q _{max}	cfs	22579.2	22579.2
Minimum Flow of Record	Q _{min}	cfs	0.01	0.01
10-year peak flow	Q ₁₀	cfs	29414.3	29414.3
Coefficient of DDF	day1	days & cfs	23720.72	24587.28
Exponent of DDF	day2	days & cfs	-0.76	-0.76
Number of Bins	N _B	--	25	25
Bin Size	H _{B-log}	--	0.610	0.610

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
<i>B</i>	<i>B_{lwr-log (cfs)}</i>	<i>B_{upr-log (cfs)}</i>	<i>Q (cfs)</i>	<i>R (ft)</i>	<i>v (ft/s)</i>	<i>τ (psf)</i>	<i>W</i>		<i>W*duration</i>		<i>W*duration</i>
1	0.01	0.01	0.01	0.00	0.02	0.000	0.000	955692	0.00	1005555	0.00
2	0.01	0.02	0.01	0.00	0.02	0.000	0.000	601390	0.00	631581	0.00
3	0.02	0.03	0.03	0.00	0.03	0.000	0.000	378438	0.00	396691	0.00
4	0.03	0.06	0.05	0.00	0.03	0.000	0.000	238140	0.00	249158	0.00
5	0.06	0.11	0.09	0.00	0.04	0.000	0.000	149855	0.00	156494	0.00
6	0.11	0.21	0.16	0.01	0.05	0.001	0.000	94299	0.00	98293	0.00
7	0.21	0.39	0.30	0.01	0.07	0.001	0.000	59340	0.00	61737	0.00
8	0.39	0.71	0.55	0.01	0.08	0.001	0.000	37341	0.00	38776	0.00
9	0.71	1.31	1.0	0.02	0.11	0.002	0.000	23498	0.00	24355	0.00
10	1.3	2.4	1.9	0.02	0.14	0.002	0.000	14786	0.00	15297	0.00
11	2.4	4.4	3.4	0.03	0.17	0.004	0.000	9305	0.00	9608	0.00
12	4.4	8.2	6.3	0.05	0.22	0.006	0.000	5855	0.00	6035	0.00
13	8.2	15.0	11.6	0.07	0.27	0.008	0.000	3684	0.00	3790	0.00
14	15.0	27.6	21.3	0.10	0.35	0.012	0.000	2319	0.00	2381	0.00
15	27.6	50.9	39.2	0.14	0.44	0.017	0.000	1459	0.00	1495	0.00
16	50.9	93.6	72.2	0.20	0.55	0.024	0.000	918	0.00	939	0.00
17	93.6	172.1	132.8	0.28	0.70	0.033	0.000	578	0.00	590	0.00
18	172.1	316.6	244.4	0.40	0.87	0.047	0.000	364	0.00	371	0.00
19	316.6	582.5	449.6	0.55	1.09	0.065	0.000	229	0.00	233	0.00
20	582.5	1071.6	827.0	0.76	1.35	0.090	0.002	144	0.29	146	0.29
21	1071.6	1971.3	1521.4	1.07	1.69	0.127	0.019	91	1.70	92	1.72
22	1971.3	3626.6	2798.9	1.50	2.12	0.178	0.068	57	3.87	58	3.91
23	3626.6	6671.6	5149.1	2.09	2.65	0.248	0.187	36	6.71	36	6.77
24	6671.6	12273.5	9472.6	2.92	3.31	0.346	0.462	23	10.43	23	10.51
25	12273.5	22579.2	17426.3	4.06	4.12	0.481	1.059	14	15.04	14	15.13

Erosion Potential Analysis for Sweetwater River

Erosion Potential (Ep) **1.025**

Channel Slope	0.0033	ft/ft
Estimated Q ₂	110	cfs
0.5Q ₂	55	cfs
Critical Shear	0.136	lb/sq. ft
Y	62.4	lb/ft ³

			Existing Condition	Future Condition
Tributary Area	A	sq mi	42	42
Mean Annual Precip	MAP	in/yr	12.0	12.0
Length of Daily Flow Record	Yr	yr	30	30
Imperviousness	Impav	mi ² /mi ²	0.397	0.401
Maximum Flow of Record	Q _{max}	cfs	1114.9	1114.9
Minimum Flow of Record	Q _{min}	cfs	0.01	0.01
10-year peak flow	Q ₁₀	cfs	3105.6	3105.6
Coefficient of DDF	day1	days & cfs	40664.46	42754.73
Exponent of DDF	day2	days & cfs	-1.01	-1.01
Number of Bins	N _B	--	25	25
Bin Size	H _{B-log}	--	0.484	0.484

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Hydraulic Radius	Flow Velocity	Shear Stress	Work	Duration	Cumulative Work	Duration	Cumulative Work
<i>B</i>	<i>B_{lwr-log (cfs)}</i>	<i>B_{upr-log (cfs)}</i>	<i>Q (cfs)</i>	<i>R (ft)</i>	<i>v (ft/s)</i>	<i>τ (psf)</i>	<i>W</i>		<i>W*duration</i>		<i>W*duration</i>
1	0.006	0.010	0.01	0.03	0.18	0.006	0.000	5155264	0.00	5533785	0.00
2	0.010	0.016	0.01	0.03	0.18	0.006	0.000	3168799	0.00	3394387	0.00
3	0.016	0.026	0.02	0.03	0.22	0.006	0.000	1947774	0.00	2082094	0.00
4	0.026	0.043	0.03	0.04	0.24	0.008	0.000	1197243	0.00	1277143	0.00
5	0.043	0.069	0.06	0.05	0.29	0.010	0.000	735912	0.00	783391	0.00
6	0.069	0.113	0.09	0.06	0.32	0.012	0.000	452345	0.00	480527	0.00
7	0.113	0.183	0.15	0.07	0.36	0.014	0.000	278044	0.00	294752	0.00
8	0.183	0.297	0.24	0.08	0.40	0.016	0.000	170906	0.00	180799	0.00
9	0.297	0.481	0.39	0.10	0.46	0.021	0.000	105051	0.00	110901	0.00
10	0.481	0.781	0.63	0.12	0.51	0.025	0.000	64572	0.00	68026	0.00
11	0.781	1.268	1.02	0.14	0.58	0.029	0.000	39691	0.00	41727	0.00
12	1.268	2.057	1.66	0.17	0.66	0.035	0.000	24397	0.00	25595	0.00
13	2.057	3.339	2.70	0.20	0.74	0.041	0.000	14996	0.00	15700	0.00
14	3.339	5.419	4.38	0.24	0.83	0.049	0.000	9218	0.00	9630	0.00
15	5.419	8.795	7.11	0.29	0.94	0.060	0.000	5666	0.00	5907	0.00
16	8.795	14.273	11.53	0.35	1.06	0.072	0.000	3483	0.00	3623	0.00
17	14.273	23.165	18.72	0.42	1.20	0.086	0.000	2141	0.00	2223	0.00
18	23.165	37.595	30.38	0.51	1.36	0.105	0.000	1316	0.00	1363	0.00
19	37.595	61.014	49.30	0.63	1.57	0.130	0.000	809	0.00	836	0.00
20	61.014	99.022	80.02	0.78	1.81	0.161	0.007	497	3.50	513	3.61
21	99.022	160.707	129.86	0.70	1.67	0.144	0.001	306	0.38	315	0.39
22	160.707	260.818	210.76	0.71	1.69	0.146	0.002	188	0.33	193	0.34
23	260.818	423.291	342.05	0.81	1.85	0.167	0.010	115	1.16	118	1.19
24	423.291	686.974	555.13	1.04	2.19	0.214	0.048	71	3.40	73	3.48
25	686.974	1114.916	900.95	1.35	2.61	0.278	0.140	44	6.10	45	6.23

ATTACHMENT B.1.2
SUPPORT MATERIALS FOR ANALYSIS OF FORESTER
CREEK AS A STABILIZED CONVEYANCE SYSTEM

Forester Creek Erosion Potential Analysis for Cross Section 1300 Located Downstream of Mission Gorge Road

			Existing Condition	Future Condition
Tributary Area	<i>A</i>	sq mi	23.36	23.36
Mean Annual Precip	<i>MAP</i>	in/yr	14	14
Length of Daily Flow Record	<i>Yr</i>	yr	30	30
Imperviousness	<i>Impav</i>	mi ² /mi ²	0.4634	0.4792
Maximum Flow of Record	<i>Qmax</i>	cfs	836.0	836.0
Minimum Flow of Record	<i>Qmin</i>	cfs	0.01	0.01
10-year peak flow	<i>Q10</i>	cfs	2120.2	2120.2
Coefficient of DDF	<i>day1</i>	days & cfs	121556.06	151171.59
Exponent of DDF	<i>day2</i>	days & cfs	-1.17	-1.19
Number of Bins	<i>N_B</i>	--	25	25
Bin Size	<i>H_{B,des}</i>	--	0.472	0.472

γ	62.4	lb/ft ³
Critical Shear	2.100	lb/sq. ft
Channel Slope	0.0060	ft/ft

Critical Shear Flow Rate	2150	cfs
Critical Shear Flow Depth	6.3	ft

Approximate flow rate that would achieve critical shear stress for this channel cross section

Approximate flow depth that would achieve critical shear stress for this channel cross section

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Flow Depth	Flow Area	Wetted Perimeter	Hydraulic Radius	Flow Velocity	Channel Slope	Shear Stress	Work	Existing Condition Duration	Existing Condition Duration	Existing Condition Cumulative Work	Future Condition Duration	Future Condition Duration	Future Condition Cumulative Work	
<i>B</i>	<i>B_{low,des}</i>	<i>B_{high,des}</i>	<i>Q</i>	<i>D</i>	<i>A</i>	<i>P</i>	<i>R</i>	<i>v</i>	<i>f/ft</i>	τ	<i>W</i>	<i>days</i>	<i>years</i>	<i>W*days</i>	<i>days</i>	<i>years</i>	<i>W*days</i>	
--	cfs	cfs	cfs	ft	sq ft	ft	ft	ft/s	ft/ft	psf	--	days	years	--	days	years	--	
1	0.006	0.010	0.008	0.00	0.30	84.01	0.00	0.03	0.006	0.000	0.000	34249940.4	93771.2	0.00	46609552.7	127610.0	0.00	
2	0.010	0.016	0.013	0.00	0.40	84.02	0.00	0.03	0.006	0.000	0.000	19693227.1	53917.1	0.00	26564034.2	72728.4	0.00	
3	0.016	0.026	0.021	0.01	0.53	84.03	0.01	0.04	0.006	0.004	0.000	11323324.6	31001.6	0.00	15139555.5	41449.8	0.00	
4	0.026	0.041	0.033	0.01	0.70	84.03	0.01	0.05	0.006	0.004	0.000	6510750.1	17825.5	0.00	8628438.7	23623.4	0.00	
5	0.041	0.066	0.054	0.01	0.94	84.05	0.01	0.06	0.006	0.004	0.000	3743588.4	10249.4	0.00	4917578.7	13463.6	0.00	
6	0.066	0.106	0.086	0.01	1.24	84.06	0.01	0.07	0.006	0.004	0.000	2152509.9	5893.3	0.00	2802660.0	7673.3	0.00	
7	0.106	0.170	0.138	0.02	1.65	84.08	0.02	0.08	0.006	0.007	0.000	1237662.5	3388.5	0.00	1597311.1	4373.2	0.00	
8	0.170	0.273	0.221	0.03	2.19	84.11	0.03	0.10	0.006	0.011	0.000	711638.3	1948.4	0.00	910350.4	2492.4	0.00	
9	0.273	0.437	0.355	0.03	2.91	84.14	0.03	0.12	0.006	0.011	0.000	409181.9	1120.3	0.00	518833.1	1420.5	0.00	
10	0.437	0.701	0.569	0.05	3.86	84.19	0.05	0.15	0.006	0.019	0.000	235273.7	644.1	0.00	295696.9	809.6	0.00	
11	0.701	1.124	0.913	0.06	5.13	84.25	0.06	0.18	0.006	0.022	0.000	135279.0	370.4	0.00	168525.6	461.4	0.00	
12	1.124	1.803	1.464	0.08	6.81	84.33	0.08	0.22	0.006	0.030	0.000	77783.5	213.0	0.00	96047.3	263.0	0.00	
13	1.803	2.891	2.347	0.11	9.04	84.43	0.11	0.26	0.006	0.041	0.000	44724.4	122.4	0.00	54739.9	149.9	0.00	
14	2.891	4.636	3.764	0.14	12.01	84.58	0.14	0.31	0.006	0.052	0.000	25715.9	70.4	0.00	31197.7	85.4	0.00	
15	4.636	7.435	6.036	0.19	15.96	84.76	0.19	0.38	0.006	0.071	0.000	14786.3	40.5	0.00	17780.4	48.7	0.00	
16	7.435	11.922	9.679	0.25	21.22	85.01	0.25	0.46	0.006	0.094	0.000	8501.9	23.3	0.00	10133.5	27.7	0.00	
17	11.922	19.119	15.520	0.33	28.21	85.35	0.33	0.55	0.006	0.124	0.000	4888.5	13.4	0.00	5775.4	15.8	0.00	
18	19.119	30.658	24.888	0.44	37.53	85.79	0.44	0.66	0.006	0.165	0.000	2810.8	7.7	0.00	3291.5	9.0	0.00	
19	30.658	49.163	39.911	0.59	49.95	86.37	0.58	0.80	0.006	0.217	0.000	1616.2	4.4	0.00	1875.9	5.1	0.00	
20	49.163	78.837	64.000	0.78	66.55	87.15	0.76	0.96	0.006	0.285	0.000	929.3	2.5	0.00	1069.1	2.9	0.00	
21	78.837	126.421	102.629	1.03	88.77	88.18	1.01	1.16	0.006	0.378	0.000	534.3	1.5	0.00	609.3	1.7	0.00	
22	126.421	202.726	164.574	1.37	118.57	89.54	1.32	1.39	0.006	0.494	0.000	307.2	0.8	0.00	347.3	1.0	0.00	
23	202.726	325.088	263.907	1.82	158.67	91.35	1.74	1.66	0.006	0.651	0.000	176.7	0.5	0.00	197.9	0.5	0.00	
24	325.088	521.305	423.196	2.41	212.84	93.74	2.27	1.99	0.006	0.850	0.000	101.6	0.3	0.00	112.8	0.3	0.00	
25	521.305	835.955	678.630	3.20	286.33	96.91	2.95	2.37	0.006	1.104	0.000	58.4	0.2	0.00	64.3	0.2	0.00	
															0.000000		0.000000	

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(No work occurs in existing or future condition for the range of geomorphically significant flows)

Calculations shown below are for reference only - the flow rates are higher than the range of geomorphically significant flows:

Maximum Flow of Record			836.0	3.62	326.77	98.61	3.31	2.56	0.006	1.239	0.000
10-year peak flow			2120.2	6.27	595.18	109.31	5.44	3.56	0.006	2.037	0.000
Critical Shear Flow Rate			2150.0	6.32	600.64	109.52	5.48	3.58	0.006	2.052	0.000

Forester Creek Erosion Potential Analysis for Cross Section 2475 Located between Mission Gorge Road and State Route 52

			Existing Condition	Future Condition
Tributary Area	<i>A</i>	sq mi	23.36	23.36
Mean Annual Precip	<i>MAP</i>	in/yr	14	14
Length of Daily Flow Record	<i>Yr</i>	yr	30	30
Imperviousness	<i>Impav</i>	mi ² /mi ²	0.4634	0.4792
Maximum Flow of Record	<i>Qmax</i>	cfs	836.0	836.0
Minimum Flow of Record	<i>Qmin</i>	cfs	0.01	0.01
10-year peak flow	<i>Q10</i>	cfs	2120.2	2120.2
Coefficient of DDF	<i>day1</i>	days & cfs	121556.06	151171.59
Exponent of DDF	<i>day2</i>	days & cfs	-1.17	-1.19
Number of Bins	<i>N_B</i>	--	25	25
Bin Size	<i>H_{B,des}</i>	--	0.472	0.472

γ	62.4	lb/ft ³
Critical Shear	2.100	lb/sq. ft
Channel Slope	0.0030	ft/ft

Critical Shear Flow Rate	9400	cfs
Critical Shear Flow Depth	12.92	ft

Approximate flow rate that would achieve critical shear stress for this channel cross section

Approximate flow depth that would achieve critical shear stress for this channel cross section

Bin Number	Lower Bound of Bin Number	Upper Bound of Bin Number	Flow	Flow Depth	Flow Area	Wetted Perimeter	Hydraulic Radius	Flow Velocity	Channel Slope	Shear Stress	Work	Existing Condition Duration	Existing Condition Duration	Existing Condition Cumulative Work	Future Condition Duration	Future Condition Duration	Future Condition Cumulative Work
<i>B</i>	<i>B_{low,des}</i>	<i>B_{high,des}</i>	<i>Q</i>	<i>D</i>	<i>A</i>	<i>P</i>	<i>R</i>	<i>v</i>	<i>ft/ft</i>	τ	<i>W</i>	<i>days</i>	<i>years</i>	<i>W*days</i>	<i>days</i>	<i>years</i>	<i>W*days</i>
--	cfs	cfs	cfs	ft	sq ft	ft	ft	ft/s	ft/ft	psf	--	days	years	--	days	years	--
1	0.006	0.010	0.008	0.00	0.47	155.01	0.00	0.02	0.003	0.000	0.000	34249940.4	93771.2	0.00	46609552.7	127610.0	0.00
2	0.010	0.016	0.013	0.00	0.63	155.02	0.00	0.02	0.003	0.000	0.000	19693227.1	53917.1	0.00	26564034.2	72728.4	0.00
3	0.016	0.026	0.021	0.01	0.84	155.02	0.01	0.03	0.003	0.002	0.000	11323324.6	31001.6	0.00	15139555.5	41449.8	0.00
4	0.026	0.041	0.033	0.01	1.10	155.03	0.01	0.03	0.003	0.002	0.000	6510750.1	17825.5	0.00	8628438.7	23623.4	0.00
5	0.041	0.066	0.054	0.01	1.48	155.04	0.01	0.04	0.003	0.002	0.000	3743588.4	10249.4	0.00	4917578.7	13463.6	0.00
6	0.066	0.106	0.086	0.01	1.95	155.06	0.01	0.04	0.003	0.002	0.000	2152509.9	5893.3	0.00	2802660.0	7673.3	0.00
7	0.106	0.170	0.138	0.02	2.59	155.07	0.02	0.05	0.003	0.004	0.000	1237662.5	3388.5	0.00	1597311.1	4373.2	0.00
8	0.170	0.273	0.221	0.02	3.44	155.10	0.02	0.06	0.003	0.004	0.000	711638.3	1948.4	0.00	910350.4	2492.4	0.00
9	0.273	0.437	0.355	0.03	4.57	155.13	0.03	0.08	0.003	0.006	0.000	409181.9	1120.3	0.00	518833.1	1420.5	0.00
10	0.437	0.701	0.569	0.04	6.07	155.17	0.04	0.09	0.003	0.007	0.000	235273.7	644.1	0.00	295696.9	809.6	0.00
11	0.701	1.124	0.913	0.05	8.06	155.23	0.05	0.11	0.003	0.009	0.000	135279.0	370.4	0.00	168525.6	461.4	0.00
12	1.124	1.803	1.464	0.07	10.70	155.31	0.07	0.14	0.003	0.013	0.000	77783.5	213.0	0.00	96047.3	263.0	0.00
13	1.803	2.891	2.347	0.09	14.21	155.41	0.09	0.17	0.003	0.017	0.000	44724.4	122.4	0.00	54739.9	149.9	0.00
14	2.891	4.636	3.764	0.12	18.87	155.54	0.12	0.20	0.003	0.022	0.000	25715.9	70.4	0.00	31197.7	85.4	0.00
15	4.636	7.435	6.036	0.16	25.06	155.72	0.16	0.24	0.003	0.030	0.000	14786.3	40.5	0.00	17780.4	48.7	0.00
16	7.435	11.922	9.679	0.21	33.29	155.96	0.21	0.29	0.003	0.039	0.000	8501.9	23.3	0.00	10133.5	27.7	0.00
17	11.922	19.119	15.520	0.28	44.23	156.27	0.28	0.35	0.003	0.052	0.000	4888.5	13.4	0.00	5775.4	15.8	0.00
18	19.119	30.658	24.888	0.38	58.79	156.69	0.38	0.42	0.003	0.071	0.000	2810.8	7.7	0.00	3291.5	9.0	0.00
19	30.658	49.163	39.911	0.50	78.15	157.24	0.50	0.51	0.003	0.094	0.000	1616.2	4.4	0.00	1875.9	5.1	0.00
20	49.163	78.837	64.000	0.66	103.94	157.97	0.66	0.62	0.003	0.124	0.000	929.3	2.5	0.00	1069.1	2.9	0.00
21	78.837	126.421	102.629	0.88	138.32	158.95	0.87	0.74	0.003	0.163	0.000	534.3	1.5	0.00	609.3	1.7	0.00
22	126.421	202.726	164.574	1.17	184.24	160.24	1.15	0.89	0.003	0.215	0.000	307.2	0.8	0.00	347.3	1.0	0.00
23	202.726	325.088	263.907	1.55	245.63	161.95	1.52	1.07	0.003	0.285	0.000	176.7	0.5	0.00	197.9	0.5	0.00
24	325.088	521.305	423.196	2.06	327.91	164.22	2.00	1.29	0.003	0.374	0.000	101.6	0.3	0.00	112.8	0.3	0.00
25	521.305	835.955	678.630	2.73	438.50	167.22	2.62	1.55	0.003	0.490	0.000	58.4	0.2	0.00	64.3	0.2	0.00

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(No work occurs in existing or future condition for the range of geomorphically significant flows)

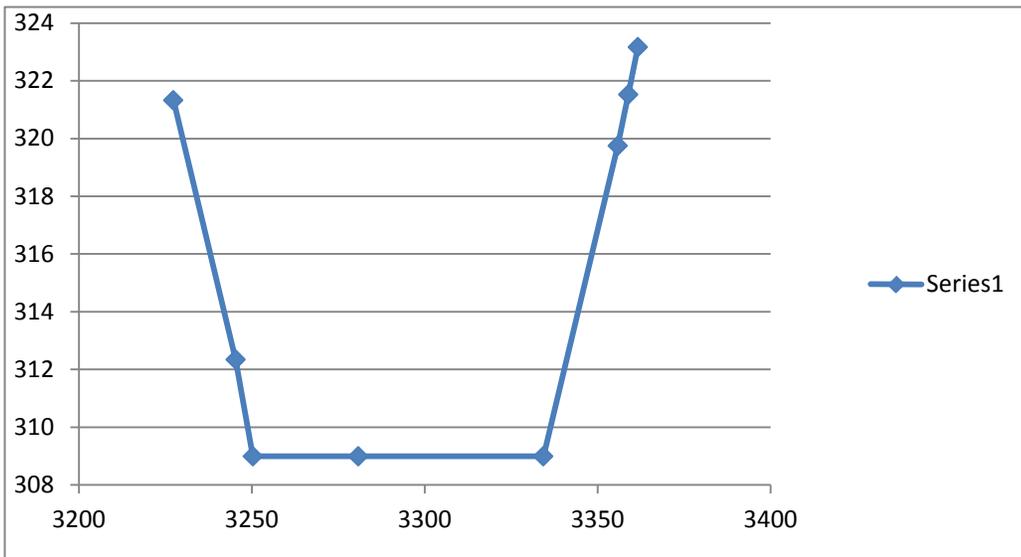
Calculations shown below are for reference only - the flow rates are higher than the range of geomorphically significant flows:

Maximum Flow of Record			836.0	3.09	498.85	168.84	2.95	1.68	0.003	0.552	0.000
10-year peak flow			2120.2	5.39	892.72	179.08	4.98	2.37	0.003	0.932	0.000
Critical Shear Flow Rate			9400.0	12.92	2337.34	212.80	10.98	4.02	0.003	2.055	0.000

CHANNEL GEOMETRY FOR FORESTER CREEK SECTION 1300
 DOWNSTREAM OF MISSION GORGE ROAD

RS = 1300

STATION (FT)	ELEVATION (FT)
3227.329	321.325
3245.341	312.336
3250.328	308.99
3280.84	308.99
3334.35	308.99
3355.84	319.751
3358.858	321.522
3361.621	323.163



DEPTH = 321.325 - 308.99
 12.335 (12 FEET)

TOP = 3358.858 - 3227.329
 131.529 (132 FEET)

BOTTOM = 3334.35 - 3250.328
 84.022 (84 FEET)

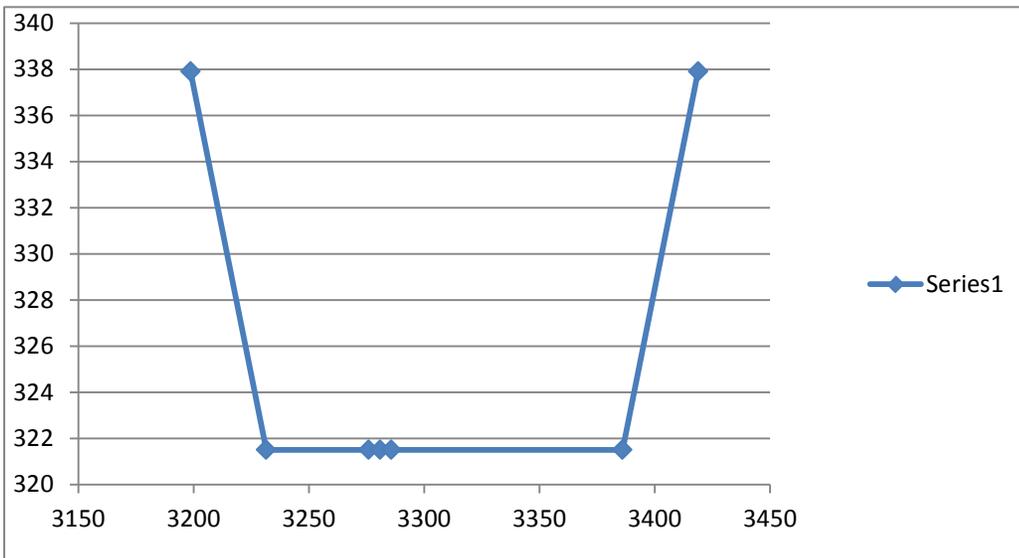
Z1 = (3250.328 - 3245.321) / (312.336 - 308.99)
 1.5

Z2 = (3355.84 - 3334.35) / (319.751 - 308.99)
 2.0

CHANNEL GEOMETRY FOR FORESTER CREEK SECTION 2475
 BETWEEN MISSION GORGE ROAD AND STATE ROUTE 52

RS = 2475

STATION (FT)	ELEVATION (FT)
3198.688	337.913
3231.463	321.509
3275.919	321.509
3280.84	321.509
3285.761	321.509
3385.991	321.509
3418.799	337.913



DEPTH = 337.913 - 321.509
 16.404 (16 FEET)

TOP = 3418.799 - 3198.688
 220.111 (220 FEET)

BOTTOM = 3385.991 - 3231.463
 154.528 (155 FEET)

Z1 = (3418.799 - 3385.991) / (337.913 - 321.509)
 2.0

Z2 = (3231.463 - 3198.688) / (337.913 - 321.509)
 2.0

Impervious Area Calculations for Forester Creek Watershed

Existing Condition

Existing Land Use

FREQUENCY	lu	landuse	Acres	% Impervious	A_Imp
81	1000	Spaced Rural Residential	754.48	0.10	75.45
	1100	Single Family Residential	0	0.42	0.00
1039	1110	Single Family Detached	5821.90	0.42	2445.20
353	1120	Single Family Multiple-Units	227.58	0.42	95.58
149	1190	Single Family Residential Without Units	45.72	0.42	19.20
297	1200	Multi-Family Residential	844.76	0.74	625.13
12	1290	Multi-Family Residential Without Units	1.44	0.74	1.06
40	1300	Mobile Home Park	399.85	0.74	295.89
25	1409	Other Group Quarters Facility	42.06	0.47	19.77
20	1501	Hotel/Motel (Low-Rise)	27.71	0.50	13.86
1	2001	Heavy Industry	20.29	0.80	16.23
52	2101	Industrial Park	587.62	0.82	481.85
15	2103	Light Industry - General	108.35	0.84	91.02
8	2104	Warehousing	16.18	0.84	13.59
15	2105	Public Storage	26.97	0.84	22.65
1	2301	Junkyard/Dump/Landfill	0.83	0.62	0.51
1	4103	General Aviation Airport	390.90	0.45	175.90
5	4111	Rail Station/Transit Center	6.62	0.77	5.10
8	4112	Freeway	365.74	0.58	212.13
44	4113	Communications and Utilities	38.39	0.40	15.35
11	4114	Parking Lot - Surface	3.28	0.75	2.46
1	4115	Parking Lot - Structure	1.30	0.61	0.79
1	4116	Park and Ride Lot	0.88	0.87	0.77
18	4117	Railroad Right of Way	25.88	0.52	13.46
58	4118	Road Right of Way	1907.10	0.60	1144.26
5	4119	Other Transportation	33.72	0.55	18.54
1	5002	Regional Shopping Center	73.97	0.94	69.53
4	5003	Community Shopping Center	37.14	0.83	30.83
17	5004	Neighborhood Shopping Center	110.81	0.85	94.19
21	5006	Automobile Dealership	58.88	0.89	52.40
193	5007	Arterial Commercial	260.86	0.83	216.52
37	5008	Service Station	18.68	0.94	17.56
42	5009	Other Retail Trade and Strip Commercial	74.30	0.80	59.44
	6001	Office (High-Rise)	0	0.61	0.00
38	6002	Office (Low-Rise)	44.03	0.65	28.62
2	6003	Government Office/Civic Center	16.31	0.80	13.05
2	6101	Cemetery	12.41	0.44	5.46
49	6102	Religious Facility	105.29	0.48	50.54
1	6103	Library	1.44	0.57	0.82
2	6104	Post Office	4.70	0.78	3.66
11	6105	Fire/Police Station	30.20	0.63	19.02
11	6109	Other Public Services	18.60	0.56	10.42
1	6502	Hospital - General	12.28	0.74	9.09
24	6509	Other Health Care	44.38	0.68	30.18
1	6701	Military Use	4.70	0.62	2.92
2	6802	Other University or College	34.53	0.54	18.64
4	6804	Senior High School	130.06	0.56	72.83
4	6805	Junior High School or Middle School	62.55	0.55	34.40
18	6806	Elementary School	163.06	0.56	91.31
1	6807	School District Office	13.59	0.72	9.78
5	6809	Other School	7.39	0.51	3.77
3	7210	Other Recreation - High	14.52	0.34	4.94
13	7601	Park - Active	83.80	0.14	11.73
42	7603	Open Space Park or Preserve	894.01	0.06	53.64
90	7606	Landscape Open Space	49.08	0.42	20.61
9	7607	Residential Recreation	10.06	0.42	4.22
	7609	Undevelopable Natural Area	0	0.06	0.00
	9700	Mixed Use	0	0.74	0.00
3	8001	Orchard or Vineyard	7.72	0.03	0.23
1	8002	Intensive Agriculture	2.09	0.12	0.25
1	8003	Field Crops	2.12	0.09	0.19
323	9101	Vacant and Undeveloped Land	806.75	0.08	64.54
23	9501	Residential Under Construction	37.51	0.42	15.76
1	9506	Road Under Construction	0.31	0.60	0.18
1	9507	Freeway Under Construction	0.79	0.58	0.46
			14948.47		6927.50
		square miles:	23.36		10.82

46.34%

Impervious Area Calculations for Forester Creek Watershed

Future Condition

Planned Land Use

FREQUENCY	plu	plannedlu	Acres	% Impervious	A_Imp
45	1000	Spaced Rural Residential	1139.00	0.10	113.90
237	1100	Single Family Residential	391.50	0.42	164.43
996	1110	Single Family Detached	5691.47	0.42	2390.42
272	1120	Single Family Multiple-Units	200.38	0.42	84.16
161	1190	Single Family Residential Without Units	28.38	0.42	11.92
320	1200	Multi-Family Residential	975.71	0.74	722.02
15	1290	Multi-Family Residential Without Units	6.62	0.74	4.90
33	1300	Mobile Home Park	370.34	0.74	274.05
26	1409	Other Group Quarters Facility	42.48	0.47	19.97
12	1501	Hotel/Motel (Low-Rise)	20.38	0.50	10.19
1	2001	Heavy Industry	20.29	0.80	16.23
52	2101	Industrial Park	613.06	0.82	502.71
20	2103	Light Industry - General	143.05	0.84	120.16
8	2104	Warehousing	18.92	0.84	15.89
13	2105	Public Storage	24.52	0.84	20.59
	2301	Junkyard/Dump/Landfill	0	0.62	0.00
2	4103	General Aviation Airport	331.86	0.45	149.34
4	4111	Rail Station/Transit Center	6.91	0.77	5.32
11	4112	Freeway	366.71	0.58	212.69
46	4113	Communications and Utilities	38.92	0.40	15.57
	4114	Parking Lot - Surface	0	0.75	0.00
	4115	Parking Lot - Structure	0	0.61	0.00
1	4116	Park and Ride Lot	0.88	0.87	0.77
17	4117	Railroad Right of Way	34.97	0.52	18.19
58	4118	Road Right of Way	1919.19	0.60	1151.52
6	4119	Other Transportation	32.96	0.55	18.13
1	5002	Regional Shopping Center	73.97	0.94	69.53
4	5003	Community Shopping Center	38.33	0.83	31.82
21	5004	Neighborhood Shopping Center	110.59	0.85	94.00
12	5006	Automobile Dealership	39.76	0.89	35.39
134	5007	Arterial Commercial	202.24	0.83	167.86
34	5008	Service Station	17.73	0.94	16.67
74	5009	Other Retail Trade and Strip Commercial	95.29	0.80	76.23
11	6001	Office (High-Rise)	37.42	0.61	22.83
35	6002	Office (Low-Rise)	52.57	0.65	34.17
2	6003	Government Office/Civic Center	16.31	0.80	13.05
2	6101	Cemetery	12.42	0.44	5.46
42	6102	Religious Facility	97.91	0.48	47.00
1	6103	Library	1.44	0.57	0.82
2	6104	Post Office	4.70	0.78	3.66
11	6105	Fire/Police Station	28.83	0.63	18.16
12	6109	Other Public Services	20.95	0.56	11.73
1	6502	Hospital - General	12.28	0.74	9.09
22	6509	Other Health Care	45.84	0.68	31.17
1	6701	Military Use	4.70	0.62	2.92
2	6802	Other University or College	34.53	0.54	18.64
4	6804	Senior High School	130.09	0.56	72.85
4	6805	Junior High School or Middle School	62.60	0.55	34.43
19	6806	Elementary School	171.68	0.56	96.14
1	6807	School District Office	4.98	0.72	3.59
6	6809	Other School	11.02	0.51	5.62
2	7210	Other Recreation - High	11.59	0.34	3.94
23	7601	Park - Active	89.56	0.14	12.54
41	7603	Open Space Park or Preserve	866.19	0.06	51.97
90	7606	Landscape Open Space	55.58	0.42	23.34
10	7607	Residential Recreation	9.77	0.42	4.10
21	7609	Undevelopable Natural Area	34.38	0.06	2.06
77	9700	Mixed Use	134.73	0.74	99.70
	8001	Orchard or Vineyard	0	0.03	0.00
	8002	Intensive Agriculture	0	0.12	0.00
	8003	Field Crops	0	0.09	0.00
	9101	Vacant and Undeveloped Land	0	0.08	0.00
	9501	Residential Under Construction	0	0.42	0.00
	9506	Road Under Construction	0	0.60	0.00
	9507	Freeway Under Construction	0	0.58	0.00
			14948.47		7163.55
		square miles:	23.36		11.19

47.92%

ATTACHMENT B.1.3

**EXCERPT OF VENTURA COUNTY HCP (FINAL DRAFT
DATED SEPTEMBER 2013): APPENDIX D, BASIS FOR
DESIGNATING NEGLIGIBLE RISK BASED ON
CUMULATIVE FUTURE BUILDOUT**

APPENDIX D

Basis for Designating Negligible Risk Based on Cumulative Future Buildout

APPENDIX D

BASIS FOR DESIGNATING NEGLIGIBLE RISK BASED ON CUMULATIVE FUTURE BUILDOUT

1. BACKGROUND

Hydromodification impacts are typically most severe just downstream of development and tend to decrease if more undeveloped watershed area contributes to the channel in the downstream direction. Analyses were performed to evaluate thresholds for additional impervious cover, from existing conditions (at the time of the HCP effective date) to buildout conditions, for the area tributary to a susceptible receiving water below which the risk of hydromodification impacts is considered negligible for that channel.

The following results are provided as a function of a susceptible channel's tributary area (A) and median grain size (D_{50}):

- If $A \geq 1$ square mile and $D_{50} \leq 16$ mm, then the threshold of additional imperviousness is evaluated using the nomograph in Figure 3-12.

Figure 3-12 is based on empirical flow duration equations (Hawley and Bledsoe, 2011), empirical channel geometry relationships (Coleman et al, 2005 and County of San Diego, 2009), and Erosion Potential analyses (see HCP Section 6.3 for a discussion on the Erosion Potential analysis method). The results range from 0.46% to 1.00% additional imperviousness, depending on watershed size and mean annual precipitation (MAP).

- If $A < 1$ square mile and $D_{50} \leq 16$ mm, then the threshold of additional imperviousness is 0.44%. (See Section 6.2 below.)
- If $D_{50} \geq 16$ mm, then the threshold of additional imperviousness is 1.65%. (See Section 6.2 below.)

The analyses used to establish these thresholds are described below.

2. HYDROLOGIC ANALYSIS

2.1 Identify the Typical Range of Rainfall Conditions

For the purposes of this analysis, the typical range of mean annual precipitation (MAP) is assumed to be 14 inches to 18 inches per year because most of the developed regions within Ventura County fall within this range on the isohyetal map (Figure 2-5) and this range is consistent with Ventura County's long-term precipitation gage records

(VCWPD 2007). It is anticipated that future development will impact the most miles of susceptible channel in the Calleguas Watershed within and downstream of the Cities of Thousand Oaks, Simi Valley, and Moorpark. The long-term precipitation records in these areas are all within the 14 inch to 18 inch range and thus these two MAPs were used in this analysis.

Table D-1. Long-Term Precipitation Gage Records in Ventura County

Precipitation Gage ID	Period of Record	Mean Annual Precipitation (inches)
Camarillo #219	1965-2006	13.45
Port Hueneme #17	1891-2006	13.62
Moorpark #141	1949-2006	14.45
Ventura #66	1873-2006	14.71
Simi Valley #154	1948-2006	14.89
Thousand Oaks #128	1943 -2006	15.6
Santa Paula #245	1961-2006	17.35
Piru #36	1927-2006	17.39
Fillmore #199	1959-2006	18.44
Ojai #30	1906-2006	21.32

2.2 Identify the Range of Watershed Areas

The range of typical watershed areas used in the sensitivity analysis were established based on an inventory of a subset of natural drainage channels that have significant urban development in their tributary areas. While there are a few susceptible drainage channels with watershed areas over 100 square miles or less than 1 square mile, most of the susceptible channels downstream of development are lower order with watershed areas ranging from about 2 to 10 square miles. Seven categories of watershed area (1-, 2-, 5-, 10-, 20-, 50-, and 100-square miles) were used in this analysis.

2.3 Identify Length of Daily Flow Record

A 30-year length of daily flow record was assumed in this analysis. During preliminary runs it was found that the threshold of additional impervious cover was not sensitive to changes in the assumed length of daily flow record.

2.4 Calculate Necessary Peak Flow Inputs (Q_2, Q_5, Q_{10})

Empirical peak flow equations used to estimate the 2-, 5-, and 10-year recurrence interval flows (Hawley and Bledsoe, 2011). The general form of the equation is:

$$Q_i = e^{(\text{Incpt}) * A^a * P^p * e^{(\text{impmax} * \text{Impmax})}}$$

Where:

- Q_i = the instantaneous peak flow at return interval i years (cfs)
 - Incpt = the vertical axis intercept of the log-transformed linear regression model
 - A = total drainage area (mi^2)
 - P = average annual precipitation (in)
 - Impmax = the maximum spatial extent of the total impervious area during the gage record as a fraction of the total drainage area (mi^2/mi^2)
- $a, p,$ and impmax = regression parameters specific to each return period

Table D-2 provides the regression parameters for each return period of interest.

Table D-2. Regression parameters for the 2-, 5-, and 10-year peak flows

Return Period (yrs)	Incpt (-)	a (mi^2)	p (in)	Impmax (-)
2	-0.644	0.667	1.29	8.61
5	2.137	0.838	0.773	3.23
10	2.90	0.868	0.767	0

Table D-3 presents the resulting flowrates for each combination of tributary area and mean annual precipitation analyzed (14 total) assuming no imperviousness.

Table D-3. Peak Flow (Q₂, Q₅, Q₁₀) Results

Tributary Area	Mean Annual Precipitation	Q ₂	Q ₅	Q ₁₀
A	MAP			
sq mi	in/yr	cfs	cfs	cfs
1	14	15.8	65.2	138
2	14	25.1	116	251
5	14	46.2	251	556
10	14	73.4	449	1015
20	14	117	802	1853
50	14	215	1729	4104
100	14	341	3091	7491
1	18	21.9	79.1	167
2	18	34.7	141	304
5	18	63.9	305	674
10	18	102	545	1231
20	18	161	974	2247
50	18	297	2100	4977
100	18	472	3753	9083

2.5 Calculate Inputs for Long-Term Cumulative Durations (Q_{max}, Q_{min}, day1, day2, N_B, H_{B-log})

In order to represent the mean daily flows with cumulative duration curves, logarithmic histogram bins were created to represent flow frequencies without any discontinuities

following the Hawley and Bledsoe (2011) methodology. The bin size of the logarithmically-spaced histogram bins ($H_{B-\log}$) is represented as follows:

$$H_{B-\log} = \{\ln(Q_{\max}) - \ln(Q_{\min})\} / (N_B - 1)$$

Where:

Q_{\max} = the maximum flow of record (cfs)

Q_{\min} = the minimum flow of record (cfs)

N_B = the number of bins

The minimum flow (Q_{\min}) was set equal to 0.01 cfs, which represents the lowest non-zero mean daily flow reported at any gage used in the Hawley and Bledsoe (2011) analysis. The number of bins (N_B) was set at 25 to provide a balance between using small enough bin sizes for adequate resolution and ensuring that the flow-record data would be capable of populating each of the bins. The maximum flow of record (Q_{\max}) is equivalent to the maximum mean 24-hour flow and is estimated using the following equation:

$$Q_{\max} = e^{(-2.24) * A^{0.979} * P^{1.79} * Y_r^{0.341}}$$

Where:

A = total drainage area (mi²)

P = average annual precipitation (in)

Yr = the length of the mean daily flow record (30 years)

Q_{\max} is also the scaling factor for the duration density function (DDF), or conditional probability density function, used to predict the cumulative durations of the binned geomorphically-effective flows. A power function is used to represent the duration in days, with the following form:

$$\text{days} = \text{day1} * Q^{\text{day2}}$$

The parameter 'day1' represents the magnitude of the power function calibrated in 'days' and 'cfs' and is estimated using the following relationship:

$$\text{day1} = e^{(-12.9) * A^{0.676} * P^{3.71} * Y_r^{1.85} * e^{(13.8 * \text{Impav})}}$$

Where:

A = total drainage area (mi²)

- P = average annual precipitation (in)
 Yr = the length of the mean daily flow record (30 years)
 Impav = the average spatial extent of the total impervious area expressed as a fraction of the total drainage area (mi²/mi²)

The parameter 'day2' represents the shape of the power function and is calibrated in 'days' and 'cfs' through the following relationship:

$$\text{day2} = -1.60 + 0.166 * \ln(Q_{10}) - 0.138 * \ln(\text{day1}) + 0.129 * \ln(Yr) + 0.720 * \text{Impav}$$

Where:

- Q₁₀ = the instantaneous 10-year peak flow
 Yr = the length of the mean daily flow record (30 years)
 Impav = the average spatial extent of the total impervious area expressed as a fraction of the total drainage area (mi²/mi²)

2.6 Calculate Long-Term Cumulative Durations for Each Flow Bin (B, B_{lwr-log}, B_{upr-log}, Q, days)

Using the bin size estimated above (H_{B-log}), the lower and upper bounds of each logarithmically-spaced bin (B) can be calculated as follows:

$$B_{lwr-log} = e^{\{\ln(Q_{min}) + (B-2) * H_{B-log}\}}$$

$$B_{upr-log} = e^{\{\ln(Q_{min}) + (B-1) * H_{B-log}\}}$$

The average flow within each of the bins was used in the power function to calculate the cumulative duration for the histogram.

$$Q = (B_{lwr-log} + B_{upr-log}) / 2$$

$$\text{days} = \text{day1} * Q^{\text{day2}}$$

3. HYDRAULIC ANALYSIS

3.1 Identify a Range of Typical Receiving Channel Geometry Dimensions

An empirical relationship developed by Coleman et al (2005), modified by Stein (County of San Diego, 2009) was used to express channel dimensions (width, depth,

and, to a lesser extent, gradient) as a function of dominant discharge (Q_{bf} , in cfs). The Stein and Coleman relationship was used because it: (1) produced more consistent and conservative results than the Hey-Thorne (1986) relationship; (2) resulted in Q_{crit} results within the range of values suggested for implementation in the San Diego HMP (0.1 Q_2 , 0.3 Q_2 , 0.5 Q_2); (3) was general in that it did not require an assumption of D50; and (4) is applicable to the most sensitive sand bedded channels, which the Parker (2007) relationship is not. The geometry relationships are as follows:

$$\text{Width (ft)} = 0.6012 * Q_{bf}^{0.6875}$$

$$\text{Depth (ft)} = 0.3854 * Q_{bf}^{0.3652}$$

Q_{bf} , assumed to be approximately the 5-year peak discharge (Q_5), was estimated using the empirical equation from Hawley and Bledsoe (2011) provided in Section 2.4 of this Appendix. This equation calculates Q_5 (cfs) as a function of watershed area (sq. mi.), mean annual precipitation (MAP, in/yr), and percent impervious cover (%) based on empirical observations of USGS gages.

Manning's equation was used to iteratively find the slope for each channel dimension, such that the wetted cross sectional area at bankfull conveys the Q_5 . Manning's equation is expressed as:

$$Q = \frac{1.49AR^{0.67}S^{0.5}}{n}$$

Where:

Q	=	Flowrate (cfs)
A	=	Cross Section Flow Area (ft ²)
R	=	Hydraulic Radius (ft) = A / P
P	=	Wetted Perimeter (ft)
S	=	Energy Gradient Assumed Equal to Longitudinal Slope (ft/ft)
n	=	Manning Roughness (unitless)

The hydraulic analysis assumed a Manning Roughness value (n) of 0.035 for the main channel, corresponding to a non-vegetated, straight channel with no riffles and pools. This reflects the small, ephemeral receiving channels which are prevalent in Southern California. A relatively low 'n' value was used at the request of the San Diego Regional Water Board in the development of the San Diego HMP. A Manning's roughness of

0.07 was used for the over bank floodplain with an assumed side slope of 10 to 1 (Horizontal:Vertical). The overbank parameters were not as sensitive of parameters as longitudinal slope and channel geometry for the purpose of this analysis, therefore a range was not evaluated.

The receiving channel geometry dimensions used for hydraulic analysis of each model scenario are presented in Table D-4.

Table D-4. Receiving Channel Geometry Dimensions

Tributary Area	Mean Annual Precipitation	Longitudinal Slope	Bankfull Width	Bankfull Depth
<i>A</i>	<i>MAP</i>	<i>S</i>	<i>W</i>	<i>D</i>
sq mi	in/yr	%	ft	ft
1	14	0.45	10.6	1.8
2	14	0.30	15.8	2.2
5	14	0.18	26.8	2.9
10	14	0.12	40.0	3.6
20	14	0.08	59.7	4.4
50	14	0.05	101.2	5.9
100	14	0.04	150.8	7.3
1	18	0.40	12.1	1.9
2	18	0.27	18.1	2.4
5	18	0.16	30.7	3.1
10	18	0.11	45.7	3.8
20	18	0.07	68.2	4.8
50	18	0.05	115.6	6.3
100	18	0.03	172.4	7.8

3.2 Calculate Effective Shear Stress and Velocity for Each Flow Bin

The flow velocity was calculated after iterating for the slope to achieve $Q=Q_5$ as:

$$V = Q/A$$

Where:

V = Flow Velocity (ft/s)

Q = Flowrate (cfs)

A = Cross Section Flow Area (ft²)

Average boundary shear stress was calculated as:

$$\tau = \gamma R S$$

Where:

τ = Effective Shear Stress (lb/ft²)

γ = Unit Weight of Water (lb/ft³)

R = Hydraulic Radius (ft)

S = Longitudinal slope (ft/ft)

4. WORK ANALYSIS

4.1 Identify Critical Flowrate (10%Q₂)

The regional default critical flowrate of 10% Q₂, per Appendix E, was used for this analysis. Flow rates below this value were assumed to perform no work on the channel.

4.2 Calculate Work for Each Flow Bin

The simplified effective work equation used is specified in the Ventura County MS4 Permit (LARWQCB, 2010) and is expressed as:

$$W = (\tau - \tau_c)^{1.5} V$$

Where:

W = Work [dimensionless];

τ = Effective Shear Stress [lb/ft²];

τ_c = Critical Shear Stress [lb/ft²];

V = Flow Velocity [ft/s]

If the effective shear stress for a given flow bin is less than the critical shear stress, then the effective work is equal to zero.

5. CUMULATIVE WORK ANALYSIS

Cumulative work is a measure of the long-term total work or sediment transport capacity performed at a creek location. It incorporates the distribution of both discharge magnitude and duration for the full range of flowrates simulated. To calculate cumulative work, first the work and duration associated with each flow bin is multiplied. Then the cumulative work for all flow bins is summed to obtain total work. This analysis can be expressed as:

$$W_t = \sum_{i=1}^n W_i \Delta t_i$$

Where:

W_t	=	Total Work [unitless]
W_i	=	Work per flow bin [unitless]
Δt	=	Duration per flow bin [days]
n	=	number of flow bins

6. EROSION POTENTIAL ANALYSIS

E_p is calculated by simply dividing the total work of the post-project condition by that of the pre-project condition. E_p is expressed as:

$$E_p = W_{t,post} / W_{t,pre}$$

Where:

E_p	=	Erosion Potential [unitless]
$W_{t,post}$	=	Total Work associated with the post-project condition [unitless]
$W_{t,pre}$	=	Total Work associated with the pre-project condition [unitless]

6.1 Iterate % Impervious Cover to Meet the Hydromodification Management Standard ($E_p < 1.05$)

Considering that the Hydromodification Management Standard for Ventura County aims to “maintain the E_p in-stream at a value of 1.0”, it is assumed that an E_p value less than 5% of the target value meets the Management Standard (i.e., an E_p value of 1.04 rounds to 1.0). Additional basis for the use of a +/- 5% allowance on E_p is supported in Section 6.3.7 in the HCP. An iterative process was used to determine the percentage of

impervious cover that meets the hydromodification management standard ($E_p < 1.05$). The percent imperviousness is an input for the DDF power function coefficient and exponent (day1 and day2, respectively) and modifies the duration of flows within each of the logarithmically-spaced flow bin. The new durations (days) for each flow bin are multiplied by the work per flow bin (W_i) and summed across all bins to arrive at a new value for total work associated with the post-project condition ($W_{t,post}$) and Erosion Potential (E_p). Percent impervious cover is subsequently adjusted until an E_p of 1.05 is converged upon.

In preliminary runs it was evaluated that the threshold additional impervious cover associated with E_p equal to 1.05 was not highly sensitive to the baseline pre-development (or existing condition) imperviousness. For example, an increase in imperviousness from 0% to 1% resulted in the same E_p as an increase from 10% to 11%. The resulting thresholds of additional imperviousness from existing (at the time of the HCP effective date) to buildout conditions are provided below in Table D-5 and in Figure 3-12. The results provided used an existing imperviousness of 0%.

Table D-5: Threshold Additional Imperviousness Results

Tributary Area	Mean Annual Precipitation	Threshold Additional Imperviousness	Pre-Project Total Cumulative Work	Post-Project Total Cumulative Work	Erosion Potential
<i>A</i>	<i>MAP</i>	<i>Impav</i>	<i>Wt, pre</i>	<i>Wt, post</i>	<i>Ep</i>
sq mi	in/yr	%	--	--	--
1	14	0.46	1.67	1.75	1.05
2	14	0.50	1.52	1.59	1.05
5	14	0.56	1.45	1.52	1.05
10	14	0.61	1.48	1.55	1.05
20	14	0.68	1.59	1.67	1.05
50	14	0.80	1.89	1.98	1.05
100	14	0.92	2.27	2.39	1.05
1	18	0.48	2.69	2.82	1.05
2	18	0.52	2.44	2.57	1.05
5	18	0.59	2.12	2.23	1.05
10	18	0.65	2.07	2.17	1.05
20	18	0.72	2.12	2.23	1.05
50	18	0.85	2.25	2.36	1.05
100	18	1.00	2.54	2.67	1.05

6.2 Thresholds of Additional Imperviousness Based on Hawley and Bledsoe (2013)

For susceptible channels with a tributary area less than one square mile, the threshold of additional imperviousness below which the risk of hydromodification impacts is considered negligible for that channel is 0.44%. This result is based on equating two of the channel enlargement equations listed in Hawley and Bledsoe (2013) and solving for an E_p of 1.05. The two enlargement functions are:

$$Ar = 1.18 * E_p^{0.998}$$

and

$$Ar = 1.18 * e^{(11.0 * Imp)}$$

Where:

Ar = Enlargement expressed as the relative magnitude

E_p = Sediment-transport capacity load ratio between 25-yr post-developed and pre-developed DDF simulations

Imp = Total impervious area as a fraction of total drainage area

The following equation expresses Imp as a function of E_p :

$$Imp = (0.998/11) * \ln(E_p)$$

Assuming E_p is equal to 1.05, the resulting Imp is 0.44%.

For susceptible channels with a median grain size (D_{50}) greater than 16 mm, a +/- 20% allowance on E_p is supported in Section 6.3.7 in the HCP. Assuming an E_p of 1.20 and using the equation above, the threshold additional imperviousness, below which the risk of hydromodification impacts is considered negligible for that channel, is 1.65%.

7. REFERENCES

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ATTACHMENT B.1.4

**TEXT AND HMP EXEMPTION EXHIBITS EXCERPTED
FROM: "HYDROMODIFICATION EXEMPTION ANALYSES
FOR SELECT CARLSBAD WATERSHEDS," PREPARED BY
CHANG CONSULTANTS, DATED SEPTEMBER 17, 2015**

**HYDROMODIFICATION EXEMPTION
ANALYSES
FOR
SELECT CARLSBAD WATERSHEDS**

September 17, 2015



A handwritten signature in black ink, appearing to read "Wayne W. Chang".

Wayne W. Chang, MS, PE 46548

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EXECUTIVE SUMMARY

In accordance with Order No. R9-2013-0001, issued by the California Regional Water Quality Control Board (Municipal Permit), projects that are subject to Priority Development Project requirements must incorporate: 1) Treatment control best management practices, and 2) Flow-control requirements to address potential hydromodification impacts to downstream natural (non-hardened) channels.

However, certain improved/hardened drainage systems are not impacted by channel erosion. For these cases, the Municipal Permit includes provisions where a local agency may provide exemptions from hydromodification:

Each Copermittee has the discretion to exempt a Priority Development Project from hydromodification management BMP performance requirements of Provisions E.3.c.(2) where the project discharges water runoff to:

- (i) Existing underground storm drains discharging directly to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean.*
- ii) Conveyance channels whose bed and bank are concrete lined all the way from the point of discharge to water storage reservoirs, lakes, enclosed embayments, or the Pacific Ocean;*

Having development/redevelopment projects explore HMP exemption criteria could require an individual project proponent to undertake significant engineering analyses and evaluation of downstream drainage facilities and conditions within a watershed area. Consequently, the City of Carlsbad's Land Development Engineering Division commissioned this hydromodification exemption study.

This report focuses on certain watershed areas tributary to the Agua Hedionda Lagoon, Batiqitos Lagoon, and Buena Vista Lagoon. All three Lagoons are located within the Carlsbad Watershed area and are considered enclosed embayments per the Municipal Permit.

The study limits focus on select areas draining to the lagoons that are highly-developed and are served by improved existing paved streets that collect and convey runoff via reinforced concrete pipes (hardened systems) that are not subject to erosion potential. For each storm drain network discharging to the lagoon, the discharge locations were evaluated to ensure they qualify as a 'direct discharge'. To qualify as a direct discharge, field visits were performed at each outlet location to verify properly sized energy dissipation and, by a review of record drawings, that the discharge locations are below the 100-year flood elevation of the lagoon (consistent with Watershed Management Area Analysis (WMAA) for the San Diego River). Pictures of the outlet locations are at the end of this study.

The HMP Exemption Exhibit in the map pocket at the back of this report includes the limits of the study areas. For those projects located within a hatched area, they are considered exempt from hydromodification requirements either under current conditions or with some future

improvements. In accordance with the Municipal Permit, projects that are exempt from hydromodification must still satisfy all other applicable storm water standards (i.e.: site design, source control measures, treatment control best management practices, low impact development, etc.).

Although several watershed areas were evaluated, not all drainage areas qualified for exemption from hydromodification requirements. These reasons why they did not qualify will be explained further in the study and are, therefore, not included as exempt areas in the HMP Exemption Exhibit.

INTRODUCTION

In accordance with the Municipal Permit, development and redevelopment projects are subject to either: 1) Standard Stormwater or 2) Priority Development Project (PDP) requirements, which are more rigorous. The City's "Storm Water Standards Questionnaire E-34" (see Figure 11) is used to determine whether a project must meet Standard Stormwater or PDP requirements. The questionnaire, using criteria from the Municipal Permit, provides specific thresholds under which these new development/redevelopment projects trigger PDP requirements.

Among other things, projects subject to PDP requirements must include treatment control best management practices (BMPs) and are required to incorporate hydromodification BMPs. Hydromodification provides requirements to control post-development storm water runoff rates, velocities, and durations in order to maintain or reduce pre-development downstream erosion, sediment pollutant generation, and protect beneficial uses and stream habitat.

For this study, a focus was made to look at the three lagoons within the city (Buena Vista, Agua Hedionda, and Batiquitos Lagoon) and explore applicable HMP exemptions. This study assesses the lagoons and seven (7) major drainage areas contributing to the lagoons to determine whether they meet hydromodification exemption criteria. The seven major drainage areas are tributary to one of the seven following storm drain outlets into Buena Vista, Agua Hedionda, or Batiquitos Lagoon (see the Study Area Exhibits and HMP Exemption Exhibit in the map pocket):

Buena Vista Lagoon

- 48" and 66" outlets on the east side of Carlsbad Boulevard into the south side of the lagoon
- 48" outlet on the west side of Interstate 5 into the south side of the lagoon
- 66" outlet on the west side of Jefferson Street into the south side of the lagoon

Agua Hedionda Lagoon

- 18" outlet on the west end of Date Avenue into the north side of the lagoon
- 84" outlet on the east side of the railroad tracks into the north side of the lagoon
- 60" outlet near the south end of Marina Drive into the north side of the lagoon

Batiquitos Lagoon

- 84" outlet on the east side of Carlsbad Boulevard into the north side of the lagoon

With the exception of one area, the studied tributary areas do not include natural (non-hardened) channels directly to a lagoon. Each of these major drainage areas is served by a network of improved (hardened) public drainage facilities that outlet into a lagoon. The majority of the public facilities are underground storm drain systems or paved streets. Some facilities are also lined (concrete, gunite, etc.) drainage ditches or swales. Provided runoff from the study area discharges into a non-erodible drainage network that is continuous with a direct discharge to a lagoon, it is potentially eligible for a hydromodification exemption. Based on record drawing research and field reconnaissance, the Study Area Exhibits identify the improved (hardened) drainage networks. The exhibits demonstrate that each major drainage area, except the 48" outlet

towards Buena Vista Lagoon on the west side of Interstate 5, contains a continuously improved non-erodible network that serves the drainage area; therefore MS4's draining directly into the lagoons are not subject to potential impacts from hydromodification. The discharge points must be below the 100-year water surface elevations in the lagoon (consistent with Watershed Management Area Analysis (WMAA) for the San Diego River).

Areas Draining to Buena Vista Lagoon

Using rational method analyses from the 2003 County *Hydrology Manual* and as-built (record drawing) research, the existing storm drain network collecting run-off for all of the Buena Vista Lagoon drainage areas (Major Drainage Basins 100, 200, and 300 as shown on the Study Area Exhibits) analyzed in this report have been shown to be adequate to convey the Q_{10} runoff, which is the upper range for hydromodification as described the Municipal Permit. Each outlet structure was observed to ensure they include adequate energy dissipation to address erosion potential. For details of how these each of these criteria were satisfied, refer to the Appendices of this study. The select areas draining to the Buena Vista Lagoon from Major Drainage Basins 100 and 300, which are determined to be exempt from HMP are shown in the HMP Exemption Exhibit.

Although Major Drainage Basin 200 includes an improved non-erosive (hardened) storm drain system, the existing 48" outlet is not directly adjacent to the waters edge of Buena Vista Lagoon; therefore, does not qualify as a direct discharge to an exempt water body. In order for Major Drainage Basin 200 to qualify for an exemption a non-erodible drainage facility capable of conveying at least the 10-year flow will need to be constructed from the existing 48" outlet to the 100-year floodplain in the receiving lagoon.

Areas Draining to Agua Hedionda Lagoon and Batiquitos Lagoon

Certain drainage areas that drain to these lagoons were selected (Major Drainage Basin 400, 500, 600, and 700 as shown on the Study Area Exhibits). The existing storm drain network for each drainage area was also evaluated against their ability to carry the Q_{10} . As provided in the Technical Appendices, the storm drain system for each drainage areas has the capacity to carry the Q_{10} . The outlet for each storm drain system was also observed to ensure they include adequate energy dissipation to address erosion potential. For details of how these each of these criteria were satisfied, refer to the Appendices of this study. Based on these findings, the select areas draining to Agua Hedionda Lagoon and Batiquitos Lagoon are shall be considered exempt from HMP. These exempt areas are shown in the HMP Exemption Exhibit.

There are two isolated areas within Major Drainage Basin 600 that direct storm runoff over the natural ground surface west of the railroad tracks. Without further analysis using erosion potential (or equivalent), the naturally-lined swales are not considered exempt from hydromodification. Therefore, these areas were excluded from the exemption area in HMP Exemption Exhibit and from further analysis.

OUTLET CONDITIONS

Since the storm drain networks considered in this report are continuously non-erodible to one of the three lagoons (except from Major Drainage Basin 200 and a portion of 600), the energy dissipation to be studied are at the lagoon outlets. As-built drawings were reviewed and a site visit was performed to determine the conditions at each outlet. The following describes the findings for each outlet. In addition, the Lagoon Assessment section contained next in this report confirms that each outlet is below the 100-year water surface elevation. This effort confirms the storm drain network (MS4's) qualifies as a 'direct discharge' to an exempt water body.

Buena Vista Lagoon 48" and 66" Outlets

These are adjacent reinforced concrete pipe outlets that discharge into the south edge of Buena Vista Lagoon immediately east of the merge of State Street and Carlsbad Boulevard. During the site visit, the lagoon water level was at the invert of the 48" outlet and just above the invert of the 66" outlet (see Figure 1 after this report text). Riprap energy dissipation was not observed below the outlets nor was there evidence of erosion below the outlets (see Figure 2).

Drawing No. 215-9 shows that the invert elevation of the 66" reinforced concrete pipe outlet is at 6.0 feet NGVD 29 (the reference drawings are included on the compact disc in the map pocket). The 48" outlet is shown on Drawing 153-9, but the plan does not identify the vertical datum. Based on the site visit, the 48" outlet invert is approximately 6 inches higher than the 66" outlet invert. Buena Vista Lagoon contains a weir structure near the Pacific Ocean that controls the water surface in the lagoon. A field survey by Algert Engineering revealed that the top of the weir structure is at 7.6 feet NAVD 88 or 5.5 feet NGVD 29. Therefore, the water level in the lagoon will be within at least 6 to 12 inches of the outlets. During most periods, the water level should be higher than 5.5 feet due to natural sand build-up above the weir crest caused by littoral processes as well as backwater in the lagoon. Since ponded water is an effective energy dissipater, the 48" and 66" outlets contain proper energy dissipation. This is further evidenced by the absence of erosion below the outlets even though they have been in place since at least the mid-1980's.

Buena Vista Lagoon 48" Outlet

This 48" reinforced concrete pipe is a Caltrans facility whose outlet discharges towards, but not directly into, the south edge of Buena Vista Lagoon immediately west of Interstate 5. The as-built plans (Document No. 40002483) show that the outlet is at elevation 22.0 feet and was designed with "rock slope protection." During the site visit, riprap was observed below the 48" outlet (see Figure 3). The typical riprap diameter was over 12 inches, which is consistent with the sizing proposed on the design plans. Tall grasses obscured some of the riprap, but the grass indicates that the energy dissipation is effective. However, since this outlet is not a 'direct' discharge to the lagoon (see Lagoon Assessment section), no further analysis is provided.

Buena Vista Lagoon 66" Outlet

This 66" reinforced concrete pipe discharges into the south edge of Buena Vista Lagoon immediately west of Jefferson Street. The as-built plans (Drawing No. 182-10) show that the outlet invert is at elevation 5.3 feet NGVD 29 and contains ¼-ton riprap. The outlet invert was just below the lagoon water level (see Figure 4) during the site visit, which is consistent with the

weir-controlled lagoon water level. Riprap was not observed at the outlet during the site visit due to the difficulty in accessing the outlet through the dense vegetation. However, the fact that the water level will be at or above the outlet invert indicates that this outlet has appropriate energy dissipation.

Agua Hedionda Lagoon 18" Outlet

This 18" corrugated metal pipe discharges onto a riprap-lined revetment protecting the northeast bank of Agua Hedionda Lagoon immediately west of the intersection of Date Avenue with Garfield Street (see Figure 5). Storm runoff flows a short distance down the revetment and into the lagoon. As-built plans (Drawing No. 133-3) show that the outlet invert is at elevation 5.36 feet and that energy dissipation has been designed below the outlet. In addition, the tributary drainage area covers approximately 5.2 acres, so the pipe flows will be relatively small.

Agua Hedionda Lagoon 84" Outlet

This 84" reinforced concrete pipe discharges into the north edge of Agua Hedionda Lagoon just east of the railroad tracks. The engineering plans (Drawing No. 360-5) were as-built in 2006, so this is a relatively recent system. The plans show that the storm drain system and its grouted riprap energy dissipater were designed for the 100-year storm flow in accordance with current engineering criteria. A site visit confirmed that the grouted riprap energy dissipater exists and is in substantial conformance with the plans (see Figure 6).

Agua Hedionda Lagoon 60" Outlet

This 60" reinforced concrete pipe discharges directly into the north edge of Agua Hedionda Lagoon just west of Marina Drive. The as-built plans (Drawing No. 152-3) show that the outlet invert elevation is -1.75 feet NGVD 29. This elevation is lower than mean sea level, so the lagoon water level will serve as appropriate energy dissipation for the outflow. A site visit confirmed that the invert is lower than the lagoon water level (see Figure 8).

Batiquitos Lagoon 84" Outlet

This 84" reinforced concrete pipe discharges into the north edge of Batiquitos Lagoon just east of Carlsbad Boulevard and west of the railroad tracks. The as-built drawings (Drawing No. 337-9) show that the storm drain system and its energy dissipater (1-ton riprap and concrete sill) were designed for the 100-year storm flow in accordance with current engineering criteria. A site visit confirmed that the energy dissipater exists in substantial conformance with the plans (see Figure 9).

Summary

For those outlets that qualify as direct discharges, the above information confirms that proper energy dissipation currently exists at each of the storm drain outlet locations for the drainage areas. The dissipation is provided by either riprap or the water level in a lagoon.

DISCHARGE TO LAGOONS

The October 3, 2014, *San Diego River Watershed Management Area Analysis*, states that “to qualify for the potential [hydromodification] exemption, the outlet elevation must be between the river bottom elevation and the 100-year floodplain elevation and properly designed energy dissipation must be provided.” Proper energy dissipation was verified in the prior section. This section discusses the 100-year floodplain elevations. Research was performed to determine the 100-year water surface elevations in each of the three lagoons. FEMA provides 100-year floodplain information for many waterbodies. FEMA defines a 100-year floodplain for the lagoons, but does not provide the necessary water surface elevations. However, Dokken Engineering (Dokken) performed detailed HEC-RAS hydraulic analyses of each lagoon as part of their December 2008, *Interstate 5 North Coast Floodplain Studies*, for Caltrans. Relevant excerpts from the Dokken studies are included in the Appendices. Table 1 summarizes the outlet elevations of each discharge point from the as-built drawings (discussed in the prior section) and the associated 100-year floodplain elevation from the Dokken studies. The as-built drawings are either identified as being on NGVD 29 datum or were prepared prior to 1988, so by default should be on NGVD 29. On the other hand, the Dokken studies are on NAVD 88 datum. Corpcon is provided by the US Army Corps of Engineers for coordinate conversions, and shows that 2.2 feet is added to the NGVD 29 elevations to convert to NAVD 88 elevations.

Major Drainage Basin	Description	Outlet Elevation, feet ¹	Lagoon 100-Year Water Surface Elevation, feet ²
100	Buena Vista Lagoon 48” and 66” Outlets	6.00	13.93
200	Buena Vista Lagoon 48” Outlet	22.00	13.89
300	Buena Vista Lagoon 66” Outlet	5.30	15.75
400	Agua Hedionda Lagoon 60” Outlet	-1.75	12.33
500	Agua Hedionda Lagoon 18” Outlet	5.36	11.68
600	Agua Hedionda Lagoon 84” Outlet	7.95	12.21
700	Batiquitos Lagoon 84” Outlet	6.27	8.90

¹Elevations are on NGVD 29 (add 2.2 feet to convert to NAVD 88)

²Elevations are on NAVD 88

Table 1. Summary of Storm Drain Outlet Elevations and Lagoon Elevations

Table 1 shows that all of the storm drain outlets (with the conversion applied) except at Major Drainage Basin 200 are below the 100-year water surface elevation in the associated lagoon. Therefore, the hydromodification exemption requirement to have the outlet elevation below the 100-year floodplain elevation is met except at Major Drainage Basin 200.

Summary

The four drainage areas (Major Drainage Basins 400, 500, 600, 700) tributary to the Agua Hedionda Lagoon and Batiquitos Lagoon are served by an improved (non-erosive) street and underground storm drains system and have capacity to convey the 10-year rain event condition. The storm drain outlets for these drainage areas to the lagoon are considered direct discharges. Therefore, these areas are considered exempt from hydromodification.

The easterly and westerly drainage areas (Major Drainage Basins 100 and 300) tributary to and outletting directly into Buena Vista Lagoon are served by an improved (non-erosive) street and underground storm drains system and have capacity to convey the 10-year rain event condition. The storm drain outlets for these drainage areas to the lagoon are considered direct discharges. Therefore, these areas are also considered exempt from hydromodification.

The westerly drainage areas (Major Drainage Basin 200) tributary to and outletting adjacent to the Buena Vista Lagoon west of Interstate 15 is served by an improved (non-erosive) street and underground storm drains system and have capacity to convey the 10-year rain event condition. However, this outlet is not considered a direct discharge. In order to create a direct discharge, drainage improvements will need to be constructed that are capable of conveying the 10-year flow to the lagoon. The new outlet must have proper energy dissipation and extend below the 100-year water surface elevation. If such improvements are constructed in the future, this area can be considered as exempt from hydromodification.

HYDROLOGIC AND HYDRAULIC ANALYSES

As mentioned in the Introduction, hydromodification applies to flows up to the 10-year event. Consequently, the drainage network (storm drain pipes, streets, etc.) within each major drainage area are required to convey the 10-year flow in order to qualify for an exemption. All of the available as-built plans for the public storm drain systems in the seven major drainage areas were obtained and reviewed. Several of the more recent as-built plans list 10- or 100-year flow rates in the pipes and/or hydraulic grade lines on the storm drain profiles. These systems have been identified on the Study Area Exhibits and further analyses were not required since the systems have been designed to convey the 10-year or greater flow rates. Therefore, development within these areas is exempt from HMP.

Hydrologic and hydraulic analyses have been performed for the remaining systems whose plans do not contain the flow or hydraulic grade line data. The hydrologic analyses were performed to determine the ultimate condition 10-year flow rates. The County of San Diego's 2003 *Hydrology Manual* rational method procedure was used for the 10-year hydrologic analyses. The rational method input parameters are summarized below and the supporting data is included in Appendix B:

- **Precipitation:** The 10-year, 6- and 24-hour precipitation values are 1.7 and 3.1 inches, respectively, for the drainage areas tributary to Buena Vista and Agua Hedionda Lagoon. The 10-year, 6- and 24-hour precipitation values are 1.7 and 2.9 inches, respectively, for the drainage areas tributary to Batiquitos Lagoon.
- **Drainage subbasin:** The drainage subbasins were delineated from the City's 2005 2-foot contour interval topographic mapping, the City's GIS storm drain network, available as-built plans, and a site investigation. See the Study Area Exhibits in the map pocket for the major and subbasin boundaries, rational method node numbers, and subbasin areas.
- **Hydrologic soil groups:** The hydrologic soil groups were determined from the *San Diego County Soils Interpretation Study* maps for Encinitas and Rancho Santa Fe. The soil group in the study area is primarily A with some pockets of C and D.
- **Runoff coefficients:** The runoff coefficients were assigned based on the underlying land uses and soil groups. The land uses range from undisturbed areas to commercial/industrial development. The land uses were determined from a 2009 aerial photograph from the City and 2010 Google Earth aerials as well as a site investigation. For undeveloped areas that could be subject to development, a developed condition was assumed. Therefore, the hydrologic analyses essentially model a fully built-out condition. This approach is similar to what would be done for a storm water master plan.
- **Flow lengths and elevations:** The flow lengths and elevations were obtained from the topographic mapping and engineering plans.

The 10-year rational method analyses were performed using CivilDesign's San Diego County Rational Hydrology Program and the results are included in Appendix B. Separate analyses were performed for the major drainage areas and are labeled as follows:

Buena Vista Lagoon

- Major Basin 100 is tributary to the 48" and 66" outlet on the east side of Carlsbad Boulevard
- Major Basin 200 is tributary to the 48" outlet on the west side of Interstate 5
- Major Basin 300 is tributary to the 66" outlet on the west side of Jefferson Street

Agua Hedionda Lagoon

- Major Basin 400 is tributary to the 60" outlet at the south end of Marina Drive
- Major Basin 500 is tributary to the 18" outlet at the west end of Date Avenue
- Analyses were not performed for the 84" outlet on the east side of the railroad tracks because flow rates and hydraulic grade lines were provided on the majority of the as-built plans.

Batiquitos Lagoon

- Analyses were not performed for the 84" outlet on the east side of Carlsbad Boulevard because flow rates and hydraulic grade lines were provided on the majority of the as-built plans.

The CivilDesign rational method analyses include pipeflow routines for modeling flow in circular pipes. The upstream and downstream invert elevations and pipe length are entered in the model for each storm drain segment. The program then determines the required normal depth pipe size based on the calculated 10-year flow rate, longitudinal slope, and roughness coefficient. The pipeflow routines were used to assess the adequacy of the existing pipes. Invert elevations were selected so that the longitudinal slope from the as-built plans was accurately modeled in the analyses. The longitudinal slope of each storm drain segment was determined from a review of all relevant as-built plans. Some storm drain segments contain varying or multiple slopes. In this case, the flattest slope was used because it will result in the most conservative sizing. A few segments were missing elevations on the as-built plans. For these segments, the average street slope was used. The pipe size from the hydraulic analyses were then compared to the size from the as-built plans to identify pipes with adequate capacity and those with deficiencies.

Since the rational method program determines the minimum required pipe size to convey the 10-year flow in each specific segment, it is possible that program will show the required size increasing or decreasing in adjacent segments of the overall storm drain system. For instance, if the same flow rate is conveyed in two adjacent segments, but the downstream segment has a steeper longitudinal slope, the results can show that the downstream pipe is smaller. Engineering design criteria typically does not allow subsequent segments in a storm drain system to be smaller. However, since the rational method results are merely used as a comparison with the sizes from the as-built plans, any usual telescoping effects are not relevant.

The pipes have been categorized based on their capacity and identified on the Study Area Exhibits per their category. The first category represents pipes in which the as-built plans contain flow rate or hydraulic grade line information indicating that the pipes can convey the 10-year runoff. As mentioned above, analyses were not specifically performed for these systems since detailed information is contained on the as-built plans. The second category represents pipes in which the rational method analyses show that the existing size can convey the 10-year flow rate. The third category represents pipes in which the rational method analyses show that the existing pipes need to be upsized by at most one pipe size (6 inches) to convey the 10-year flow. The fourth category represents pipes in which the rational method analyses show that the existing pipes need to be upsized by more than one pipe size to convey the 10-year flow.

The first and second categories represent no major deficiencies in capacity. The third category indicates that the existing pipe is slightly undersized. However, if pressure flow and street capacity are considered, these systems will be capable of conveying the 10-year flows since the additional flow associated with an at most 6 inch increase in pipe size can be conveyed under pressure or within the adjacent street. This was confirmed by comparing the 10-year flow rates with a street flow capacity chart. For a given pipe segment, the street flow capacity chart indicated that the associated street can convey the required flow. Therefore, the drainage systems within the first three categories have capacity for the 10-year flow.

Existing pipes under the fourth category require additional review to determine whether the 10-year flow can be conveyed. Additional review resulted in the following assessment of the storm drain systems within the fourth category.

Major Basin 100

There are four storm drain segments in Major Basin 100 that fall within the fourth category. The segments are between rational method nodes 105 to 109, 135 to 136, 137 to 138, and 138 to 141. The following assesses the pipe and street capacity of each of these four segments.

The existing pipe from nodes 105 to 109 has an 18" diameter with a normal depth capacity of approximately 10 cubic feet per second (cfs). However, the rational method results show that the 10-year flow rate is 37 cfs, and the pipe size needed to convey 37 cfs varies from 30" to 33". The corridor along the street between these nodes has capacity for the additional 27 cfs ($37 - 10 = 27$ cfs) needed beyond the pipe capacity. Therefore, the combined pipe and street in this area can convey the 10-year flow.

A similar assessment is made for the other three segments. The existing pipe from nodes 135 to 136 is a 24" reinforced concrete pipe (RCP), while the analyses show that a 33" RCP is needed. The existing pipe from nodes 137 to 138 is a 36" RCP while the analyses show that a 45" RCP is needed. The existing pipe from nodes 138 to 141 is a 12" RCP while the analyses show that a 30" RCP is needed. For each of these deficient segments, the associated streets can handle the additional capacity needs. In addition, the adjacent upstream and downstream pipe segments are not deficient. Therefore, the overall drainage systems along these nodes can convey the 10-year flow.

Major Basin 300

There are two storm drain segments in Major Basin 300 that fall within the fourth category. The segments are between rational method nodes 309 to 316 and nodes 340 to 343. The existing pipes from nodes 309 to 316 are 24" RCPs, while the required pipe varies from 36" to 39". The existing pipes from nodes 340 to 343 are 66" RCPs, while the required size varies from 78" to 81". For both of these areas, the associated streets can handle the additional capacity needs, so these areas can convey the 10-year flow.

Major Basin 400

There are two storm drain segments in Major Basin 400 that fall within the fourth category. The segments are between rational method nodes 408 to 409 and 418 to 420. The existing pipe between nodes 408 and 409 is an 18" RCP, while a 30" RCP is needed. This pipe crosses a sump in the street. The excess stormwater will pond in the street until it drains through the 18" RCP. Therefore, the 10-year flow will be detained in this area. In addition, there are no natural streams in the vicinity that would be subject to HMP requirements.

The existing pipe between nodes 418 and 420 is a 60" RCP that outlets into Agua Hedionda Lagoon, while the analyses show that a 72" RCP is required. However, a 60" bypass structure near the upper end of this segment can divert a portion of the runoff to a second outlet that discharges to a cove connecting to Agua Hedionda Lagoon. The as-built plans (Drawing No. 152-3) show that the bypass is controlled by stop logs. If the bypass is open, then the pipe capacity below the bypass will be sufficient for the 10-year flow. The City of Carlsbad's Utilities Operations staff has a "Weir Wall Removal Procedure," so the stop logs will be removed during high flow events to ensure 10-year flow capacity. Therefore, this area conveys the 10-year runoff to Agua Hedionda Lagoon.

CONCLUSION

The City of Carlsbad's final HMP outlines conditions under which a Priority Development Project can be exempt from hydromodification requirements. The purpose of this study is to explore HMP exemptions based on the January 2011 Carlsbad SUSMP and Order No. R9-2013-0001 adopted by the Regional Water Quality Control Board. In particular, this study examines the criteria necessary for HMP exemptions for 1) enclosed embayments (lagoons) and 2) stabilized conveyances to exempt systems.

These analyses have been performed for seven major drainage areas selected by the City of Carlsbad and are summarized below based on the two primary criteria that were investigated. Additional criteria must be met in addition to the primary criteria to achieve an exemption. The additional criteria is also summarized below.

Stabilized Conveyances with Energy Dissipation

The hydrologic and hydraulic analyses show that the 10-year flow is conveyed by the underground storm drain alone in most areas, and the combination of the underground storm drain and improved public streets in the remaining areas. In addition, each storm drain outlet into

a lagoon has proper energy dissipation. Therefore, each study area contains an underground storm drain or conveyance channel that discharges directly to an enclosed conveyance.

Lagoon Floodplains

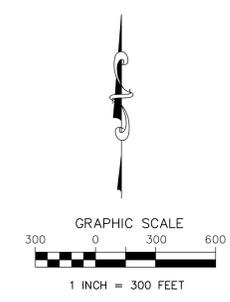
A comparison of as-built drawings with a recent detailed HEC-RAS analysis of each lagoon confirmed that each outlet is below the 100-year floodplain except in Major Drainage Basin 200. Each outlet is also at or above the associated lagoon floor. Therefore, each outlet except in Major Drainage Basin 200 meets the floodplain criteria for a hydromodification exemption. Major Drainage Basin 200 can meet the criteria if its non-erodible drainage system is extended to the lagoon.

Future Projects

Based on the findings in this report, future projects within one of the studied drainage areas (except Major Drainage Basin 200) qualify for an exemption if their storm runoff is directed to a public drainage facility included in this report without being conveyed over a natural drainage course.

However, future projects in certain locations within the study area will be required to perform additional analyses prior to receiving a hydromodification exemption. These exceptions are outlined below.

The major drainage area tributary to the 84" outlet into Agua Hedionda Lagoon is bisected along its westerly side by the existing railroad tracks. Storm runoff from two areas west of the tracks will be directed to naturally-lined swales near the tracks. Since naturally-lined swales prevent a hydromodification exemption, development west of the tracks may need to replace a natural swale with a non-erodible conveyance. It will be the responsibility for a future development project west of the tracks to assess this situation in detail and propose a solution, as needed. The HMP Exemption Exhibit delineates the two non-exempt areas for reference. Hydrologic analyses have not been performed for these two areas.



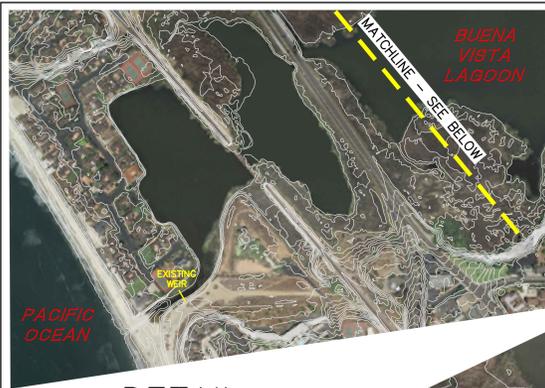
- LEGEND:**
- MAJOR DRAINAGE BASIN BOUNDARY
 - - - MINOR DRAINAGE BASIN BOUNDARY (SUBBASIN)
 - OVERLAND FLOW PATH
 - 3.62 AC DRAINAGE BASIN AREA
 - 10 RATIONAL METHOD NODE NUMBER
 - EXISTING CATCH BASIN OR INLET
 - - - EXISTING DRAINAGE DITCH OR SWALE
 - MINOR EXISTING STORM DRAIN PIPE OR LATERAL
 - AS-BUILT PLANS SHOWING 10-YEAR OR HIGHER FLOW CONTAINED IN EXISTING PIPE
 - NORMAL DEPTH ANALYSIS SHOWING 10-YEAR FLOW CONTAINED IN EXISTING PIPE
 - NORMAL DEPTH ANALYSIS SHOWING EXISTING PIPE INCREASED BY ONE PIPE SIZE (6") TO CONTAIN 10-YEAR FLOW (SEE TABLE FOR DETAILS)
 - NORMAL DEPTH ANALYSIS SHOWING EXISTING PIPE INCREASED BY MORE THAN ONE PIPE SIZE TO CONTAIN 10-YEAR FLOW (SEE TABLE FOR DETAILS)
 - STORM DRAIN DISCHARGES INTO NATURAL CHANNEL SO PROPOSED DEVELOPMENT WITHIN DRAINAGE AREA MUST PROVIDE PROJECT-SPECIFIC ASSESSMENT TO DETERMINE IF AN EXEMPTION IS POSSIBLE.
 - OUTLET INTO LAGOON
 - (A) PIPE SEGMENT IDENTIFIER (SEE TABLE FOR DETAILS)

PIPE SEGMENT	AS-BUILT DRAWING NO.	EXISTING FACILITY AND MINIMUM SLOPE	10-YEAR FLOW, CFS	10-YEAR FLOW CONTAINED IN PIPE UNDER PRESSURE	EXCESS 10-YEAR FLOW CONTAINED IN STREET	EXCESS 10-YEAR FLOW ENTERS ADJACENT LAGOON
A	287-2	18" RCP AT 0.5%	13	Y		
B	220-8	18" RCP (UNKNOWN SLOPE)	37		Y	
C	462-6	18" RCP AT 0.5%	13	Y		
D	137-3A	12" RCP AT 0.24%	18		Y	
E	133-9	36" RCP AT 0.76%	91		Y	
F	146-8	24" RCP AT 0.43%	57	Y		
G	CALTRANS CONTRACT 11-039724	30" RCP (UNKNOWN SLOPE)	32	Y		
H	182-10, 304-2	66" RCP AT 0.28%	293	Y	Y	
I	166-8, 189-6, 206-2	36" RCP AT 1.00% TO 48" RCP AT 2.27%	116 TO 265	Y		
J	141-3	24" RCP AT 1.03% TO 27" RCP AT 2.30%	56 TO 104	Y	Y	
K	146-3	18" RCP AT 1.52%	19	Y		
L	125-4	18" RCP AT 1.23%	16	Y		
M	158-6	18" RCP AT 1.00%	34		Y	
N	158-6	24" RCP AT 1.00%	39	Y		
O	167-4	24" RCP AT 2.00%	39	Y		
P	167-4	21" RCP AT 10.00% TO 24" RCP AT 2.00%	36	Y		
Q	167-5	42" RCP AT 1.00%	117	Y		
R	152-3	60" RCP AT 0.4%	263			Y

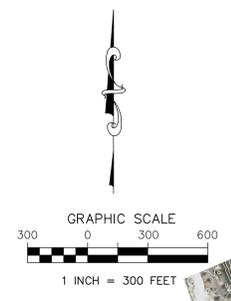
NOTE:
 THE STORM DRAIN SEGMENTS IN THIS TABLE ARE ONES IN WHICH THE HYDRAULIC ANALYSES SHOW INSUFFICIENT NORMAL DEPTH CAPACITY TO CONVEY THE 10-YEAR FLOW (YELLOW AND RED LINES ON THE LEGEND). THIS TABLE INDICATES IF THE SEGMENTS HAVE CAPACITY TO CONVEY THE 10-YEAR FLOW UNDER PRESSURE. FOR SYSTEMS THAT CANNOT CONVEY THE 10-YEAR FLOW UNDER PRESSURE, THE TABLE INDICATES IF THE EXCESS FLOW CAN BE CONVEYED BY THE STREET OR WILL DIRECTLY ENTER AN ADJACENT LAGOON. ALL OF THE SEGMENTS MEET ONE OF THESE CRITERIA AND, HENCE, SATISFIES THE HYDROMODIFICATION EXEMPTION REQUIREMENT FOR CONVEYING THE 10-YEAR FLOW.
 THE DRAINAGE AREAS ENCOMPASSING SEGMENTS A THROUGH L ARE ON STUDY AREA EXHIBIT SHEET 2. THE DRAINAGE AREAS ENCOMPASSING SEGMENTS M THROUGH R ARE ON STUDY AREA EXHIBIT SHEET 1.

STUDY AREA EXHIBIT HYDROMODIFICATION EXEMPTION

AGUA HEDIONDA CREEK
 DRAINAGE AREAS



DETAIL



BUENA VISTA CREEK DRAINAGE AREAS

PIPE SEGMENT	AS-BUILT DRAWING NO.	EXISTING FACILITY AND MINIMUM SLOPE	10-YEAR FLOW, CFS	10-YEAR FLOW CONTAINED IN PIPE UNDER PRESSURE	EXCESS 10-YEAR FLOW CONTAINED IN STREET	EXCESS 10-YEAR FLOW ENTERS ADJACENT LAGOON
A	287-2	18" RCP AT 0.5%	13	Y		
B	220-8	18" RCP (UNKNOWN SLOPE)	37		Y	
C	462-6	18" RCP AT 0.5%	13	Y		
D	137-3A	12" RCP AT 0.24%	18		Y	
E	133-9	36" RCP AT 0.76%	91		Y	
F	146-8	24" RCP AT 0.43%	37	Y		
G	CALTRANS CONTRACT 11-039724	30" RCP (UNKNOWN SLOPE)	32		Y	
H	182-10, 304-2	66" RCP AT 0.28%	293		Y	
I	166-8, 189-6, 206-2	36" RCP AT 1.60% TO 48" RCP AT 2.27%	116 TO 265	Y		
J	141-3	24" RCP AT 1.03% TO 27" RCP AT 2.30%	56 TO 104	Y	Y	
K	146-3	18" RCP AT 1.52%	19	Y		
L	125-4	18" RCP AT 1.23%	16	Y		
M	158-6	18" RCP AT 1.00%	34		Y	
N	158-6	24" RCP AT 1.00%	39	Y		
O	167-4	24" RCP AT 2.00%	39	Y		
P	167-4	21" RCP AT 10.00% TO 24" RCP AT 2.00%	36	Y	Y	
Q	167-5	42" RCP AT 1.00%	117	Y		
R	152-3	60" RCP AT 0.4%	263			Y

NOTE:
THE STORM DRAIN SEGMENTS IN THIS TABLE ARE ONES IN WHICH THE HYDRAULIC ANALYSES SHOW INSUFFICIENT NORMAL DEPTH CAPACITY TO CONVEY THE 10-YEAR FLOW (YELLOW AND RED LINES ON THE LEGEND). THIS TABLE INDICATES IF THE SEGMENTS HAVE CAPACITY TO CONVEY THE 10-YEAR FLOW UNDER PRESSURE. FOR SYSTEMS THAT CANNOT CONVEY THE 10-YEAR FLOW UNDER PRESSURE, THE TABLE INDICATES IF THE EXCESS FLOW CAN BE CONVEYED IN THE STREET OR WILL DIRECTLY ENTER AN ADJACENT LAGOON. ALL OF THE SEGMENTS MEET ONE OF THESE CRITERIA AND, HENCE, SATISFIES THE HYDROMODIFICATION EXEMPTION REQUIREMENT FOR CONVEYING THE 10-YEAR FLOW.

THE DRAINAGE AREAS ENCOMPASSING SEGMENTS A THROUGH L ARE ON STUDY AREA EXHIBIT SHEET 2. THE DRAINAGE AREAS ENCOMPASSING SEGMENTS M THROUGH R ARE ON STUDY AREA EXHIBIT SHEET 1.

- LEGEND:
- MAJOR DRAINAGE BASIN BOUNDARY
 - - - MINOR DRAINAGE BASIN BOUNDARY (SUBBASIN)
 - OVERLAND FLOW PATH
 - 3.62 AC DRAINAGE BASIN AREA
 - [10] RATIONAL METHOD NODE NUMBER
 - EXISTING CATCH BASIN OR INLET
 - - - EXISTING DRAINAGE DITCH OR SWALE
 - MINOR EXISTING STORM DRAIN PIPE OR LATERAL
 - AS-BUILT PLANS SHOWING 10-YEAR OR HIGHER FLOW CONTAINED IN EXISTING PIPE
 - NORMAL DEPTH ANALYSIS SHOWING 10-YEAR FLOW CONTAINED IN EXISTING PIPE
 - NORMAL DEPTH ANALYSIS SHOWING EXISTING PIPE INCREASED BY ONE PIPE SIZE (6") TO CONTAIN 10-YEAR FLOW (SEE TABLE FOR DETAILS)
 - NORMAL DEPTH ANALYSIS SHOWING EXISTING PIPE INCREASED BY MORE THAN ONE PIPE SIZE TO CONTAIN 10-YEAR FLOW (SEE TABLE FOR DETAILS)
 - OUTLET INTO LAGOON
 - ⓐ PIPE SEGMENT (SEE TABLE FOR DETAILS)

STUDY AREA EXHIBIT
HYDROMODIFICATION EXEMPTION

BATIQUITOS CREEK DRAINAGE AREAS



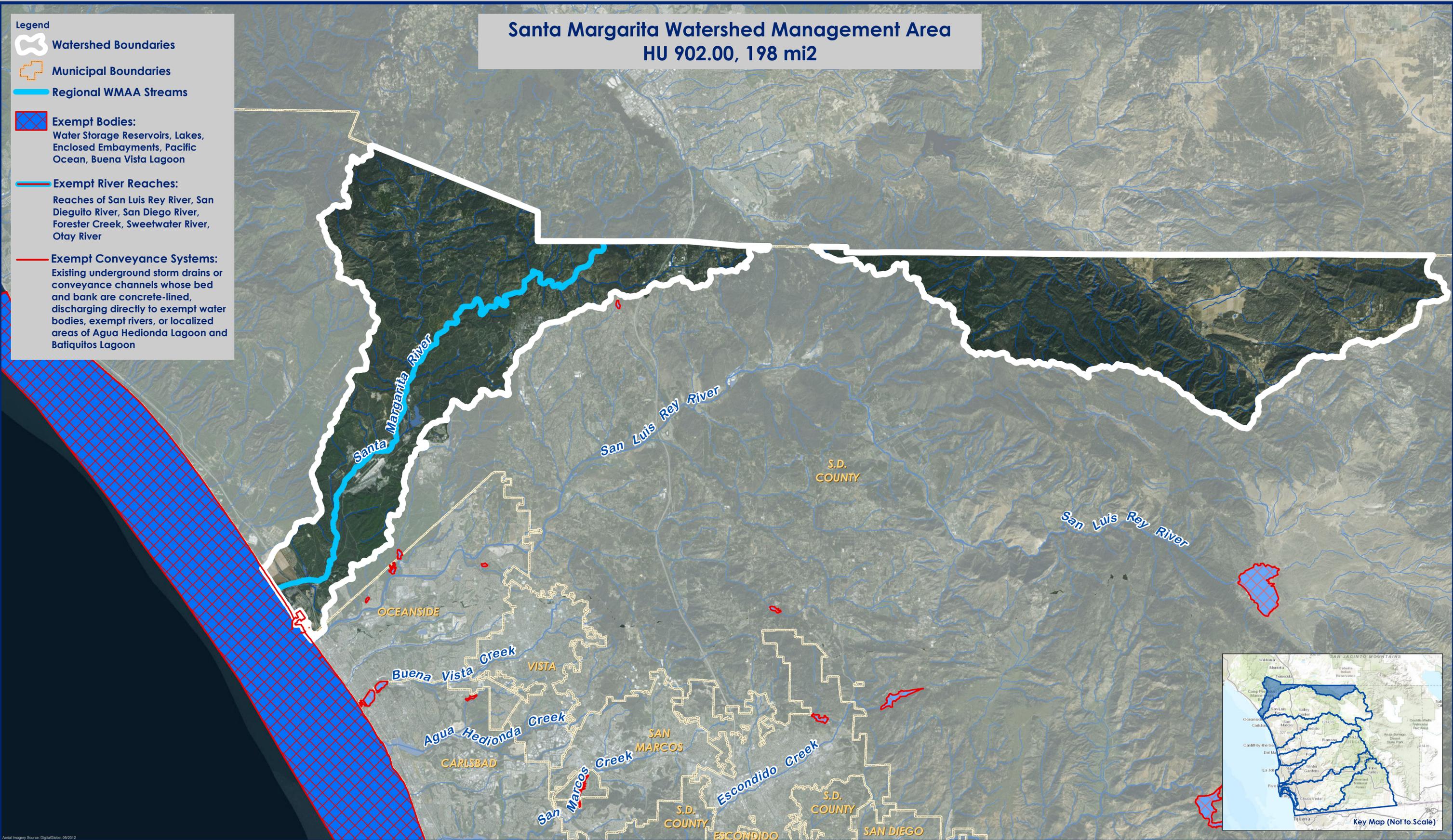
HMP EXEMPTION EXHIBIT

ATTACHMENT B.2
HYDROMODIFICATION MANAGEMENT EXEMPTION
MAPS

Legend

-  Watershed Boundaries
-  Municipal Boundaries
-  Regional WMAA Streams
-  **Exempt Bodies:**
Water Storage Reservoirs, Lakes, Enclosed Embayments, Pacific Ocean, Buena Vista Lagoon
-  **Exempt River Reaches:**
Reaches of San Luis Rey River, San Dieguito River, San Diego River, Forester Creek, Sweetwater River, Otay River
-  **Exempt Conveyance Systems:**
Existing underground storm drains or conveyance channels whose bed and bank are concrete-lined, discharging directly to exempt water bodies, exempt rivers, or localized areas of Agua Hedionda Lagoon and Batiquitos Lagoon

Santa Margarita Watershed Management Area
HU 902.00, 198 mi²



Aerial Imagery Source: DigitalGlobe, 09/2012



Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

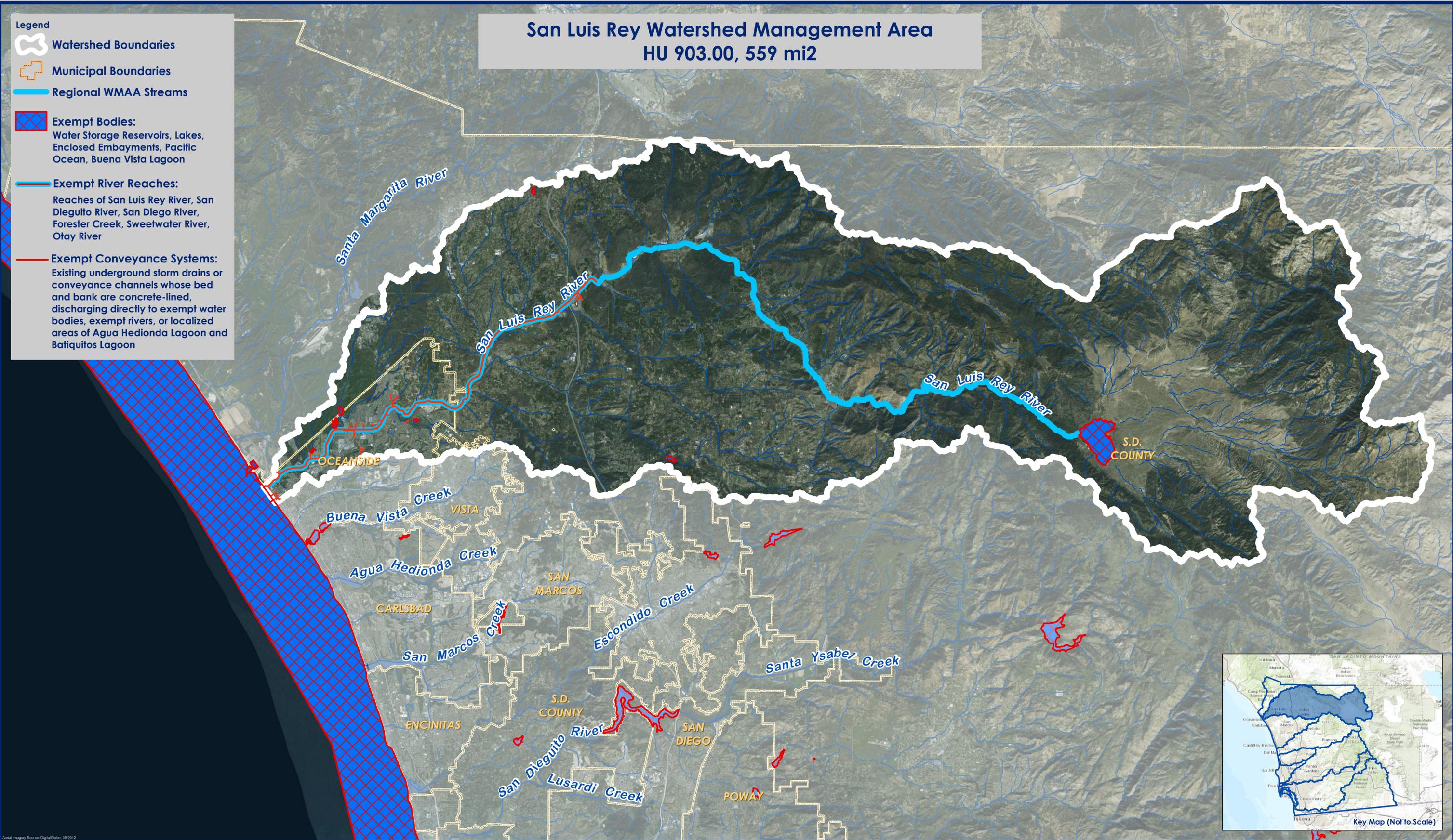
Exhibit Date: Sept. 8, 2014





San Luis Rey Watershed Management Area HU 903.00, 559 mi²

- Legend**
-  Watershed Boundaries
 -  Municipal Boundaries
 -  Regional WMAA Streams
 -  **Exempt Bodies:**
Water Storage Reservoirs, Lakes,
Enclosed Embayments, Pacific
Ocean, Buena Vista Lagoon
 -  **Exempt River Reaches:**
Reaches of San Luis Rey River, San
Dieguito River, San Diego River,
Forester Creek, Sweetwater River,
Otay River
 -  **Exempt Conveyance Systems:**
Existing underground storm drains or
conveyance channels whose bed
and bank are concrete-lined,
discharging directly to exempt water
bodies, exempt rivers, or localized
areas of Agua Hedionda Lagoon and
Batiqitos Lagoon



Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

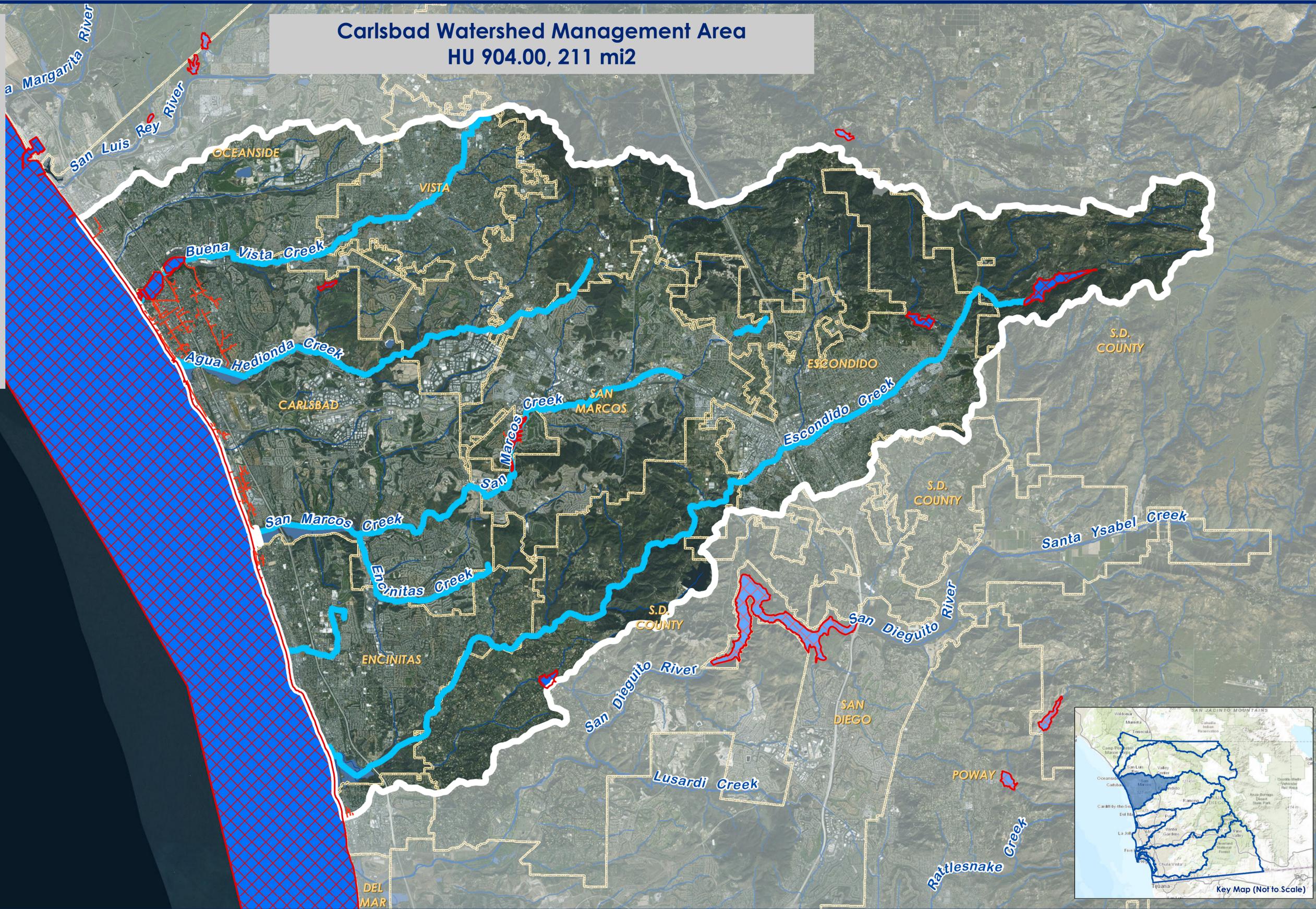
Exhibit Date: Sept. 8, 2014



Aerial Imagery Source: DigitalGlobe, 09/2012

Carlsbad Watershed Management Area HU 904.00, 211 mi²

- Legend**
-  Watershed Boundaries
 -  Municipal Boundaries
 -  Regional WMAA Streams
 -  Exempt Bodies:
Water Storage Reservoirs, Lakes,
Enclosed Embayments, Pacific
Ocean, Buena Vista Lagoon
 -  Exempt River Reaches:
Reaches of San Luis Rey River, San
Dieguito River, San Diego River,
Forester Creek, Sweetwater River,
Otay River
 -  Exempt Conveyance Systems:
Existing underground storm drains or
conveyance channels whose bed
and bank are concrete-lined,
discharging directly to exempt water
bodies, exempt rivers, or localized
areas of Agua Hedionda Lagoon and
Batiqitos Lagoon



Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements



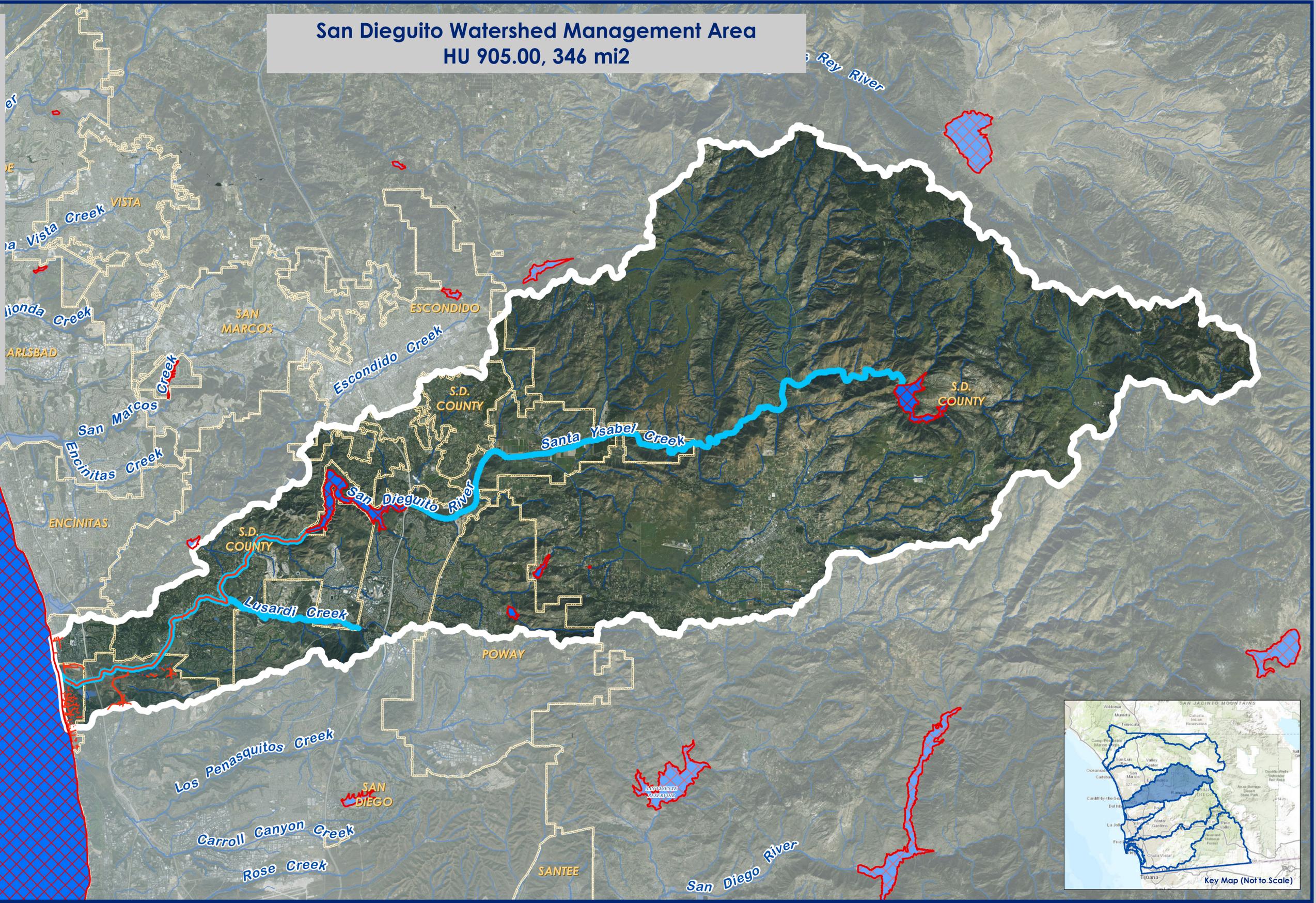
Exhibit Date: Sept. 8, 2014



Aerial Imagery Source: DigitalGlobe, 09/2012

San Dieguito Watershed Management Area HU 905.00, 346 mi²

- Legend**
-  Watershed Boundaries
 -  Municipal Boundaries
 -  Regional WMAA Streams
 -  Exempt Bodies:
Water Storage Reservoirs, Lakes,
Enclosed Embayments, Pacific
Ocean, Buena Vista Lagoon
 -  Exempt River Reaches:
Reaches of San Luis Rey River, San
Dieguito River, San Diego River,
Forester Creek, Sweetwater River,
Otay River
 -  Exempt Conveyance Systems:
Existing underground storm drains or
conveyance channels whose bed
and bank are concrete-lined,
discharging directly to exempt water
bodies, exempt rivers, or localized
areas of Agua Hedionda Lagoon and
Batiqitos Lagoon



Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

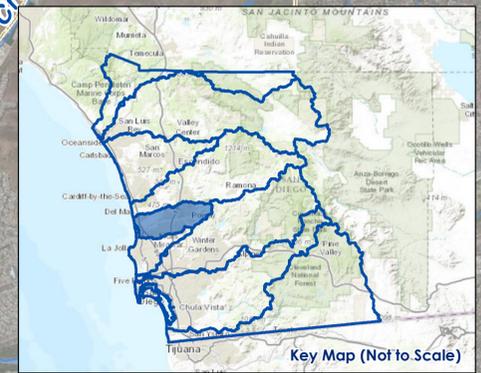
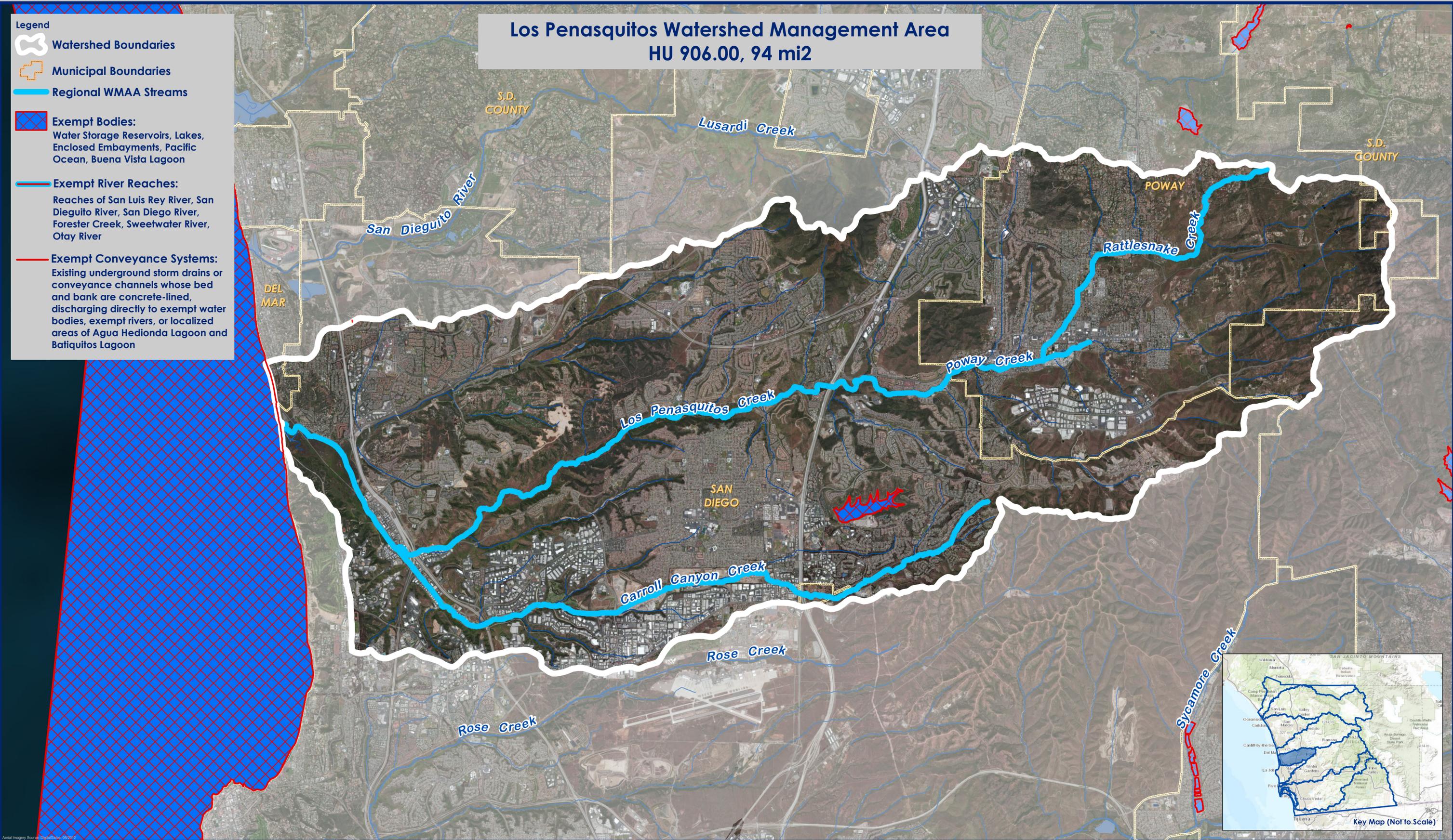


Exhibit Date: Sept. 8, 2014



Los Penasquitos Watershed Management Area HU 906.00, 94 mi²

- Legend**
-  Watershed Boundaries
 -  Municipal Boundaries
 -  Regional WMAA Streams
 -  Exempt Bodies:
Water Storage Reservoirs, Lakes,
Enclosed Embayments, Pacific
Ocean, Buena Vista Lagoon
 -  Exempt River Reaches:
Reaches of San Luis Rey River, San
Dieguito River, San Diego River,
Forester Creek, Sweetwater River,
Otay River
 -  Exempt Conveyance Systems:
Existing underground storm drains or
conveyance channels whose bed
and bank are concrete-lined,
discharging directly to exempt water
bodies, exempt rivers, or localized
areas of Agua Hedionda Lagoon and
Baticuitos Lagoon

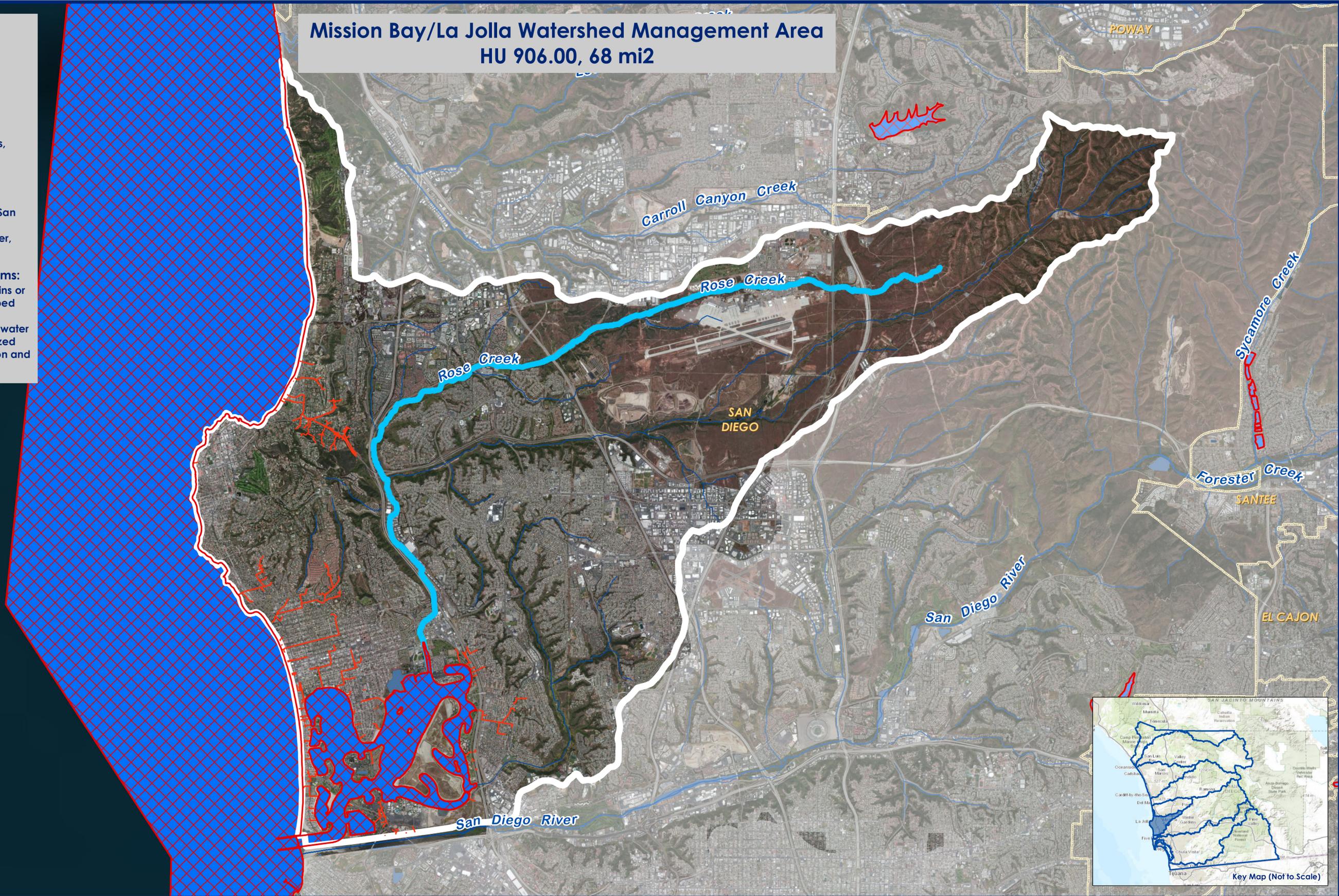


Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014

- Legend**
-  Watershed Boundaries
 -  Municipal Boundaries
 -  Regional WMAA Streams
 -  **Exempt Bodies:**
Water Storage Reservoirs, Lakes, Enclosed Embayments, Pacific Ocean, Buena Vista Lagoon
 -  **Exempt River Reaches:**
Reaches of San Luis Rey River, San Dieguito River, San Diego River, Forester Creek, Sweetwater River, Otay River
 -  **Exempt Conveyance Systems:**
Existing underground storm drains or conveyance channels whose bed and bank are concrete-lined, discharging directly to exempt water bodies, exempt rivers, or localized areas of Agua Hedionda Lagoon and Batiquitos Lagoon

Mission Bay/La Jolla Watershed Management Area
HU 906.00, 68 mi²



Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

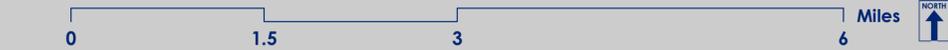


Exhibit Date: Sept. 8, 2014

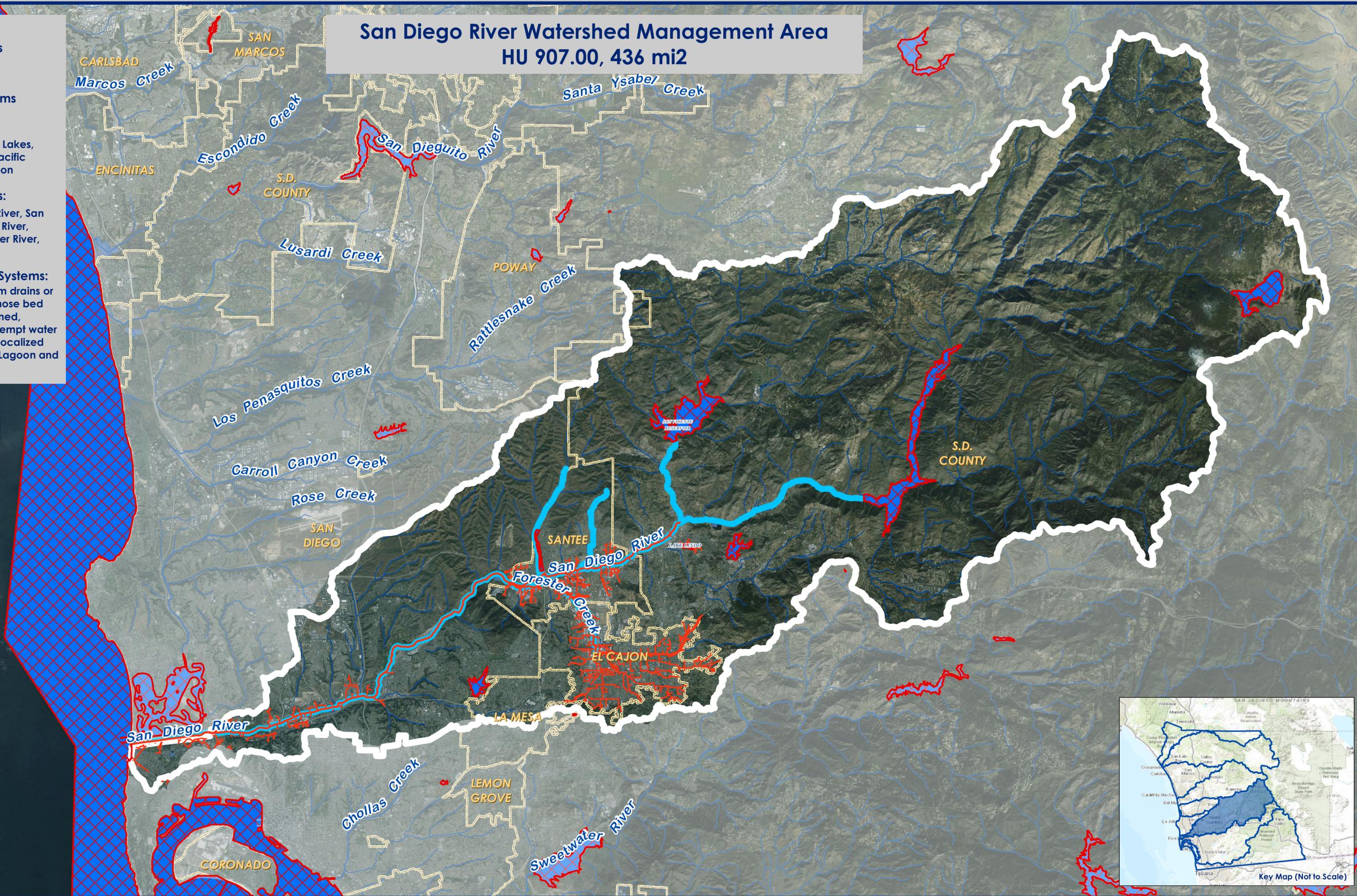
Geosyntec consultants | RICK ENGINEERING COMPANY



Aerial Imagery Source: DigitalGlobe, 09/2012

- Legend**
-  Watershed Boundaries
 -  Municipal Boundaries
 -  Regional WMAA Streams
 -  Exempt Bodies:
Water Storage Reservoirs, Lakes,
Enclosed Embayments, Pacific
Ocean, Buena Vista Lagoon
 -  Exempt River Reaches:
Reaches of San Luis Rey River, San
Dieguito River, San Diego River,
Forester Creek, Sweetwater River,
Otay River
 -  Exempt Conveyance Systems:
Existing underground storm drains or
conveyance channels whose bed
and bank are concrete-lined,
discharging directly to exempt water
bodies, exempt rivers, or localized
areas of Agua Hedionda Lagoon and
Batiqitos Lagoon

San Diego River Watershed Management Area
HU 907.00, 436 mi2



Aerial Imagery Source: DigitalGlobe, 09/2012



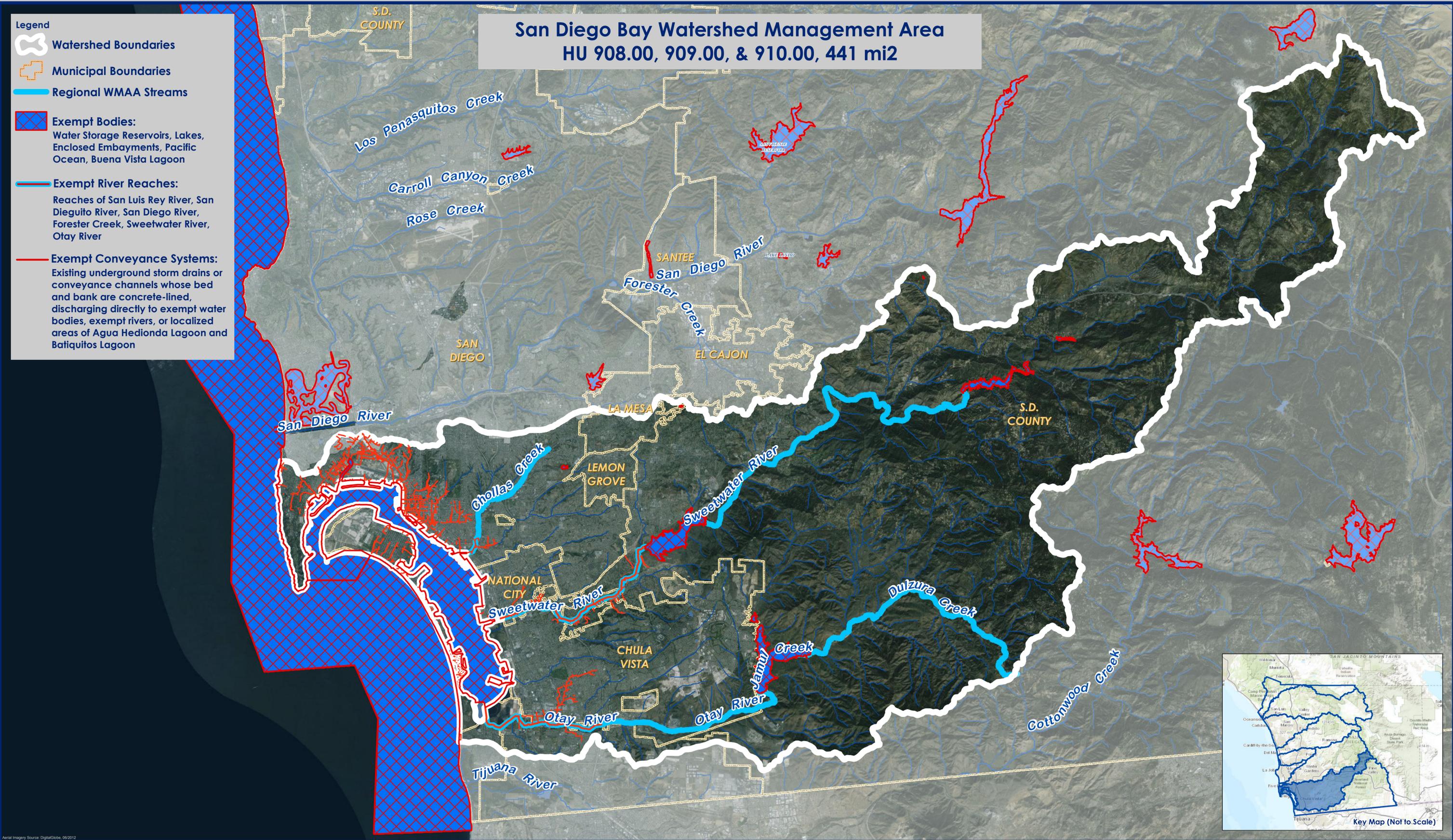
Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014



- Legend**
-  Watershed Boundaries
 -  Municipal Boundaries
 -  Regional WMAA Streams
 -  Exempt Bodies:
Water Storage Reservoirs, Lakes,
Enclosed Embayments, Pacific
Ocean, Buena Vista Lagoon
 -  Exempt River Reaches:
Reaches of San Luis Rey River, San
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Forester Creek, Sweetwater River,
Otay River
 -  Exempt Conveyance Systems:
Existing underground storm drains or
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and bank are concrete-lined,
discharging directly to exempt
water bodies, exempt rivers, or
localized areas of Agua Hedionda
Lagoon and Batiquitos Lagoon

**San Diego Bay Watershed Management Area
HU 908.00, 909.00, & 910.00, 441 mi²**



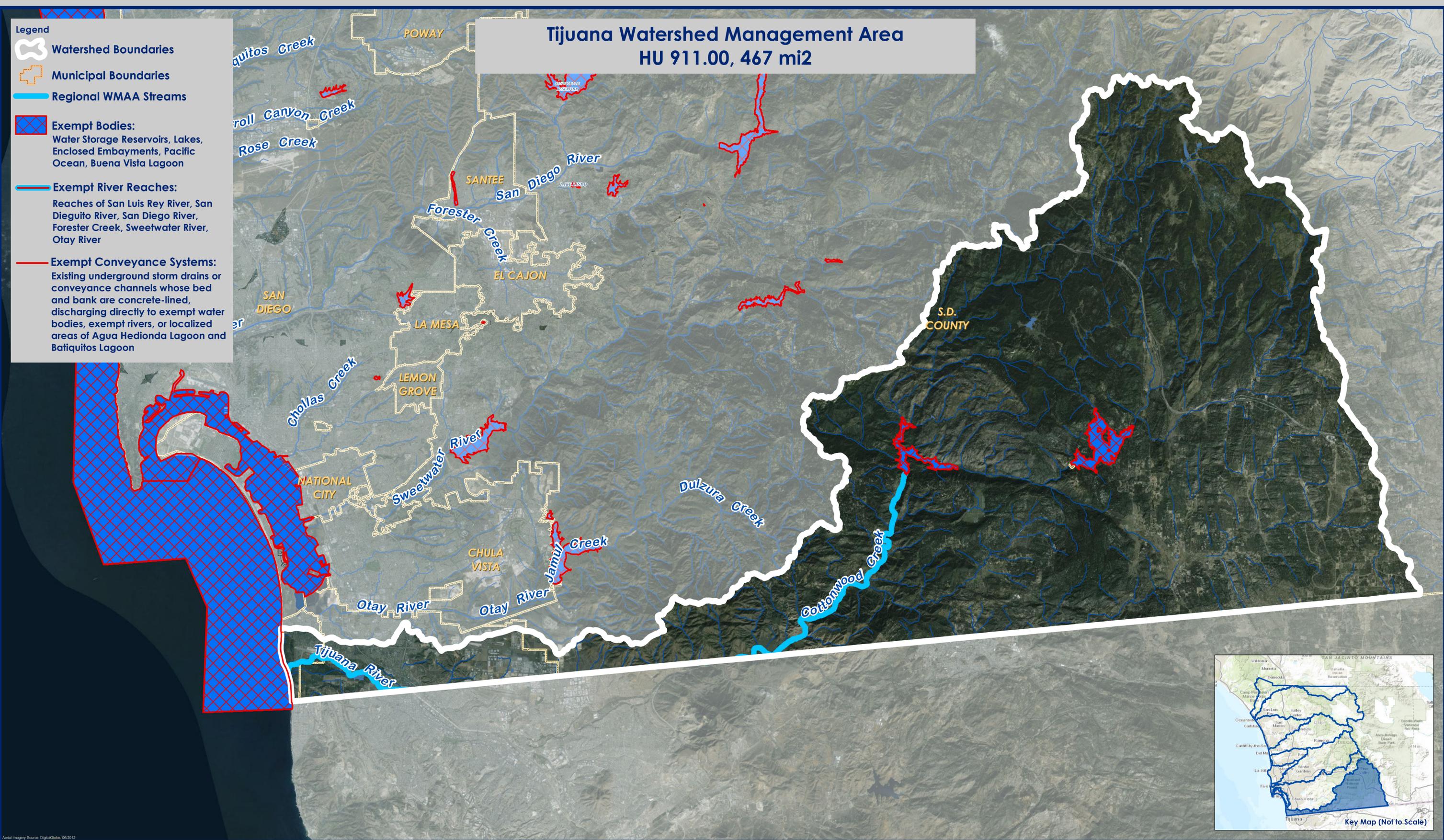
**Receiving Waters and Conveyance Systems Exempt
from Hydromodification Management Requirements**

Exhibit Date: Sept. 8, 2014



- Legend**
-  Watershed Boundaries
 -  Municipal Boundaries
 -  Regional WMAA Streams
 -  Exempt Bodies:
Water Storage Reservoirs, Lakes,
Enclosed Embayments, Pacific
Ocean, Buena Vista Lagoon
 -  Exempt River Reaches:
Reaches of San Luis Rey River, San
Dieguito River, San Diego River,
Forester Creek, Sweetwater River,
Otay River
 -  Exempt Conveyance Systems:
Existing underground storm drains or
conveyance channels whose bed
and bank are concrete-lined,
discharging directly to exempt water
bodies, exempt rivers, or localized
areas of Agua Hedionda Lagoon and
Batiqitos Lagoon

Tijuana Watershed Management Area
HU 911.00, 467 mi²



Receiving Waters and Conveyance Systems Exempt from Hydromodification Management Requirements

Exhibit Date: Sept. 8, 2014



Aerial Imagery Source: DigitalGlobe, 09/2012

ATTACHMENT C
ELECTRONIC FILES

Electronic Folder titled “Attachment _C_ElectronicData_Regional.zip” Contents:

1. ArcMap 10.0 and 10.1 map files created for purpose of viewing Regional WMAA data
 - Regional_WMAA_Data_2014_0908_v10.mxd (
 - Regional_WMAA_Data_2014_0908_v101.mxd (
2. ESRI Geodatabase titled "Regional_WMAA_Data_2014_0908_v10.gdb" containing the following data:
 - WatershedBoundaries
 - Watershed_Boundaries
 - HydrologicProcesses
 - HRUAnalysis
 - Streams – description of existing streams in the watershed
 - SD_Regional_WMAA_Streams (streams selected for detailed analysis)
 - SD_NHD_Streams (portion of NHD dataset included for reference)
 - LandUsePlanning
 - SanGIS_ExistingLandUse
 - SanGIS_PlannedLandUse
 - SanGIS_DevelopableLands
 - SanGIS_RedevelopmentandInfill
 - SanGIS_MunicipalBoundaries
 - Federal_State_Indian_Lands
 - SanGIS_MHPA_SD
 - SanGIS_MSCP_CN
 - SanGIS_MSCP_EAST_DRAFT_CN
 - SanGIS_Draft_North_County_MSCP_Version_8_Categories
 - PotentialCoarseSedimentYield
 - GLUAnalysis
 - PotentialCoarseSedimentYieldAreas
 - MacroLevelPotentialCriticalAreas
 - PotentialCriticalCoarseSedimentYieldAreas
 - ChannelStructures
 - ChannelStructures
 - HydromodExemptions
 - Exempt_Systems
 - Exempt_Bodies
 - Floodplains: included for reference
 - FEMA_NFHL
 - Baselayers: included for reference
 - SanGIS_Lakes
 - link to ESRI World Imagery (internet connection is required to access ESRI World Imagery basemap)

3. Regional_WMAA_Data_2014_0908.kmz, KMZ file containing the following data:
 - WatershedBoundaries
 - Streams
 - SD Regional WMAA Streams (streams selected for detailed analysis)
 - SD NHD Streams (portion of NHD dataset included for reference)
 - LandUsePlanning
 - Municipal Boundaries
 - Federal/State/Indian Lands
 - ChannelStructures
 - HydromodExemptions
 - Exempt_Systems
 - Exempt_Bodies
 - Floodplains: included for reference
 - FEMA Floodplain

Notes:

- Open a map file (with extension .mxd) using ArcMap to view the data.
- All data contained in the geodatabase is loaded into the map.
- Some data such as Hydrologic Processes and Coarse Sediment are best viewed at a large scale. Zoom the map to an area of interest to review this data.

ATTACHMENT D
REGIONAL MS4 PERMIT CROSSWALK

Table below provides a linkage between the Regional MS4 Permit requirements for WMAA and this report.

Regional MS4 Permit Provision	Regional WMAA Report
B.3.b.(4)(a)	Chapter 2; Section 5.1; Attachment A and Attachment C
B.3.b.(4)(a)(i)	Section 2.1; Attachment A.1 and Attachment C
B.3.b.(4)(a)(ii)	Section 2.2; Attachment A.2 and Attachment C
B.3.b.(4)(a)(iii)	Section 2.3; Attachment A.3 and Attachment C
B.3.b.(4)(a)(iv)	Section 2.4; Attachment A.4 and Attachment C
B.3.b.(4)(a)(v)	Section 2.5; Attachment A.5 and Attachment C
B.3.b.(4)(b)	Chapter 3 and Section 5.2
B.3.b.(4)(c)	Chapter 4; Section 5.3; Attachment B and Attachment C