California Regional Water Quality Control Board
San Diego Region

Los Peñasquitos Lagoon
Sedimentation/Siltation TMDL

DRAFT
STAFF REPORT
March 3, 2011

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Los Peñasquitos Lagoon Sedimentation/Siltation TMDL

Draft
Staff Report

Adopted by the
California Regional Water Quality Control Board
San Diego Region
on ______________, 201x

Approved by the
State Water Resources Control Board
on ______________, 201x
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on ______________,201x
and the
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Abbreviations:

BAT:	Best Available Technology
BMP:	Best Management Practice
CWA:	Clean Water Act
CFR:	Code of Federal Regulations
EFDC:	Environmental Fluids Dynamic Code
EMC:	Event Mean Concentration
USEPA:	United States Environmental Protection Agency
LA:	Load Allocation
LSPC:	Loading Simulation Program in C++
MLS:	Mass Loading Station
MOS:	Margin of Safety
MS4:	Municipal Separate Storm Sewer System
NPS:	Nonpoint Source Pollution
NPDES:	National Pollutant Discharge Elimination System
SANDAG:	San Diego Association of Governments
TBELs:	Technology Based Effluent Limitations
TMDL:	Total Maximum Daily Load
TSS:	Total Suspended Solids
TWAS:	Temporary Watershed Assessment Stations
USGS:	Unites States Geological Survey
WQOs:	Water Quality Objectives
WLA:	Wasteload Allocation
WDRs:	Waste Discharge Requirements
WQBELs:	Water Quality Based Effluent Limitations (WQBELs)

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Many dedicated professionals contributed to this Staff Report through their service on the Stakeholder Advisory Group (SAG) for this Total Maximum Daily Load project. The SAG provided insightful technical comments on early drafts of this report, suggested issues for technical peer review, raised important policy issues, and assisted with drafting the Implementation Plan. The California Regional Water Quality Control Board, San Diego Region, would like to thank the individuals who served on the SAG for their significant contributions to this project.

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Executive Summary

This staff report supports tentative Resolution No. R9-2011-0021, which will amend the *Water Quality Control Plan for the San Diego Basin (9)* (Basin Plan) to incorporate the Total Maximum Daily Load (TMDL) for sedimentation/siltation in Los Peñasquitos Lagoon (Lagoon). The Basin Plan amendment will incorporate the TMDL, associated waste load allocations, and required load reductions into the Basin Plan. This TMDL is necessary to attain the sediment water quality objective (WQO) that supports beneficial uses in the Lagoon.

This TMDL represents the maximum amount of sediment that the Lagoon can receive from the watershed and still attain water quality standards. Water quality standards define the goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing provisions such as antidegradation policies to protect waterbodies from pollutants.

Water Quality Impairment of Los Peñasqutios Lagoon

As required by section 303(d) of the Clean Water Act, the Los Peñasqutios Lagoon (Lagoon) was placed on the 1996 List of Water Quality Limited Segments due to sedimentation and siltation loads that exceeded water quality objectives. The beneficial use that is most sensitive to increased sedimentation is estuarine habitat. Beneficial uses of the Lagoon may include preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (such as marine mammals or shorebirds). Other beneficial uses listed in the Basin Plan for the Lagoon include contact water recreation; non-contact water recreation; preservation of biological habitats of special significance; wildlife habitat; rare, threatened or endangered species; marine habitat; migration of aquatic organisms; spawning, reproduction and/or early development; and shellfish harvesting.

Impacts associated with increased and rapid sedimentation include: reduced tidal mixing within Lagoon channels, degraded and (in some cases) net loss of riparian and salt marsh vegetation, increased vulnerability to flooding for surrounding urban and industrial developments, increased turbidity associated with siltation in Lagoon channels, and constricted wildlife corridor.

Numeric Target

The water quality objective for sediment is contained in the Basin Plan. The Basin Plan states, “The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses.” Because the sediment water quality objective is narrative, a numeric target is needed to evaluate attainment of the narrative water quality objective for sediment. Consideration of various lines of evidence indicates that the Lagoon was likely achieving the water quality standard for sediment before the mid-1970s. A historic coverage for the Los Peñasquitos watershed was developed for this period using US Geological Survey topographic maps from the 1970s (primarily the La Jolla quadrangle-dated 1975). This historic land use distribution was used to calculate the numeric target using the LSPC watershed model (see Attachment 2). This historic sediment load of 12,360 tons per critical wet period (58.6 tons per day) represents the sediment TMDL numeric target.

Source Assessment

Sources of sediment include erosion of canyon banks, bluffs, scouring stream banks, and tidal influx. Some of these processes are exacerbated by anthropogenic disturbances, such as urban development within the watershed. Urban development transforms the natural landscape and results in increased runoff due to hydromodification resulting in scouring of sediment, primarily below storm water outfalls that discharge into canyon areas. Sediment loads are transported downstream to the Lagoon during storm events causing deposits on the salt flats and in Lagoon channels. These sediment deposits have gradually built-up over the years due to increased sediment loading and inadequate flushing, which directly and indirectly affects lagoon functions and salt marsh characteristics.

Sediment is transported and discharged to the Lagoon through the municipal separate storm sewer system (MS4); therefore, the San Diego County Phase I MS4s are identified as a source. Other sources include both Phase II MS4s and transportation infrastructure operated by the California Department of Transportation (Caltrans).

An additional sediment source is the ocean, which is an uncontrollable nonpoint source that attributes sediment to the Lagoon via storm surges, wave action, and tidal exchange via the Lagoon mouth.

Linkage Analysis

Available data were used to configure, calibrate, and validate a customized modeling framework developed to support sediment TMDL development. The modeling framework consists of a watershed model (based on the Loading Simulation Program in C++, LSPC) and a receiving water model (based on the Environmental Fluids Dynamic Code, EFDC). The watershed model was used to calculate existing and historical sediment loading to the Lagoon from the Los Peñasquitos watershed, while the Lagoon receiving water model was used to simulate hydrodynamics and sediment transport characteristics for this tidally-influenced waterbody.

TMDL and Allocations

The TMDL for sediment is equal to the total assimilative or loading capacity of the Lagoon. The loading capacity is defined as the maximum amount of sediment that the Lagoon can receive and still attain water quality objectives necessary for the protection of designated beneficial uses. Each TMDL must account for all known sources of a pollutant, whether from natural background, nonpoint sources, or point sources, and must include a margin of safety (MOS) to preclude pollutant loading from exceeding the actual assimilative capacities of the waterbodies. The TMDL calculations also account for seasonal variations and critical conditions, and were developed in a manner consistent with guidelines published by USEPA.

A total WLA was assigned to the point sources within the watershed, which include the Phase I MS4 permitees (San Diego County, the City of San Diego, the City of Del Mar, and the City of Poway), Phase II MS4 permittees, and Caltrans. A total LA was assigned to the nonpoint source in the watershed, which is the ocean boundary. An implicit MOS was included through the application of conservative assumptions in the modeling and TMDL analysis. These assumptions include selection of the critical condition; determination of the soil composition in surface runoff; determination of the reference condition; and selection of the critical location.

Allocations and Load Reductions

The TMDL results are summarized in the tables below. The overall WLA is represented by the watershed contribution in Tables ES-1 and ES-2. The ocean boundary (LA) includes sediment loads from storm surge, wave action, and tidal exchange. The historical load represents the estimated load contribution from the mid-1970s time period (reference condition).

Table ES-1. TMDL summary

Source	Critical Wet Period Load (tons)	Daily Load (tons)
TMDL	12,360	58.6
Watershed contribution (WLA)	2,580	12.2
Ocean boundary (LA)	9,780	46.4
MOS	Implicit	Implicit

Table ES-2. Current vs. historical loads and percent reduction

Source	Current Load (tons)	Historical Load (tons)	Load Reduction (tons)	Percent Reduction Required
Watershed contribution (WLA)	7,719	2,580	5,139	**67%**
Ocean boundary (LA)	5,944	9,780	+3,836 (increase)	+39% (increase)
Total	13,663	12,360	1,303	10%

Implementation of TMDL

Because the Phase I MS4s are located at the base of the watersheds and have been identified as the most significant controllable source of sediment discharging to the Lagoon, this TMDL will most likely be implemented primarily through the revision of the National Pollutant Discharge Elimination System (NPDES) discharge requirements regulating discharges from the Phase I MS4s. The Caltrans NPDES requirements will also be revised. Federal regulations require that NPDES requirements incorporate water quality based effluent limitations (WQBELs) that are consistent with the requirements and assumptions of any available WLAs.[1] WQBELs may be expressed as numeric effluent limitations, when feasible, and/or as a program of expanded or better-tailoredBest Management Program.[2] The WQBELs will likely need to include a BMP program to achieve the load reductions required to attain the TMDLs in the receiving waters.

The Phase I MS4s and Caltrans will be required to submit a Sediment Load Reduction Plan outlining a proposed BMP program that will be capable of achieving the necessary load reductions required to attain the TMDL in the Lagoon. The Phase I MS4s and Caltrans will be responsible for reducing their sediment loads and/or demonstrating that their discharges are not causing exceedances of the WQOs. Phase II MS4s will be required to comply with existing requirements upon designation and enrollment under the Statewide Phase II MS4 general NPDES permit[3] or other individual Phase II MS4 permit issued by the San Diego Water Board.

TMDL Compliance Monitoring

An essential component of implementation is water quality monitoring. Monitoring is needed to evaluate the progress toward attainment of the TMDL and restoring the beneficial uses in the receiving waters. When all discharges from controllable sources meet their assigned WLAs and the numeric targets are also met in the Lagoon, compliance with the TMDL will be achieved. Compliance with the TMDL will be assessed by monitoring the Lagoon and contributing creeks, and then comparing the results to the numeric target and surrogate goals established in the Sediment Load Reduction Plans. At the end of the TMDL compliance schedule, the annual sediment load must not exceed the numeric target.

Compliance Schedule

Full implementation of the TMDL for sediment shall be completed within 10 years from the effective date of the Basin Plan amendment. For dischargers in watersheds that undertake concurrent load reduction programs for other pollutant constituents (e.g. metals, pesticides, trash, nutrients, bacteria, etc.) together with the sediment load

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[1] Code of Federal Regulations Title 40 section 122.44(d)(1)(vii)(B)
[2] Code of Federal Regulations Title 40 section 122.44(k)(2)&(3)
[3] Order No. 2003-0005-DWQ, *National Pollutant Discharge Elimination System (NPDES) General Permit No. CAS000004, Waste Discharge Requirements for Storm Water Discharges from Small Municipal Separate Storm Sewer Systems (General Permit)*

reduction requirements in this TMDL, an alternative compliance schedule may be proposed and incorporated by the San Diego Water Board into the implementing orders.

1 Introduction

The California Regional Water Quality Control Board, San Diego Region (San Diego Water Board) is the California state agency responsible for water quality protection in the southwest portion of the state of California. It is one of nine Regional Water Boards in California, each generally separated by hydrological boundaries. Each Regional Water Board consists of nine governor-appointed members who serve four-year terms. The San Diego Water Board, under its federally designated authority, administers the Clean Water Act (CWA) within the San Diego Region.

In accordance with the CWA, the San Diego Water Board has adopted the *Water Quality Control Plan for the San Diego Region (9)* (Basin Plan) that specifies water quality standards for waters in the San Diego Region and implementation measures to enforce those standards. Section 305(b) of the CWA mandates biennial assessment of the nation's water resources to identify and list waters not meeting their water quality standards. These waters are listed in accordance with CWA section 303(d) and the list is commonly referred to as the 303(d) list. The CWA requires states to establish a priority ranking for impaired waters and to develop and implement Total Maximum Daily Loads (TMDLs) to address the impairments.

A TMDL is a written, quantitative assessment of water quality problems and contributing pollutant sources. It identifies one or more numeric targets for restoring beneficial uses based on applicable water quality standards, specifies the maximum pollutant load that can be discharged and still meet water quality standards, allocates pollutant loads among sources in the watershed and provides a basis for taking actions needed to meet the numeric target(s) and water quality standards.

The Los Peñasquitos Lagoon (Lagoon) is currently listed on the 303(d) list for impairment due to sedimentation/siltation. Sedimentation within the Lagoon restricts the tidal prism, or exchange between the ocean and the Lagoon, and degrades critical salt marsh habitats through various processes. Because the Lagoon is not meeting the sediment narrative water quality objective, numerous beneficial uses are impaired, primarily those associated with protection of aquatic life (e.g., Estuarine, Marine Life Habitat, and Preservation of Biological Habitats of Special Significance, etc.).

The San Diego Water Board proposes to amend its Basin Plan to incorporate a TMDL and implementation plan to address sedimentation problems adversely affecting water quality in the Lagoon. This TMDL staff report describes the scientific and technical basis for confirming sediment impacts, developing numeric targets, determining sediment sources, and establishing watershed loading capacity. When all discharges from controllable sources meet their assigned WLAs and the numeric targets are also met in the Lagoon, compliance with the TMDL will be achieved. Compliance with the

TMDL will be assessed by monitoring the Lagoon and contributing creeks, and then comparing the results to the numeric target and surrogate goals established in the Sediment Load Reduction Plans. At the end of the TMDL compliance schedule, the annual sediment load must not exceed the numeric target.

This TMDL was developed through close collaboration between the municipalities within the Los Peñasquitos watershed (City of San Diego, San Diego County, City of Del Mar, and City of Poway), the California Department of Transportation (Caltrans), San Diego Coastkeeper, California State Parks, the Los Peñasquitos Lagoon Foundation, and representatives from the San Diego Water Board. This third party TMDL effort was led by the City of San Diego and included detailed modeling of the Lagoon and its contributing watershed.

For the technical portion of this TMDL, the San Diego Water Board relied on the report prepared by Tetra Tech entitled, *Los Peñasquitos Lagoon Sediment/Siltation TMDL* (Technical Support Document).

2 Problem Statement

Under section 303(d) of the Clean Water Act (CWA), states are required to identify waters whose beneficial uses have been impaired due to specific constituents. Los Peñasquitos Lagoon was placed on the Section 303(d) list of Water Quality Limited Segments in 1996 for sedimentation and siltation with an estimated 469 acres affected. The Lagoon is subject to the development of a total maximum daily load (TMDL) (USEPA, 2009).

The Lagoon is an estuarine system that is part of the Torrey Pines State Natural Reserve. In addition to its marine influence, the Lagoon receives freshwater inputs from an approximately 60,000-acre watershed comprised of three major canyons (Carroll Canyon, Los Peñasquitos Canyon, and Carmel Canyon). Given the status of "Natural Preserve" by the California State Parks, the Lagoon is one of the few remaining native salt marsh lagoons in southern California, providing a home to several endangered species. (California State Parks, 2009) The Lagoon is ecologically diverse, supporting a variety of plant species, and providing habitat for numerous bird, fish, and small mammal populations. The Lagoon also serves as a stopover for the Pacific Flyway, offering migratory birds a safe place to rest and feed, as well as providing refuge for coastal marine species that use the Lagoon to feed and hide from predators.

The San Diego Basin Plan states, "The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses." Beneficial uses listed in the Basin Plan for the Lagoon include contact water recreation; non-contact water recreation (although access is not permitted in some areas per California State Parks); preservation of biological habitats of special significance; estuarine habitat; wildlife habitat; rare, threatened or endangered species; marine habitat; migration of aquatic organisms; spawning, reproduction and/or early development; and shellfish harvesting. The beneficial use that is most sensitive to increased sedimentation is estuarine habitat. Estuarine uses may include preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (such as marine mammals or shorebirds).

Impacts associated with increased and rapid sedimentation include: reduced tidal mixing within Lagoon channels, degraded and (in some cases) net loss of riparian and salt marsh vegetation, increased vulnerability to flooding for surrounding urban and industrial developments, increased turbidity associated with siltation in Lagoon channels, and constricted wildlife corridors. The Los Peñasquitos Lagoon Enhancement Plan and Program (1985), San Diego Basin Plan (1994), and Clean Water Act section 303(d) highlight sedimentation as a significant impact associated with urban development and a leading cause in the rapid loss of salt marsh habitat in the Lagoon, making sediment reduction a management priority.

According to California State Parks, the Lagoon consists of approximately 510 acres of wetland habitats including coastal salt marsh (this includes salt panne, tidal channels, and mudflats), brackish marsh, riparian woodland and scrub, and freshwater marsh. The Lagoon's 510 acres include approximately 210 acres of unimpaired tidal salt marsh and 120 acres of unimpaired freshwater wetlands (California State Parks 2010). The remaining 180 acres of salt marsh and brackish marsh vegetation are impaired by excessive sedimentation, which converted the coastal salt marsh to freshwater or upland habitats. The environmental processes that support wetland habitats in the Lagoon have been altered by urban development in three ways:

1) Increase in the volume and frequency of freshwater input
2) Increase in sediment deposition
3) Decrease in the tidal prism

These factors have led to decreases in saltwater and brackish marsh habitats and increases in freshwater habitats as well as increases in the abundance of non-native species.

Developing a sediment TMDL for the Lagoon is necessary for the restoration of the beneficial uses of the Lagoon, including the estuarine beneficial use most impacted by sediment accumulation.

3 Background Information

This section describes the Los Peñasquitos watershed and Lagoon, applicable water quality standards (including beneficial uses and WQOs), and provides background information on the impairment.

3.1 Los Peñasquitos Watershed Description

The Los Peñasquitos watershed is located in central San Diego County (Figure 1). Both the watershed and Lagoon are included in the Los Peñasquitos Hydrologic Unit (906), which also includes Mission Bay and several coastal tributaries. This 93 square mile (approximately 60,000 acres) coastal watershed includes portions of the City of San Diego, City of Poway, City of Del Mar, and San Diego County (Figure 2). There are also several major road corridors that are maintained by Caltrans within the watershed.

Figure 1. Location of the Los Peñasquitos watershed

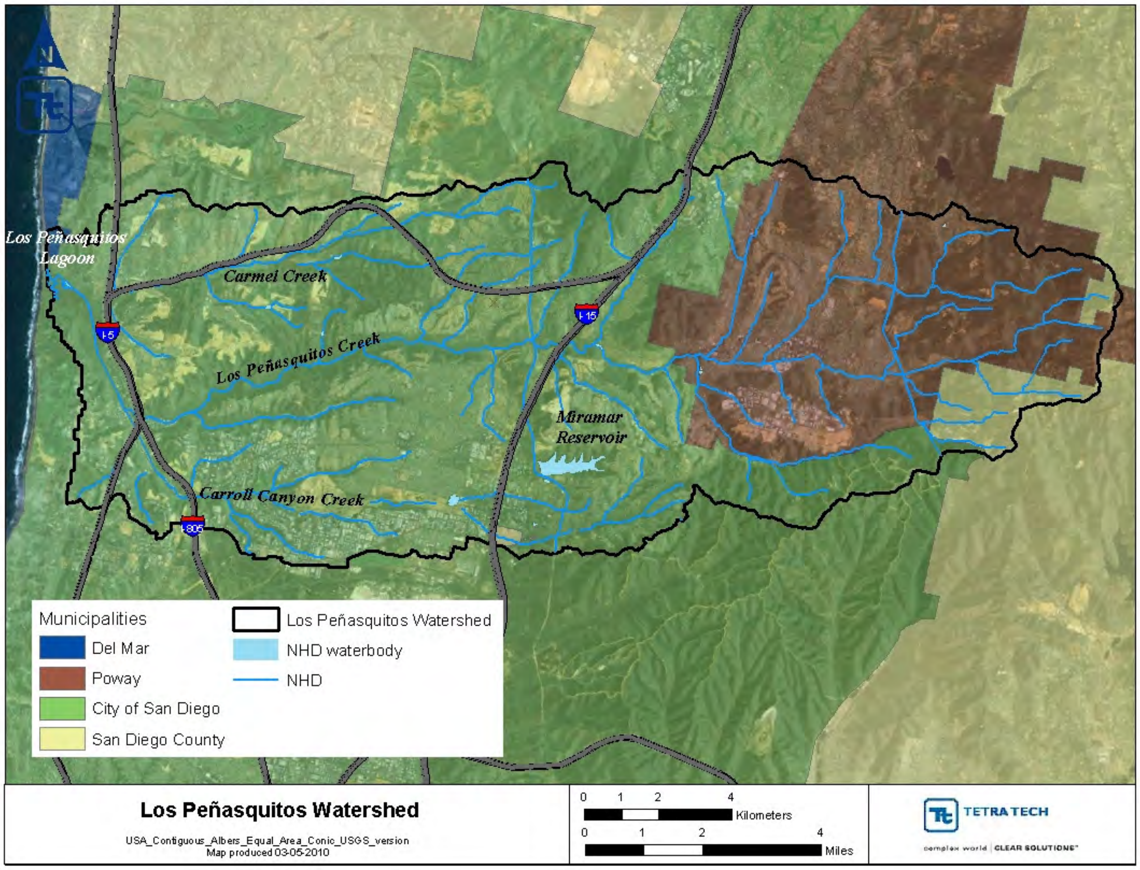

Figure 2. Municipalities within the Los Peñasquitos watershed

The climate in the Region is generally mild with annual temperatures averaging around 65°F near the coastal areas. Average annual rainfall ranges from nine to eleven inches along the coast. There are three distinct seasons in the Region. The summer dry season occurs from late April to mid-October. The winter season occurs from mid-October through early April and has two types of weather; 1) winter dry weather when rain has not fallen for the preceding 72 hours, and 2) wet weather consisting of storms of 0.2 inches of rainfall (or greater) and the following 72 hours. The winter season accounts for 85 to 90 percent of the annual rainfall .

Three major streams drain the watershed and flow into the Lagoon (Figure 2). Los Peñasquitos Creek is the largest catchment, located in the central portion of the watershed, draining 59 square miles (approximately 37,760 acres). Carroll Canyon Creek is the second largest catchment, located in the southern portion of the watershed, draining 18 square miles (approximately 11,520 acres). Carmel Creek is the smallest of the three catchments, located in the northern, coastal area, draining the remaining 16 square miles (approximately 10,240 acres). Los Peñasquitos Creek and Carroll

Canyon Creek converge prior to entering the Lagoon. There is one major dam in the Carroll Canyon Creek watershed, which drains approximately 1 square mile (approximately 640 acres) and forms Miramar Reservoir (retains imported drinking water; does not discharge downstream). Watershed elevation rises from sea level to 2,600 ft in the headwaters.

Data detailing land use in the Los Peñasquitos watershed is available through the San Diego Association of Governments 2000 land use coverage[4] and is presented in Figure 3. Approximately 54 percent of the watershed has been developed, with 46 percent of that area classified as impervious. The largest single land use type in the Los Peñasquitos watershed is open space (approximately 25,500 acres), followed by low density residential development (approximately 14,250 acres) and industrial/transportation (approximately 11,660 acres). The percent distribution of all land uses in the watershed is presented in Figure 4. Additional key watershed characteristics that were used for model configuration are described in the Modeling Report. (Attachment 2)

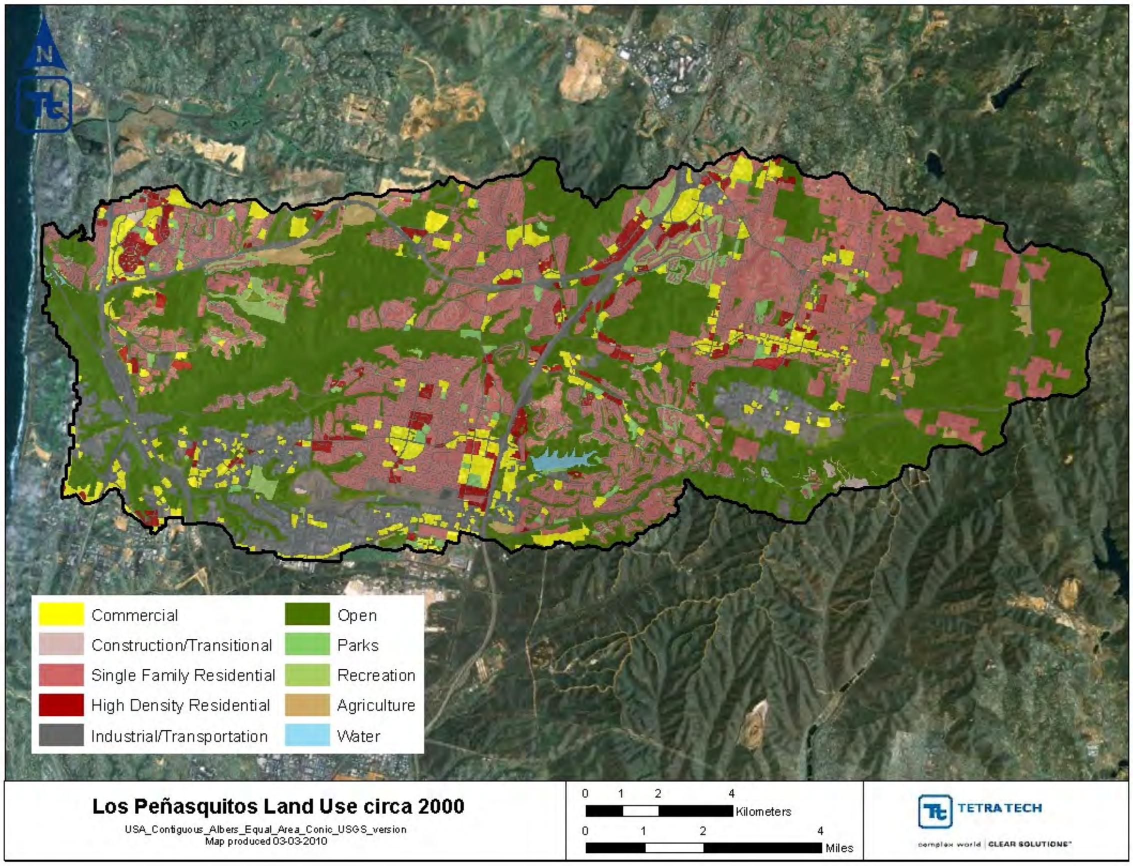

Figure 3. Land uses in the Los Peñasquitos watershed

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[4] http://www.sandag.org/resources/maps_and_gis/gis_downloads/downloads/zip/Land/CurrentLand/lu.zip

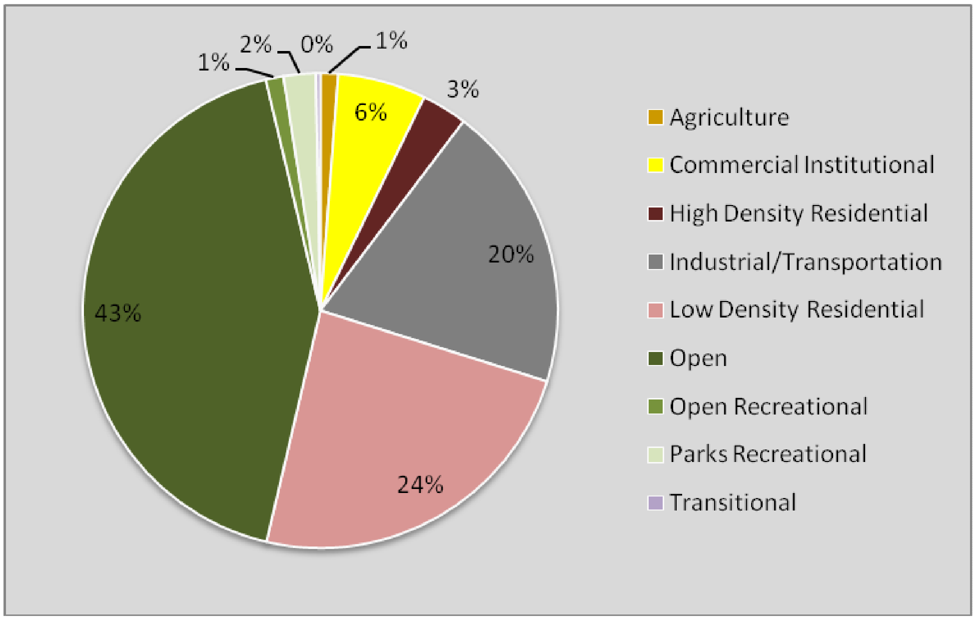


Figure 4. Land use distribution in the Los Peñasquitos watershed

3.2 Los Peñasquitos Lagoon Description

The Lagoon is a relatively small estuarine system that is part of the Torrey Pines State Natural Reserve (Figure 5). Given the status of “Natural Preserve” by the California State Parks, the Lagoon is one of the few remaining native salt marsh lagoons in southern California. The Lagoon is ecologically diverse, supporting a variety of plant species, and providing habitat for numerous bird, fish, and small mammal populations. The Lagoon also serves as a stopover for migratory birds and provides habitat for coastal marine and salt marsh species.

Figure 5. Photograph of Los Peñasquitos Lagoon

Tidal flows enter the Lagoon during periods when the Lagoon mouth is open to the ocean. Currently, the Lagoon mouth is open throughout most of the year. Mouth closures are typically caused by coastal processes (deposition of sand and cobble due to storms surges and wave action) and structures, such as the U.S. Highway 101 abutments. Mechanical dredging is used, when needed, to eliminate blockages and allow for tidal flow into the Lagoon to improve water quality conditions and support salt marsh species.

Most of the freshwater input flows through Los Peñasquitos Canyon into the Lagoon. Carroll Canyon Creek to the south and Carmel Creek to the north also contribute freshwater to the Lagoon. Historically, Los Peñasquitos Creek was the only tributary that flowed year-round, while Carroll Canyon and Carmel Creeks only flowed during significant rainfall events. Beginning in the 1990s, Carroll Canyon and Carmel Creeks also began flowing year-round due to increased urban development within the watershed.

The railroad track berm acts as a barrier between the eastern and western portions of the Lagoon. The railroad trestle along the Lagoon's northern portion provides the main connection between the eastern and western portions of the lagoon. The Lagoon channel that receives flow from Carmel Creek crosses through this area (Figure 6). There are also two smaller bridges located in the southern portion of the Lagoon which allow flow from Carroll Canyon Creek to pass through to the eastern side of the Lagoon during high flow events (Figure 7).

Figure 6. Photograph of Carmel Creek entering Los Peñasquitos Lagoon

Figure 7. Photograph of Carroll Canyon Creek entering Los Peñasquitos Lagoon

3.3 Applicable Water Quality Standards

The narrative sediment WQO, as set forth in the Water Quality Control Plan for the San Diego Basin (Basin Plan) states, "*The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses"* (San Diego Water Board, 1994). The Basin Plan identifies the beneficial uses that are designated for Los Peñasquitos Lagoon (Table 1) (San Diego Water Board, 1994). Compliance with WQOs must be assessed and maintained throughout the waterbody to protect all beneficial uses. The narrative sediment WQO is applied to all beneficial uses.

Table 1. Beneficial uses designated for Los Peñasquitos Lagoon

Beneficial Use	Beneficial Use Description
REC 1	Includes uses of water for recreation activities involving body contact with water, where ingestion of water is reasonable possible. These uses include, but are not limited to, swimming, wadding, water skiing, skin and SCUBA diving, surfing, white water activities, fishing, or use of natural hot springs. *Note that access to some areas is not permitted per California State Parks
REC 2	Includes the use of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonable possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beach combing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities. *Note that access to some areas is not permitted per California State Parks
BIOL	Includes uses of water that support designated area or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS), where the preservation or enhancement of natural resources requires special protection.
EST	Includes uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds)
WILD	Includes uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
RARE	Includes uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.
MAR	Includes uses of water that support marine ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
MIGR	Includes uses of water that support habitats necessary for migration, acclimatization, between fresh and salt water, or other temporary activities by aquatic organisms, such as anadromous fish.
SPWN	Includes uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish. This use is applicable only for the protection of anadromous fish.
SHELL	Includes uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters and mussels) for human consumption, commercial, or sport purposes.

3.4 Impairment Description

The Lagoon is listed as impaired on the 303(d) list due to sedimentation/siltation impacts. This impairment impacts several beneficial uses; however, the estuarine habitat use is the most sensitive to increased sedimentation. The Lagoon's wetland habitats consist of estuarine and riparian habitats, including coastal salt marsh habitat and wetland/upland buffer areas. The 303(d) listing indicated that the entire Lagoon was not supporting beneficial uses and was impaired by sediment . Recent surveys by California State Parks indicate that the Lagoon consists of more than 510 acres include approximately 210 acres of unimpaired tidal salt marsh and 120 acres of unimpaired freshwater wetlands (California State Parks 2010). The remaining 180 acres of salt marsh and brackish marsh vegetation are impaired by excessive sedimentation (Figure 8) (California State Parks, 2009; California State Parks, 2010).

Impacts associated with increased and rapid sedimentation include: reduced tidal mixing within Lagoon channels, degraded and net loss of riparian and salt marsh vegetation, increased vulnerability to flooding for surrounding urban and industrial developments, increased turbidity associated with siltation in Lagoon channels, and constricted wildlife corridors. There are many potential sources that have influenced the accumulation of sediment within the Lagoon. Sources include erosion of canyon banks and bluffs, scouring stream banks, and tidal influx. Some of these processes are exacerbated by anthropogenic disturbances, such as urban development within the watershed. Urban development transforms the natural landscape and results in increased runoff due to hydromodifcation resulting in scouring of sediment, primarily below storm water outfalls that discharge into canyon areas. Sediment loads are transported downstream to the Lagoon during storm events causing deposits on the salt flats and in Lagoon channels. These sediment deposits have gradually built-up over the years due to increased sediment loading and inadequate flushing, which directly and indirectly affects lagoon functions and salt marsh characteristics.

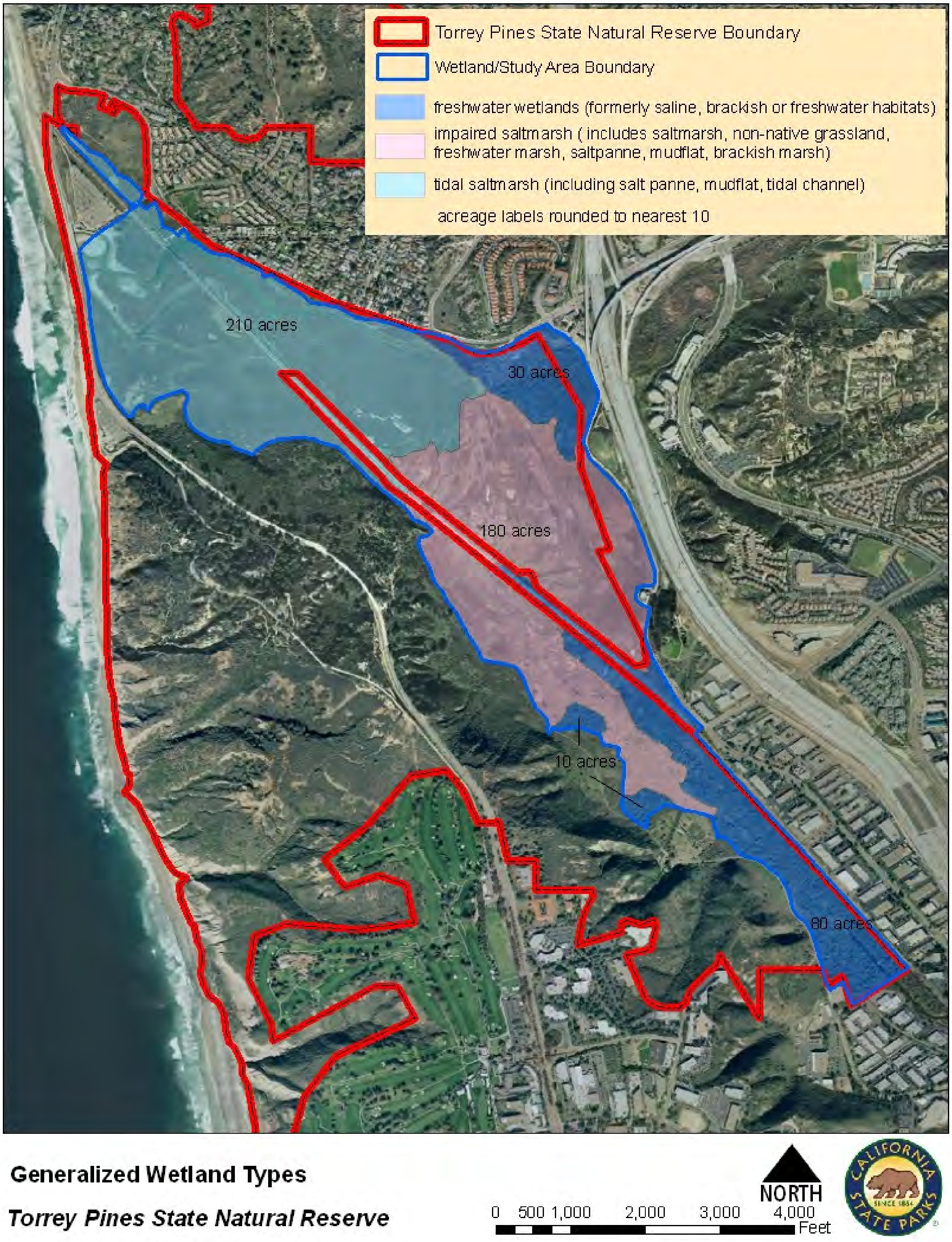


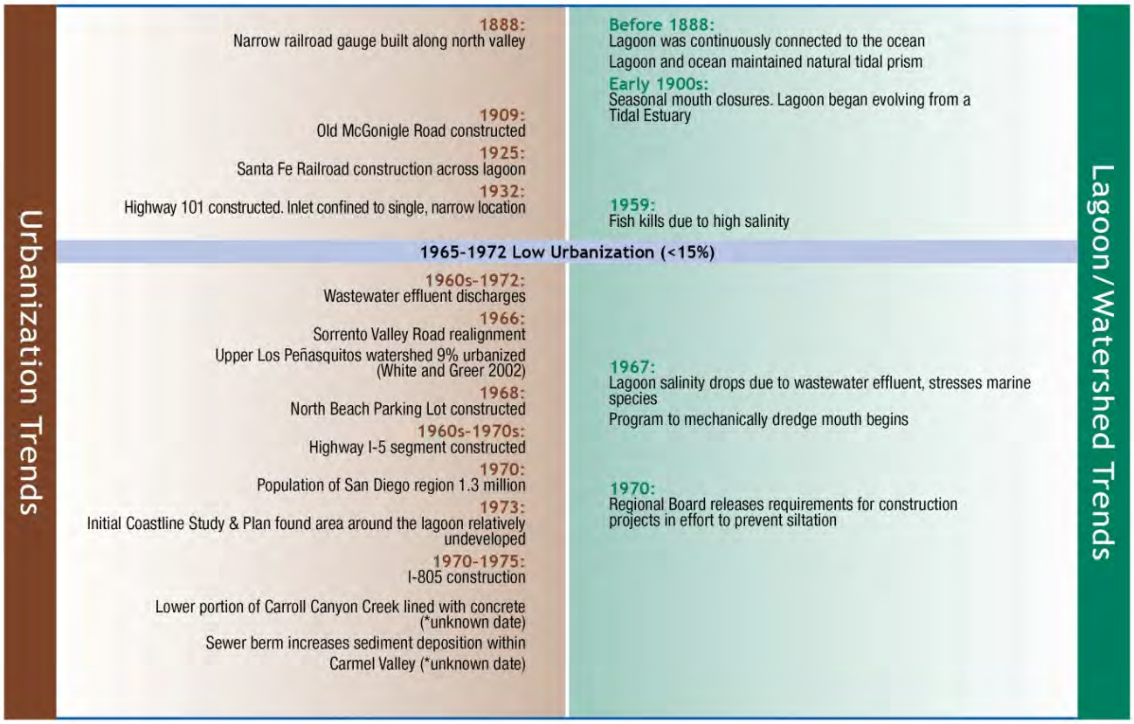
Figure 8. Wetland habitats within Los Peñasquitos Lagoon (California State Parks, 2010)

4 Numeric Targets

CWA section 303(d)(1)(C) states that TMDLs “shall be established at a level necessary to implement the applicable water quality standards." Water quality standards include the designated beneficial uses of waters and the water quality objectives established to protect beneficial uses. The narrative sediment WQO, as set forth in the Basin Plan states, “The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses” (San Diego Water Board, 1994).

Because the applicable water quality objective for this sediment TMDL is narrative, a numeric target was developed to interpret the narrative sediment-related water quality objective and ensure protection of aquatic life beneficial uses, particularly estuarine habitat. The numeric target was derived using a ‘reference watershed approach.’ The ‘reference watershed approach’ typically refers to the process of comparing the impaired waterbody to a similar-unimpaired waterbody to establish an acceptable loading capacity that would result in the attainment of water quality standards. Due to the unique characteristics of the Lagoon, it was determined that the reference watershed is the Lagoon in a historic state, when water quality standards were once met.

A historical analysis of the Lagoon and its watershed provides the best information available for determining the conditions in the Lagoon that support water quality standards. Available literature and past accounts of sedimentation impacts within the Lagoon were reviewed to understand the relationship between urbanization in the watershed and associated changes in Lagoon water quality conditions. A timeline of significant events and literature references was developed to document important changes in the Lagoon over time in relation to changes in land use (urbanization in particular) and other impacts (Figures 9 and 10).


Urbanization Trends

1888:
Narrow railroad gauge built along north valley

1909:
Old McGonigle Road constructed

1925:
Santa Fe Railroad construction across lagoon

1932:
Highway 101 constructed. Inlet confined to single, narrow location

Lagoon/Watershed Trends

Before 1888:
Lagoon was continuously connected to the ocean
Lagoon and ocean maintained natural tidal prism

Early 1900s:
Seasonal mouth closures. Lagoon began evolving from a Tidal Estuary

1959:
Fish kills due to high salinity

1965-1972 Low Urbanization (<15%)

1960s-1972:
Wastewater effluent discharges

1966:
Sorrento Valley Road realignment
Upper Los Peñasquitos watershed 9% urbanized (White and Greer 2002)

1968:
North Beach Parking Lot constructed

1960s-1970s:
Highway I-5 segment constructed

1970:
Population of San Diego region 1.3 million

1973:
Initial Coastline Study & Plan found area around the lagoon relatively undeveloped

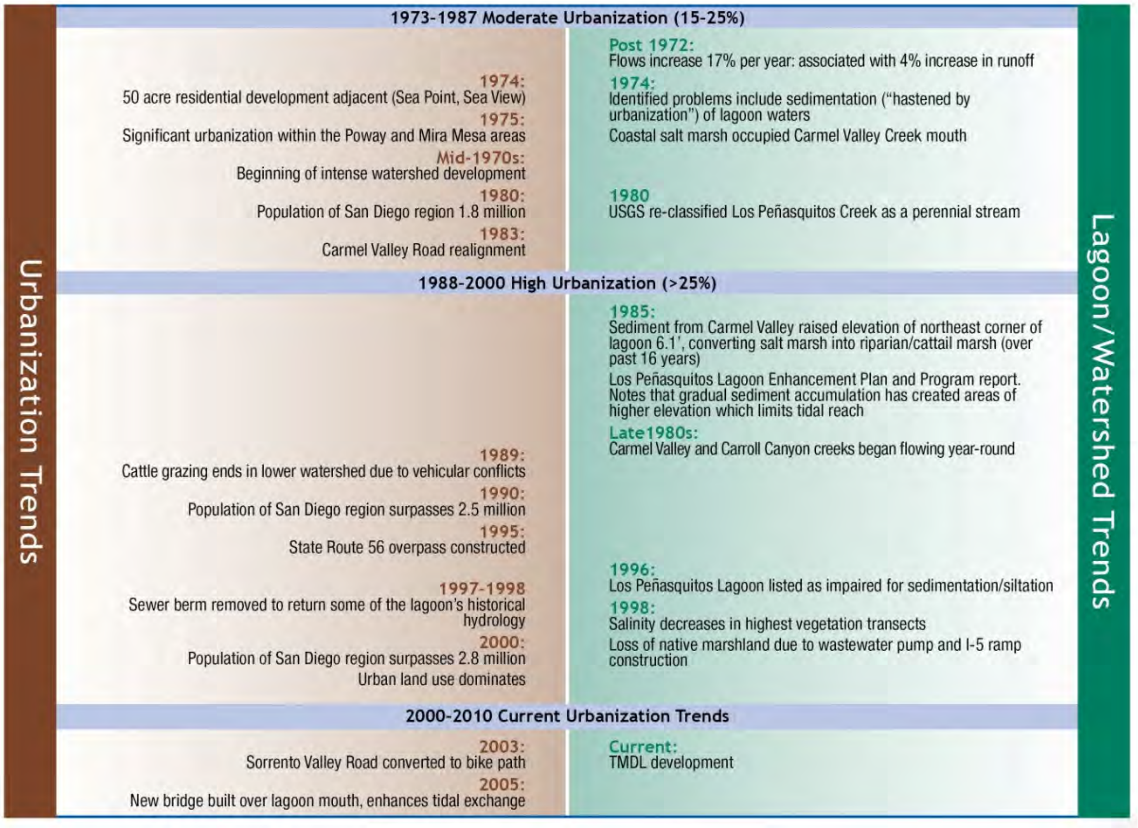
1970-1975:
I-805 construction

Lower portion of Carroll Canyon Creek lined with concrete (*unknown date)
Sewer berm increases sediment deposition within Carmel Valley (*unknown date)

1967:
Lagoon salinity drops due to wastewater effluent, stresses marine species
Program to mechanically dredge mouth begins

1970:
Regional Board releases requirements for construction projects in effort to prevent siltation

Figure 9. Timeline of urbanization and lagoon trends (1800s through early 1970s)


Urbanization Trends

1973-1987 Moderate Urbanization (15-25%)

1974:
50 acre residential development adjacent (Sea Point, Sea View)

1975:
Significant urbanization within the Poway and Mira Mesa areas

Mid-1970s:
Beginning of intense watershed development

1980:
Population of San Diego region 1.8 million

1983:
Carmel Valley Road realignment

Lagoon/Watershed Trends

Post 1972:
Flows increase 17% per year: associated with 4% increase in runoff

1974:
Identified problems include sedimentation ("hastened by urbanization") of lagoon waters
Coastal salt marsh occupied Carmel Valley Creek mouth

1980
USGS re-classified Los Peñasquitos Creek as a perennial stream

1988-2000 High Urbanization (>25%)

1989:
Cattle grazing ends in lower watershed due to vehicular conflicts

1990:
Population of San Diego region surpasses 2.5 million

1995:
State Route 56 overpass constructed

1997-1998
Sewer berm removed to return some of the lagoon's historical hydrology

2000:
Population of San Diego region surpasses 2.8 million
Urban land use dominates

1985:
Sediment from Carmel Valley raised elevation of northeast corner of lagoon 6.1', converting salt marsh into riparian/cattail marsh (over past 16 years)
Los Peñasquitos Lagoon Enhancement Plan and Program report. Notes that gradual sediment accumulation has created areas of higher elevation which limits tidal reach

Late1980s:
Carmel Valley and Carroll Canyon creeks began flowing year-round

1996:
Los Peñasquitos Lagoon listed as impaired for sedimentation/siltation

1998:
Salinity decreases in highest vegetation transects
Loss of native marshland due to wastewater pump and I-5 ramp construction

2000-2010 Current Urbanization Trends

2003:
Sorrento Valley Road converted to bike path

2005:
New bridge built over lagoon mouth, enhances tidal exchange

Current:
TMDL development

Figure 10. Timeline of urbanization and lagoon trends (mid 1970s through current)

4.1 Selection of TMDL Numeric Target

A numeric sediment TMDL target was established in the Technical Support Document (Attachment 1) prepared by Tetra Tech, Inc. in collaboration with the municipalities within the Los Peñasquitos watershed (City of San Diego, San Diego County, City of Del Mar, and City of Poway), the California Department of Transportation (Caltrans), San Diego Coastkeeper, California State Parks, the Los Peñasquitos Lagoon Foundation, and representatives from the San Diego Water Board.

Through a 'weight of evidence' approach, the numeric target provides the link to the narrative WQO for sediment and defines the conditions that will result in the attainment of WQS for the Lagoon. Available data and literature studies of the Lagoon and watershed were evaluated to help identify the general time period when sedimentation impacts were likely minimal. This time period defines the reference condition upon which the numeric sediment target load was calculated. This approach was needed because numeric criteria are not specified in California's water quality standards and available data for the Lagoon does not specifically define a sediment loading rate or other measure of natural background sediment loading that can be used for TMDL development.

Several lines of evidence were considered to determine an appropriate reference time period for TMDL development. These lines of evidence include:

- **Urbanization trends**: A review of historical literature indicates that intensive development in the Los Peñasquitos watershed began in the in the mid-1970s. Land use data shows a nearly 37 percentdecrease in open space in the watershed beginning in the mid 1970s.
- **Population data**: Trend analysis of population data indicates that the population of the San Diego region has been steadily increasing since 1970.
- **Flow data**: Review of historical streamflow data from the USGS gage on Los Peñasquitos Creek and the conclusions drawn by White and Greer (2002) indicate that flow has increased substantially since the 1970s. White and Greer (2002) associated these flow increases with urbanization trends in the watershed.
- **Evaluation of Lagoon conditions:** As described above, Lagoon conditions have been influenced by several factors, which can be separated into watershed impacts and problems associated with the lagoon mouth. Watershed impacts to the Lagoon include sediment delivery associated with urban development, which increased substantially in the mid-1970s. The wastewater treatment plants impacted water quality in the Lagoon until 1972 when the area was connected to the city sewer system, making it difficult to differentiate between the wastewater impacts and development-associated impacts during this time period (pre-1972).

> Available literature indicates that sediment deposition from the watershed is not adequately flushed out of the system due to problems at the lagoon mouth caused by the railroad berm (and other physical alterations) and sediment build-up at the ocean inlet. Note that the Highway 101 bridge abutments were recently replaced and have resulted in improved tidal exchange through the area. As discussed above, reductions in the tidal prism have resulted in increased sediment build-up at the ocean inlet. Sediment impacts at the ocean inlet are primarily a function of littoral forces (Elwany, 2008) and other factors that are largely separate from the sedimentation problems that originate from the watershed. These factors are important to understand in order to effectively manage and improve conditions within the Lagoon, but are outside the scope of the sediment TMDL analysis.

Consideration of these various lines of evidence indicates that the Lagoon was likely achieving the water quality standard for sediment before the mid-1970s. A historic coverage for the Los Peñasquitos watershed was developed for this period using US Geological Survey topographic maps from the 1970s (primarily the La Jolla quadrangle-dated 1975). This historic land use distribution (Figure 3) was used to calculate the numeric target using the LSPC watershed model (see Attachment 2). This historic sediment load of 12,360 tons per critical wet period (58.6 tons per day) represents the sediment TMDL numeric target.

5 Source Assessment

The purpose of the source assessment is to identify and quantify the sources of sediment to the Los Peñasquitos Lagoon. Sediment can enter surface waters from both point and nonpoint sources. Point sources typically discharge at a specific location from pipes, outfalls, and conveyance channels from, for example, municipal wastewater treatment plants or municipal separate storm sewer systems (MS4s). These discharges are regulated through waste discharge requirements (WDRs) that implement federal NPDES regulations issued by the State Water Board or the San Diego Water Board through various orders. Nonpoint sources are diffuse sources that have multiple routes of entry into surface waters. Some nonpoint sources, such as agricultural and livestock operations, are regulated under the Basin Plan's waste discharge requirement waiver policy. The source assessment quantification is measured as an annual or daily load, which is then used to separate the load allocations or wasteload allocations for the TMDL. The following sections discuss the sediment sources that contribute to Los Peñasquitos Lagoon.

5.1 Land Use/Sediment Source Correlation

Sources of sediment are generally the same under both wet weather and dry weather conditions; however, storm events can cause significant erosion and transport of sediment downstream (especially from canyon areas below storm water outfalls). Dry weather loading is dominated by nuisance flows from urban land use activities such as car washing, sidewalk washing, and lawn over-irrigation, which pick up and transport sediment into receiving waters. Wet weather loading is dominated by episodic storm flows that wash off built up sediment on land surfaces, erode canyon areas below storm water outfalls, and scour stream banks. Some of these processes are exacerbated by anthropogenic disturbances, such as urban development within the watershed. Urban development transforms the natural landscape and results in increased runoff due to hydromodification resulting in scouring of sediment, primarily below storm water outfalls that discharge into canyon areas. Sediment loads are transported downstream to the Lagoon during storm events causing deposits on the salt flats and in Lagoon channels. Due to the higher runoff potential associated with wet weather conditions, emphasis was placed on characterizing wet weather watershed loading.

Sediment sources were quantified by land use group since sediment loading can be highly correlated with land use practices. Since several land use types share hydrologic or pollutant loading characteristics, many were grouped into similar classifications, resulting in a subset of nine categories for modeling. Selection of these land use categories was based on the availability of monitoring data and literature values that could be used to characterize individual land use contributions and critical sediment-contributing practices associated with different land uses. For example, multiple urban categories were represented independently (e.g., high density residential, low density residential, and commercial/institutional), whereas other natural categories were grouped. The three major land use sources in the watershed are open space, low density residential, and industrial/transportation.

The sediment load contributed by each land use type was calculated using the LSPC model. Modeling parameters varied by land use to provide the correlation between sediment loading and land use type. The amount of runoff and associated sediment concentrations are highly dependent on land use.

5.2 Point Sources

Storm water runoff is regulated through the following NPDES permits: the San Diego County Phase I municipal separate storm sewer system (MS4) permit, the Phase II MS4 permit for small municipal dischargers, and the statewide storm water permit issued to Caltrans. The permitting process defines these discharges as point sources because storm water is discharged from the end of a storm water conveyance system, as described below. NPDES permits are also issued for construction and industrial sites that are enrolled in the statewide General Storm Water permit program. These sites are located within areas controlled by the San Diego County Phase I MS4 permit and are, therefore, not specifically included in the TMDL analysis.

5.2.1 Phase I Municipal Separate Storm Sewer System (MS4)

Twenty one entities are identified in San Diego Water Board Order R9-2007-0001 (NPDES No. CAS0108758) and are responsible for addressing water quality concerns for the MS4 (San Diego Water Board, 2007). Responsible Municipal Dischargers within the Los Peñasquitos watershed are San Diego County, the City of San Diego, the City of Del Mar, and the City of Poway.

All land uses were classified as generating point source loads because, although the sediment sources on these land use types may be diffuse in origin, the pollutant loading is transported and discharged to receiving waters through the MS4. Sediment loads that are attributed to point sources are discharged via the MS4 from all land uses. Note that several construction and industrial sites regulated under the General Statewide Storm Water Permit program are located within the Phase 1 MS4 permitted area.

During wet weather events, significant erosion can occur along canyon walls below storm water outfalls. Sediment also builds up on the land surface from various sources and associated management practices and is then washed off the surface during rainfall events. Runoff from urbanized areas into the MS4 can be characterized as "hungry" flows capable of exacerbating the natural erosion and scouring processes of the creek.

The amount of runoff and associated concentrations are, therefore, highly dependent on the nearby land management practices. Note that the redistribution of sediment to other areas of the Lagoon can be caused by both anthropogenic and natural processes; however, most of the sediment is contributed by point sources in the watershed so this resuspension is associated with and quantified in the MS4 load calculations.

5.2.2 Phase II Municipal Separate Storm Sewer System (MS4)

Entities that enroll in the General Permit for the Discharge of Storm Water from Small MS4s, Water Quality Order No. 2003-0005-DWQ are responsible for addressing water quality concerns from their small MS4s. In general, these are storm water systems serving public campuses (including universities, community colleges, primary schools, and other publicly owned learning institutions with campuses), military bases, and prison and hospital complexes within or adjacent to other regulated MS4s, or which pose significant water quality threats. In the San Diego Region, there are no small MS4s currently enrolled under Order No. 2003-0005-DWQ.

As with Phase I MS4s, pollutants build up on land surfaces within small MS4s and are then washed off during rainfall events. In addition, urbanized areas within the Phase II MS4s also generate "hungry" flows that exacerbate the natural erosion and scouring processes of the creek. The amount of runoff and associated concentrations are highly dependent on the nearby land uses and management practices.

5.2.3 Caltrans MS4s

Caltrans is regulated by a statewide storm water discharge permit that covers all municipal storm water activities and construction activities (State Board Order No. 99-06-DWQ; CAS000003). The Caltrans storm water permit authorizes storm water discharges from Caltrans properties such as the state highway system, park and ride facilities, and maintenance yards. The storm water discharges from most of these Caltrans properties and facilities eventually ends up in either a city or county storm drain system.

5.3 Nonpoint Sources

A nonpoint source is a source that discharges via sheet flow or natural discharges. Additionally, storm surges and ocean tides can be a source of sediment to the mouth of the Lagoon as evidenced by a recent study found that accumulated sediment at the Lagoon's ocean inlet was similar to beach sediment and tidal sources (Elwany, 2008). For this reason, watershed loading was assumed to have a less significant contribution to sediment build-up at the inlet. Beach erosion processes cannot be modeled with the existing model configuration which lacks wave, wave-breaking, and wave-current interaction components; therefore, sediment modeling used a reduced grid which sets the open ocean boundary immediately outside of the ocean inlet (see Attachment 2 for a more detailed discussion).

6 Linkage Analysis

The technical analysis of the relationship between pollutant loading from identified sources and the response of the waterbody to this loading is referred to as the linkage analysis. The purpose of the linkage analysis is to quantify the maximum allowable sediment loading that can be received by an impaired waterbody and still attain the WQOs of the applicable beneficial uses. This numeric value is represented by the TMDL.

The linkage analysis for this TMDL is based on computer models that were developed to represent the physical processes within the impaired receiving waterbody and the associated watershed. The models provide estimation of sediment loadings from the watersheds based on rainfall events and simulation of the response of the receiving water to these loadings. The following sections provide more detailed discussion regarding model selection and linkage analyses.

6.1 Date Inventory and Analysis

Multiple data sources were used to characterize the watershed and Lagoon, in particular stream flow and water quality conditions. Much of this information was recently collected by watershed stakeholders to assist with TMDL model development. Data describing the watershed's topography, land use, soil characteristics, meteorological data, and irrigation needs along with available bathymetric survey information and data sondes analyzing pressure and salinity were used to calibrate the watershed and Lagoon models. The Technical Support Document (Attachment 1) summarizes stream flow and total suspended sediment data.

6.2 Model Selection Criteria

In selecting an appropriate approach for TMDL calculation, technical and regulatory criteria were considered.

6.2.1 Technical Criteria

Technical criteria include the physical domain, source contributions, critical conditions, and constituents to be addressed. The physical domain is the one of the most important considerations in model selection and accounts for watershed or receiving water characteristics and processes

6.2.2 Regulatory Criteria

Regulatory criteria include water quality objectives or procedural protocol. The modeling framework must enable direct comparison of model results to the selected numeric target and allow for the analysis of the duration of watershed and receiving water conditions. For the watershed loading analysis and implementation of required reductions, it is also important that the modeling framework allow for the examination of gross land use loading.

6.3 Model Selection and Overview

A properly designed and applied model provides the source-response linkage component of the TMDL and enables accurate assessment of assimilative capacity and allocation distribution. The receiving water's assimilative capacity is determined by assuming adherence to WQOs. For all waters in the San Diego Region, the Basin Plan establishes the beneficial uses for each waterbody to be protected and the WQOs that protect those uses. In the case of narrative objectives, interpretation is required to develop a numeric target for TMDL development (refer to Section 4). Establishing the relationship between the receiving water quality target and source loading is a critical component of TMDL development. This allows for the evaluation of management options that will help achieve the desired source load reductions. This can be established through a number of techniques, ranging from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. The objective of this section is to present the approach taken to develop the linkage between sources and receiving water responses for TMDL development in the Lagoon.

The modeling system was divided into two components representative of the processes essential for accurately modeling hydrology, hydrodynamics, and water quality. The first component of the modeling system, the Loading Simulation Program in C++ (LSPC) model, is a watershed model that predicts runoff and external pollutant loading as a result of rainfall events. The second component, the Environmental Fluids Dynamic Code (EFDC) model, is a hydrodynamic and water quality model that simulates the complex water circulation and pollutant transport patterns in the Lagoon.

6.3.1 Watershed Model: Loading Simulation Program in C++ (LSPC)

LSPC was selected for simulation of land-use based sources of sediment and the hydrologic and hydraulic processes that affect delivery (Shen et al., 2004; Tetra Tech and USEPA, 2002; USEPA, 2003). LSPC was specifically used to simulate watershed hydrology and transport of sediments in the streams and storm drains flowing to the impaired Lagoon. LSPC is a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) (Bicknell et al., 1997) algorithms for simulating hydrology, sediment, and general water quality on land, as well as a simplified stream fate and transport model. Since its original public release, the LSPC model has been expanded to include additional GQUAL components for sorption/desorption of selected water quality constituents with sediment, enhanced temperature simulation, and the HSPF RQUAL module for simulating dissolved oxygen, nutrients, and algae.

The hydrologic (water budget) process is complex and interconnected within LSPC. Rain falls and lands on various constructed landscapes, vegetation, and bare soil areas within a watershed. Varying soil types allow the water to infiltrate at different rates while evaporation and plant matter exert a demand on this rainfall. Water flows overland and through the soil matrix. There may also be point source discharge and water withdrawals/intakes. The land representation in the LSPC model environment considers three flowpaths; surface, interflow, and groundwater outflow. The sediment routine in LSPC represents the general detachment of sediment due to rainfall, overland and instream transport, attachment when there is no rainfall, and scour.

The model can simulate sediment loadings from specific source areas (i.e., subwatershed or land use areas). This is important in terms of TMDL development and allocation analysis. For this TMDL, the LSPC model was used to calculate both historic and existing conditions within the watershed to establish the TMDL numeric target and required load reductions from existing conditions. The LSPC model output was incorporated as an input to the receiving water model for the Lagoon, as described below.

6.3.2 Lagoon Model: Environmental Fluid Dynamics Code (EFDC)

The Los Peñasquitos Lagoon was simulated using the EFDC model. The LSPC watershed model was linked to EFDC and provided all freshwater flows and loadings as model input. EFDC is a public domain, general purpose modeling package for simulating one-dimensional (1-D), two-dimensional (2-D), and three-dimensional (3-D) flow, sediment transport, and biogeochemical processes in surface water systems including rivers, lakes, estuaries, reservoirs, wetlands, and coastal regions. The EFDC model was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications (Hamrick, 1992). This model is now being supported by the USEPA and has been used extensively to support TMDL development throughout the country. In addition to hydrodynamic, salinity, and temperature transport simulation capabilities, EFDC is capable of simulating cohesive and noncohesive sediment transport, near-field and far-field discharge dilution from multiple sources, eutrophication processes, the transport and fate of toxic contaminants in the water and sediment phases, and the transport and fate of various life stages of finfish and shellfish. The EFDC model has been extensively tested, documented, and applied to environmental studies worldwide by universities, governmental agencies, and other entities.

The EFDC model includes four primary modules: (1) a hydrodynamic model, (2) a water quality model, (3) a sediment transport model, and (4) a toxics model. The hydrodynamic model predicts water depth, velocities, and water temperature. The water quality portion of the model uses the results from the hydrodynamic model to compute the transport of the water quality variables. The water quality model then computes the fate of up to 22 water quality parameters including dissolved oxygen, phytoplankton (three groups), benthic algae, various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria (Cerco and Cole 1994). The sediment transport and toxics modules use the hydrodynamic model results to calculate the settling of suspended sediment and toxics, resuspension of bottom sediments and toxics, and bed load movement of noncohesive sediments and associated toxics. For this project, the hydrodynamics and sediment transport models were used. The hydrodynamics model simulated the circulation, water temperature, and salinity in the lagoon driven by ocean tides and watershed inflows. The sediment transport model simulated the transport of sand, silt as non-cohesive sediments, and clay as cohesive sediment. Details of the EFDC model's hydrodynamic and eutrophication components are provided in Hamrick (1992) and Tetra Tech (2002, 2006a, 2006b, 2006c, 2006d).

The EFDC model was configured to simulate hydrodynamics and sediment transport in the Los Peñasquitos Lagoon for both existing and historic conditions. Specifically, water temperature and salinity were both modeled for hydrodynamics. Sediment fractions considered in the model include sand, silt, and clay. Sand and silt were modeled using the non-cohesive sediment module and clay was modeled using the cohesive sediment module in EFDC.

6.4 Model Application

A complete discussion, including model configuration, hydrologic and hydrodynamic calibration and validation, and water quality calibration and validation of the LSPC and EFDC models is provided in the Modeling Report (Attachment 2).

The models were initially calibrated to observed hydrologic and water quality data to characterize existing conditions in the watershed and Lagoon (required load reductions are based on these existing loads). In addition, the models were used to establish a TMDL numeric target for sediment. As described in Section 4, a historical review of available literature regarding urbanization trends and Lagoon impacts was used to identify an appropriate time period (mid 1970s) for calculating the numeric target that represents the sediment WQO. Conditions present at this time were associated with loads that met WQOs and did not adversely impact the Lagoon. To characterize this historical period, historic land use coverage for the watershed was developed and model simulations were performed. The resulting historical net annual sediment load was identified as the TMDL numeric target and represents the loading (assimilative) capacity for the lagoon (i.e. the TMDL). Percent reductions were calculated based on the difference between the TMDL load and the sediment load that corresponds with existing conditions.

7 Identification of Load Allocations and Reductions

The calibrated models were used to simulate historical and existing sediment loads to the Los Peñasquitos Lagoon from which numeric targets and load reductions were established. Point sources were then assigned a wasteload allocation (WLA) while nonpoint sources were assigned a load allocation (LA). This section discusses the methodology used for TMDL development and the results in terms of loading capacities and required load reductions for the Los Peñasquitos Lagoon. Other TMDL components are also discussed including the margin of safety (MOS), seasonality and critical conditions, and a daily load expression.

7.1 Loading Analysis

Existing sediment loads to the Lagoon were estimated using the calibrated LSPC model and receiving water conditions were simulated using the EFDC model (see Attachment 2). Using the EFDC model, the assimilative capacity of the Lagoon was assessed and compared to the historical numeric target for evaluation of sediment quality.

7.2 Application of Numeric Targets

As discussed in Section 4, the narrative WQO for sediment was interpreted using a weight of evidence approach to determine a reference condition to define the TMDL numeric target (i.e., a historical period when the Lagoon was not impaired for sedimentation). Several lines of evidence used to establish a numeric sediment target include: urbanization trends, population data, flow data, and evaluation of Lagoon conditions over time.

7.3 Load Estimation

Estimation of current watershed loading to the impaired Lagoon required use of the LSPC model to predict flows and pollutant concentrations. The dynamic model-simulated watershed processes, based on observed rainfall data as model input, provided temporally variable load estimates for the critical period. These load estimates were simulated using calibrated, land use-specific processes associated with hydrology and sediment transport (see Attachment 2).

7.4 Identification of Critical Conditions

Due to the higher transport potential of sediment during wet weather, the 1993 El Nino time period was selected as the critical period for assessment. The wet season that includes the 1993 El Nino storm events (10/1/92 – 4/30/93) is one of the wettest periods on record over the past several decades. Statistically, 1993 corresponds with the 93rd percentile of annual rainfall for the past 15 years measured at the San Diego Airport (Lindbergh Field). Selection of this year was also consistent with studies performed by the Southern California Coastal Water Research Project (SCCWRP). An analysis of rainfall data for the Los Angeles Airport from 1947 to 2000 shows that 1993 was the 90th percentile year; meaning 90 percent of the years between 1947 and 2000 had less annual rainfall than 1993. (Los Angeles Water Board, 2002)

7.5 Critical Locations for TMDL Calculation

Due to the variability and dynamic nature of conditions within the Lagoon (e.g., mouth closures, tidal fluctuations, sediment fate and transport, etc.), the entire modeled Lagoon area was assessed as the critical location. Load reductions for sediment were based on achieving the numeric TMDL target across the Lagoon.

7.6 Calculation of TMDL and Allocation of Loads

A TMDL was established for the Lagoon using the methodology described above (Section 6). Conceptually, a TMDL definition is represented by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

The wasteload allocation (WLA) portion of this equation is the total loading assigned to point sources. The load allocation (LA) portion is the loading assigned to nonpoint sources. The margin of safety (MOS) is the portion of loading reserved to account for any uncertainty in the data and computational methodology, as described in Section 8. An implicit MOS was incorporated for this TMDL.

Load calculations for sediment were developed using land use-based generation rates and meteorological conditions from the critical wet period (10/1/92 – 4/30/93).

7.7 Wasteload Allocations

The point sources identified in the Los Peñasquitos watershed are Phase I MS4 co-permittees (San Diego County and the cities of San Diego, Poway, and Del Mar), Phase II MS4s, and Caltrans. The existing loads estimated were solely the result of watershed runoff (land-use based) and streambank erosion and not other types of point sources. The total sediment contribution from all dischargers in the watershed is presented as the WLA.

Permittees enrolled under the General Statewide Construction and Industrial Storm Water Permit program are located within the permitted area of the Phase 1 MS4 municipalities and are, therefore, included in the total WLA. Additional information may be needed in the future to help determine the contribution from construction areas and industrial facilities in the watershed to assist with implementation planning. No other individual NPDES permits for point sources are located in the watershed.

7.8 Load Allocations

According to federal regulations (40 CFR 130.2(g)), load allocations are best estimates of the nonpoint source or background loading. For the Los Peñasquitos watershed, land use contributions to MS4 systems are included in the WLAs described above, including contributions due to hydromodification and accelerated erosion. A LA was assigned to sediment contributions from storm surges and wave action along the ocean boundary (ocean sediment contributions).

7.9 Summary of TMDL Results

The overall TMDL and its component loads are presented in Table 2. Daily loads are established by dividing the modeled loads by the number of days within the critical wet period (211 days). Current loads, historical loads, and required reductions are presented in Table 3. Existing loads were estimated based on modeling of current land use conditions (from the SANDAG 2000 land use coverage) and meteorological conditions from the critical wet period (10/1/92 – 4/30/93). As described in Section 4, the numeric target was calculated based on modeling of historical (mid-1970s) land use conditions and the same meteorological data in order to accurately compare the watershed and Lagoon response to the same weather conditions. Historic loads define the allowable load; therefore, required load reductions represent the difference between current sediment loads and historic (allowable) loads.

Note that sediment dynamics within the Lagoon are dependent on a number of factors, including runoff volumes and the amount of sediment that is transported to the lagoon from the watershed. These factors are important components in determining the timing and magnitude of erosion and depositional processes within the Lagoon. The Lagoon model shows that a reduction in watershed sediment loading affects the amount of sediment that can deposit throughout the Lagoon from oceanic inputs (considering the input of sediment from the ocean boundary under current and historical conditions is constant). The model analysis for historical conditions indicates that a greater proportion of sediment that deposits in the Lagoon originates from tidal inputs during lower watershed loading periods; therefore, the TMDL results show that a net increase in oceanic loads occurs during the critical wet period under historical landuse conditions. To meet the TMDL, the total load reduction required from the watershed is approximately 67 percent. Tidal input from the ocean boundary represents natural background loads; therefore, no reduction is required for this source category.

Table 2. TMDL summary

Source	Critical Wet Period Load (tons)	Daily Load (tons)
TMDL	12,360	58.6
Watershed contribution (WLA)	2,580	12.2
Ocean boundary (LA)	9,780	46.4
MOS	Implicit	Implicit

Table 3. Current vs. historical loads and percent reduction

Source	Current Load (tons)	Historical Load (tons)	Load Reduction (tons)	Percent Reduction Required
Watershed contribution (WLA)	7,719	2,580	5,139	**67%**
Ocean boundary (LA)	5,944	9,780	+3,836 (increase)	+39% (increase)
Total	13,663	12,360	1,303	10%

7.10 Daily Load Expression

Load allocations are expressed in terms of net sediment load for the critical period (tons) because sediment delivery to streams is highly variable on a daily and annual basis. Loads were also divided by the number of days in the critical period (211) to derive daily loading rates (tons/mi^2/day). The USEPA expects the load allocations to be evaluated using a long-term rolling average period (e.g. 15-year), because of the natural variability in sediment delivery rates. In addition, USEPA does not expect each square mile within a particular source category throughout the watershed to necessarily meet the load allocation; rather, USEPA expects the watershed average for the entire source category to meet the load allocation for that category.

7.11 Margin of Safety

A margin of safety (MOS) is incorporated into a TMDL to account for uncertainty in developing the relationship between pollutant discharges and water quality impacts (USEPA, 1991). For this TMDL, an implicit MOS was included through the application of conservative assumptions throughout TMDL development. The following list describes several key assumptions that were used.

- **Critical condition** - The wet season that includes the 1993 El Nino storm events (10/1/92 – 4/30/93) was selected as the critical condition time period for TMDL development. This is one of the wettest periods on record over the past several decades. Because of the large amount of rainfall, sediment loads were significantly higher during this period than in other years with less rainfall.

- **Soil composition** - Soils that are more easily transported typically have higher proportions of smaller particles sizes (silt and clay fractions), as compared to local parent soils, because of differences in settling rates and other sediment transport characteristics. To account for these differences in the model, soils transported by surface runoff were assumed to be composed of 5 percent sand, twice as much clay as the percentage of clay within each hydrologic soil group, and the remainder assigned to the silt fraction.

- **Numeric target** - The historical analysis involved an extensive literature search and technical analysis in order to identify an appropriate time period for development of the numeric sediment target. This comprehensive 'weight of evidence' analysis considered all available information regarding urbanization and lagoon impacts over time in order to identify a conservative reference condition.

7.12 Seasonality

The federal regulations at 40 CFR 130.7 require that TMDLs include seasonal variations. Sources of sediment are similar for both dry and wet weather seasons (the two general seasons in the San Diego region). Despite the similarity of wet/dry sources, transport mechanisms can vary between the two seasons. Throughout the TMDL monitoring period, the greatest transport of sediment occurred during rainfall events. It is recognized that dry weather will contribute a deminimus discharge of sediment; however, model calibration and TMDL development focused on wet weather conditions as sediment transport is dramatically higher during wet weather. Model simulation was completed for the 10/1/92–4/30/93 wet period to account for the much greater sediment loading and associated impacts to the Lagoon during this time period.

8 Legal Authority for TMDL Implementation Plan

This section presents the legal authority and regulatory framework used as a basis for assigning responsibilities to dischargers to implement and monitor compliance with the requirements set forth in this TMDL. The laws and policies governing point source[5] and nonpoint source discharges are described below.

Discharger accountability for attaining sediment allocations is established in this section. The legal authority and regulatory framework is described in terms of the following:

- Controllable water quality factors;
- Regulatory framework;
- Persons accountable for point source discharges; and
- Persons accountable for controllable nonpoint source discharges.

8.1 Controllable Water Quality Factors

The source analysis (section 5) found that the vast majority of sediment is transported to the Los Peñasquitos Lagoon through storm water runoff. Some of these sediment discharges result from controllable water quality factors which are defined as those actions, conditions, or circumstances resulting from human's activities that may influence the quality of the waters of the state and that may be reasonably controlled.

8.2 Regulatory Framework

The regulatory framework for point sources of pollution differs from the regulatory framework for nonpoint sources. The different regulatory frameworks are described in the subsections below.

8.2.1 Point Sources

Clean Water Act section 402 established the National Pollutant Discharge Elimination System (NPDES) program to regulate the ‘‘discharge of a pollutant,’’ other than dredged or fill materials, from a ‘‘point source’’ into ‘‘waters of the U.S.” Under section 402, discharges of pollutants to waters of the U.S. are authorized by obtaining and complying with NPDES permits.

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[5] The term ‘‘point source’’ is defined in CWA section 502(14) to mean any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.

In California, state Waste Discharge Requirements (WDRs) implement federal NPDES regulations and CWA requirements, and are referred to as NPDES requirements. NPDES requirements are issued by the State pursuant to independent State authority described in California's Porter Cologne Water Quality Control Act[6] (not authority delegated by the USEPA or derived from the Clean Water Act).

Because point source discharges of sediment to the Lagoon were largely determined to be from storm water runoff discharged from MS4s (municipal and Caltrans), the primary mechanism for TMDL attainment will be regulation of these discharges with NPDES requirements, which are discussed in the Implementation Plan, section 9.

8.2.2 Nonpoint Sources

While laws mandating control of point source discharges are contained in the federal CWA's NPDES regulations, direct control of nonpoint source pollution is left to State programs developed under State law. The LAs for nonpoint sources are not directly enforceable under the Clean Water Act and are only enforceable to the extent they are made so by State laws and regulations. The California Water Code also applies to both point and nonpoint sources of pollution and serves as the principle legal authority in California for the regulation of discharges from controllable nonpoint sources.

The State policy pertaining to regulation of controllable nonpoint sources of pollution in California is provided in the *Plan for California's Nonpoint Source Pollution Control Plan* (NPS Program Plan) and the *Policy for the Implementation and Enforcement of the Nonpoint Source Pollution Control Program* (NPS Implementation and Enforcement Policy).

Nonpoint source discharges from natural sources are considered largely uncontrollable, and therefore should not be regulated. Sediment discharged via tidal exchange is an example of an uncontrollable nonpoint sediment source that is not governed by a MS4 permit. Hydromodification and accelerated erosion via storm water runoff are considered controllable point sources of sedimentation.

8.3 Persons Responsible for Point Source Discharges

Persons identified as responsible for point source discharges of sediment include the following entities:

- Municipal Phase I urban runoff dischargers (Phase I MS4s) including the County of San Diego, City of San Diego, City of Del Mar, and City of Poway
- Phase II dischargers

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[6] Division 7 of the Water Code, commencing with section 13000

- Caltrans
- General Statewide Construction and Industrial Storm Water Permittees within the Los Peñasquitos Watershed

A total WLA, as shown in Table 2, is assigned to all point sources within the watershed.

8.4 Persons Responsible for Controllable Nonpoint Source Discharges

No controllable nonpoint source discharges are identified in the Los Peñasquitos Watershed.

9 Implementation Plan

The ultimate goal of the Implementation Plan is to restore the impaired beneficial uses of the waterbody addressed by this TMDL. Restoring the impaired beneficial uses will be accomplished by achieving the TMDLs in the receiving waters, the wasteload allocations (WLAs) for point sources, and the load allocations (LAs) for nonpoint sources. This section describes the actions necessary to implement the TMDL such that when all discharges from controllable sources meet the total assigned WLA (and concurrently the numeric target), watershed sediment contributions will no longer impact beneficial uses in the Lagoon and compliance with the TMDL will be achieved.

TMDLs are not self-implementing or directly enforceable for sources in the watershed. Instead, TMDLs must be implemented through the programs or authorities of the San Diego Water Board and/or other entities to compel dischargers responsible for controllable sources to achieve the pollutant load reductions identified by a TMDL analysis to restore and protect the designated beneficial uses of a waterbody. Federal regulations require TMDLs to be incorporated into the Basin Plan.[7] Because TMDLs must be incorporated into the Basin Plan, and are developed to implement previously established water quality standards (i.e., beneficial uses and WQOs), state statute requires the Basin Plan amendment to include a program of implementation (or Implementation Plan) for achieving water quality objectives.[8]

9.1 Regulatory Authority for Implementation Plans

TMDL implementation plans are not currently required under federal law; however, federal policy is that TMDLs should include implementation plans. USEPA policy is that states must include implementation plans as an element of TMDL Basin Plan amendments submitted to USEPA for approval.[9]

TMDL implementation plans are required under State law. Basin plans must have a program of implementation to achieve WQOs.[10] The implementation plan must include a description of actions that are necessary to achieve the objectives, a time schedule for these actions, and a description of surveillance to determine compliance with the

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[7] Code of Federal Regulations Title 40 section 130.6(c)(1)

[8] Water Code section 13242

[9] See *Guidance for Developing TMDLs in California,* USEPA Region 9, (January 7, 2000).

[10] See Water Code section 13050(j). A “Water Quality Control Plan” or “Basin Plan” consists of a designation or establishment for the waters within a specified area of all of the following: (1) Beneficial uses to be protected, (2) Water quality objectives and (3) A program of implementation needed for achieving water quality objectives.

WQOs.[11] State law requires that a TMDL include an implementation plan since a TMDL supplements, interprets, and/or refines existing water quality objectives. The TMDLs, LAs, and WLAs must be incorporated into the Basin Plan.[12]

9.2 San Diego Water Board Actions

This section describes the actions that the San Diego Water Board will take to implement the TMDLs. The San Diego Water Board uses its authorities and programs to regulate discharges from the controllable sources in the Region. The controllable sources that are subject to regulation are, in turn, responsible for complying with the requirements issued by the San Diego Water Board. Ultimately, the dischargers subject to regulation are responsible for reducing their pollutant loads in order for the TMDLs, WLAs, and LAs to be achieved and for beneficial uses to be restored.

The authorities that are available to the San Diego Water Board to regulate dischargers are given under the Porter-Cologne Water Quality Control Act (Division 7 of the Water Code). The available regulatory authorities include incorporating discharge prohibitions in to the Basin Plan,[13] issuing individual or general WDRs,[14] or issuing individual or general conditional waivers of WDRs.[15] The San Diego Water Board has the authority to enforce Basin Plan prohibitions, WDRs, or conditional waivers of WDRs through the issuance of enforcements actions (e.g., time schedule orders, cleanup and abatement orders, cease and desist orders, administrative civil liabilities).[16] The San Diego Water Board also has the authority to require monitoring and/or technical reports from dischargers,[17] which may be used to support the development, refinement, and/or implementation of TMDLs, WLAs, and/or LAs. More information on the San Diego Water Board's Regulatory Authority to take such actions can be found in Attachment 3.

The actions taken by the San Diego Water Board depends on the regulatory authority and the source. Table 4 summarizes the actions that the San Diego Water Board will use to implement this TMDL.

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[11] See Water Code section 13242.

[12] See Clean Water Act section 303(e).

[13] Pursuant to Water Code section 13243

[14] Pursuant to Water Code section 13263 and 13264

[15] Pursuant to Water Code section 13269

[16] Pursuant to Water Code sections 13301-13304, 13308, 13350, 13385 and/or 13399

[17] Pursuant to Water Code sections 13225, 13267, and/or 13383

Table 4. Summary of San Diego Water Board actions

Action	Sub-actions
Enforce Basin Plan	Enforce existing Basin Plan waste discharge prohibitions
Issue investigative Orders	Issue California Water Code section 13225, 13267, and/or 13383 investigative orders requiring load reduction plans to be developed on a watershed scale.
Enforce Phase I MS4 permit[a]	Enforce existing discharge prohibitions and receiving water limitations
Revise and reissue Phase I MS4 permit[a]	Incorporate water quality based effluent limitations into permit Incorporate requirement to develop Load Reduction Plan Incorporate compliance schedule
Enroll discharges under Phase II MS4 permit[b]	Require enrollment of small MS4 dischargers under Phase II MS4 permit.
Revise and reissue Phase II MS4 permit[b]	Incorporate water quality based effluent limitations into permit Incorporate requirement to develop Load Reduction Plan Incorporate compliance schedule
Enforce Caltrans permit[c]	discharge prohibitions and receiving water limitations
Revise and reissue Caltrans permit[c]	Incorporate water quality based effluent limitations into permit Incorporate requirement to develop Load Reduction Plan Incorporate compliance schedule
Enforce general industrial storm water permit[d]	Enforce existing discharge prohibitions, effluent limitations, and receiving water limitations
Revise and reissue general industrial storm water permit[d]	Incorporate water quality based effluent limitations into permit Incorporate requirement to develop Load Reduction Plan Incorporate compliance schedule
Enforce general construction storm water permit[e]	Enforce existing discharge prohibitions, narrative effluent limitations, and receiving water limitations
Revise and reissue general construction storm water permit[e]	Incorporate water quality based effluent limitations into permit Incorporate requirement to develop Load Reduction Plan Incorporate compliance schedule
Issue Basin Plan Amendment	Revise the requirements and/or provisions for implementing this TMDL

a. Order No. R9-2007-0001, NPDES No. CAS0108758, *Waste Discharge Requirements (WDRs) for Discharges of Urban Runoff from the Municipal Separate Storm Sewer Systems Draining the Watersheds of the County of San Diego, the Incorporated Cities of San Diego County, the San Diego Unified Port District, and the San Diego County Regional Airport Authority.*
b. Order No. 99-06-DWQ, *National Pollutant Discharge Elimination System (NPDES) Permit for Storm Water Discharges from the State of California, Department of Transportation Properties, Facilities, and Activities*
c. Order No. 2003-0005-DWQ, *National Pollutant Discharge Elimination System (NPDES) General Permit No. CAS000004, Waste Discharge Requirements for Storm Water Discharges from Small Municipal Separate Storm Sewer Systems*
d. Order No. 97-03-DWQ, *National Pollutant Discharge Elimination System (NPDES) General Permit No. CAS000001, Waste Discharge Requirements for Discharges of Storm Water Associated with Industrial Activities Excluding Construction Activities*
e. Order No. 2009-0009-DWQ, *National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities, CAS000002*

9.3 Monitoring for TMDL Compliance

An essential component of implementation is monitoring. Monitoring is needed to evaluate the progress toward attainment of the TMDL and restoring the beneficial uses in the Lagoon.

Additionally, sufficient water quality data are necessary to support the removal of a waterbody from the 303(d) List. Water quality data can also be used to identify additional regulatory actions that may need to be implemented by the San Diego Water Board to restore and protect beneficial uses.

Monitoring for compliance will initially be conducted by the Phase I MS4s and Caltrans. The minimum components for any monitoring program that will be used to evaluate progress toward attainment of the TMDLs should include the following components:

1. Baseline data. Characterize Lagoon and watershed conditions to provide a basis for future comparisons.

2. Implementation monitoring. Ensure that identified management actions are undertaken.

3. Effectiveness monitoring. Assess whether the source controls have the desired effects.

4. Trend Monitoring. Assess changes in conditions over time relative to the baseline and identified target values.

5. Validation Monitoring. Validate source analysis and linkage methods.

The monitoring program must be developed to answer the following questions:

1. What is the ecological health of the Lagoon?
2. How is the Lagoon's health changing with time?
3. Are the dischargers performing actions that are effective at reducing the sediment load?

4a. Are TMDL components accurate and effective?

4b. Are watershed sources of sediment, bacteria, and freshwater adequately characterized?

Because the Phase I MS4s discharge directly to the receiving waters addressed by this TMDL, the municipal Phase I MS4s will be primarily responsible for conducting the monitoring. Caltrans and other significant dischargers will also have monitoring responsibilities. Additional monitoring locations and frequency may be required to identify sources that need additional controls to reduce sediment loads. The municipal Phase I MS4s and other dischargers may wish to establish additional monitoring locations at key jurisdictional boundaries as part of their monitoring programs.

Investigative orders, enforcement actions, WDRs, or conditional waiver of WDRs issued by the San Diego Water Board will require monitoring program plans that include, as applicable, the minimum monitoring locations and frequencies outlined above, but also provide the dischargers an opportunity to propose additional or alternative monitoring locations and frequency of monitoring events. The San Diego Water Board may also issue investigative orders, enforcement actions, WDRs, or conditional waiver of WDRs that specify additional or alternative monitoring, monitoring locations, and/or frequency of monitoring events.

The San Diego Water Board will coordinate, to the extent possible, the monitoring that is required by the dischargers, to minimize the monitoring resources required and maximize the temporal and spatial coverage of the data collection.

9.4 Compliance Determination

When all discharges from controllable sources meet the total assigned WLA (and concurrently the numeric target), watershed sediment contributions will no longer impact beneficial uses in the Lagoon and compliance with the TMDL will be achieved.

Compliance with the WLA will be assessed primarily by comparing receiving water suspended load and flow data from the monitoring program above with the total WLA. Responsible parties may also be responsible for achieving surrogate goals (i.e. increase in Lagoon salt marsh habitat, percent improvement in stabilization of canyon bluffs, etc.)

9.5 TMDL Compliance Schedule and Implementation Milestones

The purpose of this TMDL is to restore the impaired beneficial uses of the Lagoon addressed through mandated reductions of sediment from controllable point sources discharging to the Lagoon. The requirements of this TMDL mandate that the San Diego Water Board require dischargers improve water quality conditions in the Lagoon by achieving the assigned WLAs. When all discharges from controllable sources meet the total assigned WLA (and concurrently the numeric target), watershed sediment contributions will no longer impact beneficial uses in the Lagoon and compliance with the TMDL will be achieved.

Until the dischargers achieve their assigned WLA, the beneficial uses of the waterbodies addressed by this project will likely remain impaired, and the dischargers will continue violating one or more Basin Plan waste discharge prohibitions. The San Diego Water Board recognizes that restoring the beneficial uses of the Lagoon impaired by elevated sediment will require time and multiple approaches to implementation. Therefore, the sediment TMDL is expected to be implemented in a phased approach with a monitoring component to identify sediment sources; determine the effectiveness of each phase; and guide the selection of BMPs, as outlined in the BMP programs proposed in the SLRPs.

9.5.1 Compliance Schedule

Full implementation of the TMDL for sedimentation/siltation shall be completed as soon as possible, but no later than 10 years from the effective date.[18]

The San Diego Water Board will require the Phase I MS4s to submit SLRPs outlining a proposed BMP program that will be capable of achieving the necessary load reductions required to attain the sediment TMDL in the Lagoon, within 18 months after the effective date of this TMDL. The Phase I MS4 SLRPs should be incorporated into their Watershed Runoff Management Programs. Caltrans will also be required to develop and submit a SLRP outlining a proposed BMP program that will be capable of achieving the necessary load reductions required to attain the TMDL in the Lagoon, within 18 months after the effective date of this TMDL.

The subwatershed Miramar Reservoir Hydrologic Area (906.10), which is contained in the Peñasquitos Hydrologic Unit, is the contributing watershed for Torrey Pines State Beach at Del Mar, which is identified as impaired for indictor bacteria. The municipal MS4s and Caltrans are subject to the *Revised TMDL for Indicator Bacteria, Project I-Twenty Beaches and Creeks in the San Diego Region* (Bacti I TMDL) and the requirements therein, including development of Comprehensive and Bacteria Load Reduction Plans. Dischargers in the Peñasquitos watershed may find that undertaking concurrent load reduction programs for sediment and bacteria is more cost effective and has fewer potential environmental impacts from structural BMP construction. If this is the case, the dischargers may develop and submit a CLRP for all constituents of concern in lieu of the SLRP, and to propose an appropriately tailored alternative compliance schedule. Proposed alternative compliance schedules tailored under this provision may not extend beyond 20 years from the effective date of the Bacti I TMDL, and must include at least a milestone for achieving a 50 percent sediment load reduction.

9.5.2 Implementation Milestones

Accomplishing the goals of the implementation plan will be achieved by cooperative participation from all responsible parties, including the San Diego Water Board. Major milestones are described in Table 4.

Table 5. *TMDL implementation milestones*

Item	Implementation Action	Responsible Parties	Date

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[18] The effective date is the date the Office of Administrative Law approves this Basin Plan amendment.

Item	Implementation Action	Responsible Parties	Date
1	Obtain approval of Sediment TMDL from the State Water Board, OAL, and USEPA.	San Diego Water Board	Effective date[a]
2	Issue, reissue, or revise general WDRs and NPDES requirements for the Phase I MS4s to incorporate the requirements for complying with the TMDL and total WLA.	San Diego Water Board	Within 5 years of effective date[a]
3	Issue, reissue, or revise general WDRs and NPDES requirements for Caltrans to incorporate the requirements for complying with the TMDL and total WLA.	San Diego Water Board, State Water Board	Within 5 years of effective date[a]
4	Issue, reissue, or revise general or individual WDRs and NPDES requirements for Phase II MS4s to incorporate the requirements for complying with the TMDL and total WLA.	San Diego Water Board, State Water Board	Within 5 years of effective date[a]
5	Completion of Load Reduction Plan	MS4s and NPDES permittees[b]	Within 18 months of OAL effective date of sediment TMDL[a]
6	Comments on Load Reduction Plan	MSan Diego Water Board Executive Officer	Within 6 months of submittal
7	Phased, adaptive implementation of Load Reduction Plan	MS4s and NPDES permittees[b]	In accordance with load reduction strategy - ongoing throughout implementation
8	Submit SLRP Progress Reports to San Diego Water Board	MS4s and NPDES permittees[b]	In accordance with respective permit annual reporting dates
9	Enforcement Actions	San Diego Water Board	As needed after effective date[a]

Item	Implementation Action	Responsible Parties	Date
10	Refine Load Reduction Plan	MS4s and NPDES permittees[b]	As warranted by completion of special studies, additional monitoring and data compilation, or as requested by the Executive Officer
11	Reopen and reconsider TMDL	San Diego Water Board	As defensible by additional data and significant findings as compiled by dischargers and/or watershed stakeholders[c]
12	Meet Interim Goal #1 of 20% required reduction in sediment or documented improvement in surrogate goals	MS4s and NPDES permittees[b]	Within 5 years of effective date of TMDL[a]
13	Meet Interim Goal #2 of 40% required reduction in sediment or documented improvement in surrogate goals	MS4s and NPDES permittees[b]	Within 9 years of effective date of TMDL[a]
14	Meet Interim Goal #3 of 60% required reduction in sediment or documented improvement in surrogate goals	MS4s and NPDES permittees[b]	Within 13 years of effective date of TMDL[a]
15	Meet Interim Goal #4 of 80% required reduction in sediment or documented improvement in surrogate goals	MS4s and NPDES permittees[b]	Within 15 years of effective date of TMDL[a]
16	Attain final 100% reduction in sediment or documented surrogate goals	MS4s and NPDES permittees[b]	Within 20 years of effective date of TMDL[a]

[a] Effective date is the date of approval by OAL.

[b] When a Phase II MS4 is enrolled under the State General Permit for Small MS4s or issued an individual NPDES permit, the Municipal Dischargers will be both the Phase I MS4s and Phase II MS4s in this Implementation Milestone item.

[c] If no Basin Plan amendment has been initiated within five years of the effective date of this TMDL Basin Plan amendment and the San Diego Water Board determines that insufficient data exist to support the initiation of a Basin Plan amendment, a subsequent Basin Plan amendment to revise the requirements and/or provisions for the implementation of this TMDL will not be initiated until the Executive Officer determines the conditions to initiate a Basin Plan amendment are met.

10 Environmental Analysis, Environmental Checklist, and Economic Factors

To be included after peer review.

11 Necessity of Regulatory Provisions

The Office of Administrative Law (OAL) is responsible for reviewing administrative regulations proposed by State agencies for compliance with standards set forth in California's Administrative Procedure Act, Government Code section 11340 *et seq.*, for transmitting these regulations to the Secretary of State and for publishing regulations in the California Code of Regulations. Following State Water Board approval of this Basin Plan amendment establishing a TMDL, any regulatory portions of the amendment must be approved by the OAL per Government Code section 11352. The State Water Board must include in its submittal to the OAL a summary of the necessity[19] for the regulatory provision.

This Basin Plan amendment for sediment impairment of the Los Peñasquitos Lagoon meets the "necessity standard" of Government Code section 11353(b). Amendment of the Basin Plan to establish and implement the sediment TMDL for the Los Peñasquitos Lagoon is necessary because the existing water quality does not meet the applicable narrative sediment WQOs. Applicable State and federal laws require the adoption of this Basin Plan amendment and regulations as provided below.

The State Water Board and Regional Water Boards are delegated the responsibility for implementing the California Water Code and the federal CWA. Pursuant to relevant provisions of both of these acts the State Water Board and Regional Water Boards establish water quality standards, including designated (beneficial) uses and criteria or objectives to protect those uses.

Section 303(d) of the CWA [33 USC section 1313(d)] requires the states to identify certain waters within its borders that are not attaining water quality standards and to establish TMDLs for the pollutants impairing those waters. USEPA regulations [40 CFR 130.2] provide that a TMDL is a numerical calculation of the amount of a pollutant that a water body can assimilate and still meet standards. A TMDL includes one or more numeric targets that represent attainment of the applicable standard, considering seasonal variations, a margin of safety, and load allocations. TMDLs established for impaired waters must be submitted to the USEPA for approval.

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[19] "Necessity" means the record of the rulemaking proceeding demonstrates by substantial evidence the need for a regulation to effectuate the purpose of the statute, court decision, provision of law that the regulation implements, interprets, or makes, taking into account the totality of the record. For purposes of this standard, evidence includes, but is not limited to, facts, studies, and expert opinion. [Government Code section 11349(a)]

CWA section 303(e) requires that TMDLs, upon USEPA approval, be incorporated into the state's Water Quality Management Plans, along with adequate measures to implement all aspects of the TMDL. In California, these are the basin plans for the nine regions. Water Code sections 13050(j) and 13242 require that basin plans have a program of implementation to achieve WQOs. The implementation program must include a description of actions that are necessary to achieve the objectives, a time schedule for these actions, and a description of surveillance to determine compliance with the objectives. California law requires that a TMDL project include an implementation plan because TMDLs normally are, in essence, interpretations or refinements of existing WQOs. The TMDLs have to be incorporated into the region's basin plan [CWA section 303(e)] because the TMDLs supplement, interpret, or refine existing objectives.

12 Public Participation

Public participation is an important component of TMDL development. Federal regulations [40 CFR 130.7] require that TMDL projects be subject to public review. All public hearings and public meetings have been conducted as stipulated in the regulations [40 CFR 25.5 and 25.6], for all programs under the CWA. Public participation was provided through one public workshop, and through the formation and participation of the Stakeholder Advisory Group. In addition, staff contact information was provided on the San Diego Water Board's website, along with periodically updated drafts of the TMDL project documents. Public participation also took place through the San Diego Water Board's Basin Plan amendment process, which included an additional public workshop, a hearing, and a formal public comment period. A chronology of public participation and major milestones is provided in Table 5.

Table 6. Public participation milestones

Date	Event
February 15, 2011	Public Workshop and CEQA Scoping Meeting
tbd	Draft Documents released for public review
tbd	Public Hearing and Adoption

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Attachment 1

Technical Support Document

Los Peñasquitos Lagoon Sediment/Siltation TMDL

Prepared for:

City of San Diego, Storm Water Department

and

U.S. Environmental Protection Agency Region IX

Prepared by:

TETRA TECH

Final - October 20, 2010

Table of Contents

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Abbreviations:

BAT:	Best Available Technology
BMP:	Best Management Practice
CWA:	Clean Water Act
CFR:	Code of Federal Regulations
EFDC:	Environmental Fluids Dynamic Code
EMC:	Event Mean Concentration
USEPA:	United States Environmental Protection Agency
LA:	Load Allocation
LSPC:	Loading Simulation Program in C++
MLS:	Mass Loading Station
MOS:	Margin of Safety
MS4:	Municipal Separate Storm Sewer System
NPS:	Nonpoint Source Pollution
NPDES:	National Pollutant Discharge Elimination System
SANDAG:	San Diego Association of Governments
TBELs:	Technology Based Effluent Limitations
TMDL:	Total Maximum Daily Load
TSS:	Total Suspended Solids
TWAS:	Temporary Watershed Assessment Stations
USGS:	Unites States Geological Survey
WQOs:	Water Quality Objectives
WLA:	Wasteload Allocation
WDRs:	Waste Discharge Requirements
WQBELs:	Water Quality Based Effluent Limitations (WQBELs)

Executive Summary

The purpose of this technical report is to present the development of a Total Maximum Daily Load (TMDL) for sedimentation/siltation in Los Peñasquitos Lagoon (Lagoon). Sedimentation within the Lagoon has restricted the tidal prism, or exchange between the ocean and the Lagoon, and degraded salt marsh habitats through various processes. As required by Section 303(d) of the Clean Water Act (CWA), a TMDL was developed to address sedimentation within the Lagoon, which was originally identified as impaired for sediment on the 1996 CWA Section 303(d) List of Water Quality Limited Segments.

The purpose of a TMDL is to attain water quality objectives (WQOs) that support beneficial uses in the waterbody. A TMDL is defined as the sum of the waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background [40 CFR 130.2] such that the capacity of the waterbody to assimilate pollutant loading (i.e., the loading capacity) is not exceeded. Therefore, a TMDL represents the maximum amount of the pollutant of concern that the waterbody can receive and still attain water quality standards. Additionally, a TMDL represents a strategy for meeting WQOs by allocating quantitative limits for point and nonpoint pollution sources. Once this maximum pollutant amount has been calculated, it is then divided up and allocated among all of the contributing sources in the watershed.

Based on historical and current accounts of sediment-associated impacts to the Lagoon, the San Diego Regional Water Quality Control Board (Regional Board) placed the Lagoon on the CWA Section 303(d) List of Water Quality Limited Segments as being impaired (i.e., does not meet applicable water quality standards). Sediment water quality standards are narrative in nature and ensure that sediment accumulation or alteration does not cause a nuisance or adversely affect beneficial uses. Excessive sedimentation within the Lagoon threatens critical habitat areas and beneficial uses such as, Estuarine (EST), Marine Life Habitat (MAR), and Preservation of Biological Habitats of Special Significance (BIOL). Additional information on beneficial uses impacted by the impairment is discussed in Section 3.3.

In order to calculate a TMDL for sediment, a numeric target must be identified. A numeric target was selected based on historical conditions that met WQOs and supported the designated beneficial uses of the Lagoon. A historical analysis of available literature that describes the pattern of urbanization within the watershed and impacts to the Lagoon over time was used to identify the time period when the Lagoon met WQOs. Existing and historical land use conditions were then modeled to determine the acceptable net annual sediment load that the Lagoon could assimilate and still meet WQOs.

Available data were used to configure, calibrate, and validate a customized modeling framework developed to support sediment TMDL development. The modeling framework consists of a watershed model (based on the Loading Simulation Program in C++, LSPC) and a receiving water model (based on the Environmental Fluids Dynamic Code, EFDC). The watershed model was used to calculate existing and historical sediment loading to the Lagoon from the Los Peñasquitos watershed, while the Lagoon receiving water model was used to simulate hydrodynamics and sediment transport characteristics for this tidally-influenced waterbody.

A source analysis was performed to identify and quantify the sources of sediment to the Lagoon. The most significant source identified was urban development and urban runoff delivered by the storm drain system to the Lagoon from the surrounding watershed. In particular, from open space areas located below storm water outfalls and from stream bank erosion/bed scouring. Additional sources include wave action, tidal exchange, and loads contributed by transportation infrastructure.

The TMDL also includes a margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and predicted water quality of the receiving water. An implicit MOS was included through the application of a number of conservative assumptions, including establishing the TMDL based on the 1993 critical wet period, and consideration of the overall predictive capability of the modeling framework that was developed for this study.

The TMDL is divided among the waste load allocation (WLA) for point sources, load allocation (LA) for nonpoint sources, and the MOS. Load reduction requirements are assigned to point sources and nonpoint sources. Identified point sources include the municipalities that are included in the San Diego County Phase I municipal separate storm sewer system (MS4s) permit, MS4 Phase II permittees, and the California Department of Transportation (Caltrans) storm water permit. Sediment loading to the Lagoon was estimated based on modeling of watershed runoff, streambank erosion, and sediment transport. A total WLA was assigned to the respective municipalities regulated under the Phase I MS4 permit (San Diego County, the City of San Diego, the City of Del Mar and the City of Poway), Phase II MS4 permittees, and Caltrans.

There is legal authority and a regulatory framework that empowers the Regional Board to require dischargers to implement and monitor compliance with the requirements set forth in this TMDL. As previously noted, sediment is transported to the impaired Lagoon through runoff generated from urbanization, scouring of canyons below storm outfalls, stream bank erosion/bed scouring, land use practices, and other processes. A significant amount of the sediment load results from controllable water quality factors which are defined as those actions, conditions, or circumstances resulting from anthropogenic activities that may influence the quality of the waters of the State and that may be reasonably controlled. This TMDL establishes a WLA for point sources and a LA for nonpoint sources of sediment to the Lagoon.

The regulatory framework for point sources differs from the regulatory framework for nonpoint sources. CWA section 402 establishes the National Pollutant Discharge Elimination System (NPDES) program to regulate the ‘‘discharge of a pollutant,’’ other than dredged or fill materials, from a ‘‘point source’’ into ‘‘waters of the U.S.” Under section 402, discharges of pollutants to waters of the U.S. are authorized by obtaining and complying with NPDES permits. These permits commonly contain effluent limitations consisting of either Technology Based Effluent Limitations (TBELs) or Water Quality Based Effluent Limitations (WQBELs).

In California, State Waste Discharge Requirements (WDRs) for discharges of pollutants from point sources to navigable waters of the United States that implement federal NPDES requirements and CWA requirements (NPDES requirements) serve in lieu of federal NPDES permits. These are referred to as NPDES requirements. Such requirements are issued by the State pursuant to the authority that is described in California’s Porter Cologne Water Quality Control Act. Point source discharges of sediment to the Lagoon include municipal MS4 Phase I and II dischargers, Caltrans, and NPDES construction and industrial permits within the watershed.

For each TMDL where nonpoint sources are determined to be significant, a LA is calculated, which is the maximum amount of a pollutant that may be contributed to a waterbody by “nonpoint source” discharges in order to attain WQOs. The Porter-Cologne Water Quality Control Act applies to both point and nonpoint sources of pollution and serves as the principle legal authority in California for the application and enforcement of TMDL LAs for nonpoint sources. The State plan and policy for control and regulation of nonpoint source pollution is contained in the Plan for California’s Nonpoint Source Pollution Control Program (NPS Program Plan) and the Policy for the Implementation and Enforcement of the Nonpoint Source Pollution Control Program (NPS Implementation and Enforcement Policy). Nonpoint sources that warrant regulation include, for example, runoff from farms and urban development. This policy applies to discharges from agricultural irrigation return flow, nursery irrigation return flow, orchard irrigation return flow, animal feeding operations, manure composting, soil amendment operations, and septic systems. Individual landowners and other persons engaged in these land use activities can be held accountable for attaining sediment load reductions in affected watersheds through enforcement of WDRs and the Waiver Policy.

Nonpoint source discharges from natural sources are considered largely uncontrollable, and therefore should not be regulated. Sediment discharged via tidal exchange is an example of an uncontrollable nonpoint sediment source that is not governed by a MS4 permit. Hydromodification and accelerated erosion via storm water runoff are controllable sources of sedimentation.

In order to meet the TMDL, a Sediment Load Reduction Plan (SLRP) will be developed that will describe the regulatory and/or enforcement actions that the Regional Board and dischargers may take to reduce pollutant loading and monitor effluent and/or receiving waters. The SLRP will describe the pollutant reduction actions that are recommended by the various dischargers to meet the allocation. The SLRP will include provisions to perform studies by the dischargers to fill data gaps, refine the TMDL and required load reductions, and/or modify compliance requirements. The dischargers will conduct monitoring to assess the effectiveness of the implementation measures at meeting the wasteload reduction.

The TMDL results are summarized in the tables below. The overall WLA is represented by the watershed contribution in Tables ES-1 and ES-2. The ocean boundary (LA) includes sediment loads from storm surge, wave action, and tidal exchange. The historical load represents the estimated load contribution from the mid-1970s time period (reference condition).

Table ES-1. TMDL summary

Source	Critical Wet Period Load (tons)	Daily Load (tons)
TMDL	12,360	59
Watershed contribution (WLA)	2,580	12
Ocean boundary (LA)	9,780	46
MOS	Implicit	Implicit

Table ES-2. Current vs. historical loads and percent reduction

Source	Current Load (tons)	Historical Load (tons)	Load Reduction (tons)	Percent Reduction Required
TMDL	13,663	12,360	1,303	10%
Watershed contribution (WLA)	7,719	2,580	5,139	**67%**
Ocean boundary (LA)	5,944	9,780	+3,836 (increase)	+39% (increase)

1 Introduction

The purpose of this technical report is to present the Total Maximum Daily Load (TMDL) that was developed for sediment/siltation for Los Peñasquitos Lagoon (Lagoon). The Lagoon is listed as impaired for sediment/siltation on the Clean Water Act (CWA) Section 303(d) List of Water Quality Limited Segments. Sedimentation within the Lagoon restricts the tidal prism, or exchange between the ocean and the Lagoon, and degrades critical salt marsh habitats through various processes. A TMDL is needed to help restore the beneficial uses of the Lagoon and achieve water quality standards.

Section 303(d) of the CWA requires that each state identify waterbodies within its boundaries for which the effluent limitations are not stringent enough to meet applicable water quality standards, which consist of beneficial uses, water quality objectives (WQOs), and an antidegradation policy. The CWA also requires states to establish a priority ranking for these impaired waters, known as the CWA Section 303(d) List of Water Quality Limited Segments, and to establish TMDLs for the identified waterbodies.

The purpose of a TMDL is to attain WQOs that support beneficial uses in the waterbody. A TMDL is defined as the sum of the individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for nonpoint sources and natural background, such that the capacity of the waterbody to assimilate pollutant loading (i.e., the loading capacity) is not exceeded[1]. A TMDL, therefore, represents the maximum amount of the pollutant of concern that the waterbody can receive and still attain water quality standards. Additionally, a TMDL represents a strategy for meeting WQOs by allocating quantitative limits for point and nonpoint pollution sources. Once the total maximum pollutant load has been calculated, it is divided up and allocated among all of the contributing sources in the watershed.

The TMDL process begins with the development of a technical analysis which includes the following seven components:

1) **Problem Statement** – generally describes impairment (Section 2)
2) **Numeric Targets** – identifies the historic numeric target which will result in attainment of the WQOs and protection of beneficial uses (Section 4)
3) **Source Assessment** – identifies all of the known point sources and nonpoint sources of the impairing pollutant in the watershed (Section 6)
4) **Linkage Analysis** – establishes the relationship between pollutant sources and receiving water conditions and calculates the Loading Capacity of the waterbody,

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[1] 40 CFR 130.2

which is the maximum load of the pollutant that may be discharged to the waterbody without causing exceedances of WQOs and impairment of beneficial uses (Section 7)

5) **Margin of Safety (MOS)** – accounts for uncertainties in the analysis (Section 8)
6) **Seasonal Variation and Critical Conditions** – describes how these factors are accounted for in the TMDL determination (Section 8)
7) **Allocation of the TMDL** – division of the TMDL among each of the contributing sources in the watershed; wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint and background sources (Section 9)

The write-up for the above components is generally referred to as the technical TMDL analysis. This technical report also includes background information on the Lagoon, including a description of the Lagoon and its watershed, discussion of the applicable WQOs and beneficial uses (Section 3), and a discussion summary of the data that were used to characterize the impairment and associated pollution sources (Section 5). The TMDL Implementation Section will be included later, as this information is currently being developed. This section focuses on the Regional Board's regulatory authority. This information will be updated in the future through development of a detailed Sediment Load Reduction Plan (SLRP) that will be submitted for approval after adoption of the TMDL.

This TMDL was developed through close collaboration between the municipalities within the Los Peñasquitos watershed (City of San Diego, San Diego County, City of Del Mar, and City of Poway), the California Department of Transportation (Caltrans), San Diego Coastkeeper, California State Parks, the Los Peñasquitos Lagoon Foundation, and representatives from the Regional Board. This third party TMDL effort was led by the City of San Diego and included detailed modeling of the Lagoon and its contributing watershed.

2 Problem Statement

Under Section 303(d) of the Clean Water Act (CWA), states are required to identify waters whose beneficial uses have been impaired due to specific constituents. Los Peñasquitos Lagoon was placed on Section 303 (d) list of Water Quality Limited Segments in 1996 for sedimentation and siltation with an estimated area affected of 469 acres. The Lagoon is subject to the development of a total maximum daily load (TMDL) (USEPA, 2009).

The Lagoon is an estuarine system that is part of the Torrey Pines State Natural Reserve. In addition to its marine influence, the Lagoon receives freshwater inputs from an approximately 60,000-acre watershed comprised of three major canyons (Carroll Canyon, Los Peñasquitos Canyon, and Carmel Canyon). Given the status of “Natural Preserve” by the California State Parks, the Lagoon is one of the few remaining native salt marsh lagoons in southern California, providing a home to several endangered species (California State Parks, 2009). The Lagoon is ecologically diverse, supporting a variety of plant species, and providing habitat for numerous bird, fish, and small mammal populations. The Lagoon also serves as a stopover for the Pacific Flyway, offering migratory birds a safe place to rest and feed, as well as providing refuge for coastal marine species that use the Lagoon to feed and hide from predators.

The San Diego Basin Plan states, “The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses”. Beneficial uses listed in the basin plan for the lagoon include contact water recreation, non-contact water recreation (although access is not permitted in some areas per California State Parks), preservation of biological habitats of special significance, estuarine habitat, wildlife habitat, rare, threatened or endangered species, marine habitat, migration of aquatic organisms, and spawning, reproduction and/or early development. The beneficial use that is most sensitive to increased sedimentation is estuarine habitat. Estuarine uses may include preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (such as marine mammals or shorebirds).

Impacts associated with increased and rapid sedimentation include: reduced tidal mixing within Lagoon channels, degradation and (in some cases) net loss of riparian and salt marsh vegetation, increased vulnerability to flooding for surrounding urban and industrial developments, turbidity associated with siltation in Lagoon channels, and constriction of a main wildlife corridor. The Los Peñasquitos Lagoon Enhancement Plan and Program (1985), San Diego Basin Plan (1994), and Clean Water Act Section 303(d) highlight sedimentation as a significant impact associated with urban development and a leading cause in the rapid loss of salt marsh habitt in the Lagoon, making sediment reduction a management priority.

According to California State Parks, the Lagoon consists of approximately 510 acres of wetland habitats including coastal salt marsh (this includes salt panne, tidal channels, and mudflats), brackish marsh, riparian woodland and scrub, and freshwater marsh. The Lagoon's 510 acres includes approximately 210 acres of tidal salt marsh and 120 acres of freshwater wetlands are considered unimpaired (data from California State Parks 2010; see Figure 7). The remaining 180 acres of salt marsh and brackish marsh vegetation has been impaired by sedimentation, converting coastal salt marsh to freshwater or upland habitats. The environmental processes that support wetland habitats in the Lagoon have been altered by urban development in three ways:

1) Increase in the volume and frequency of freshwater input
2) Increase in sediment deposition
3) Decrease in the tidal prism

These factors have led to decreases in saltwater and brackish marsh habitats and increases in freshwater habitats as well as increases in the abundance of non-native species.

Developing a sediment TMDL for the Lagoon is necessary for the restoration of the beneficial uses of the Lagoon, including the estuarine beneficial use most impacted by sediment accumulation.

3 Background Information

This section describes the Los Peñasquitos watershed and Lagoon, applicable water quality standards (including beneficial uses and WQOs), and provides background information on the impairment.

3.1 Los Peñasquitos Watershed Description

The Los Peñasquitos watershed is located in central San Diego County (Figure 1). Both the watershed and Lagoon are included in the Los Peñasquitos Hydrologic Unit (906), which also includes Mission Bay and several coastal tributaries. This 93 mi^2 (approximately 60,000 acres) coastal watershed includes portions of the cities of San Diego, Poway, and Del Mar (Figure 2). In addition, a small portion of San Diego County is located in the eastern headwaters area. There are also several major road corridors that are maintained by Caltrans within the watershed.

Figure 1. Location of the Los Peñasquitos watershed

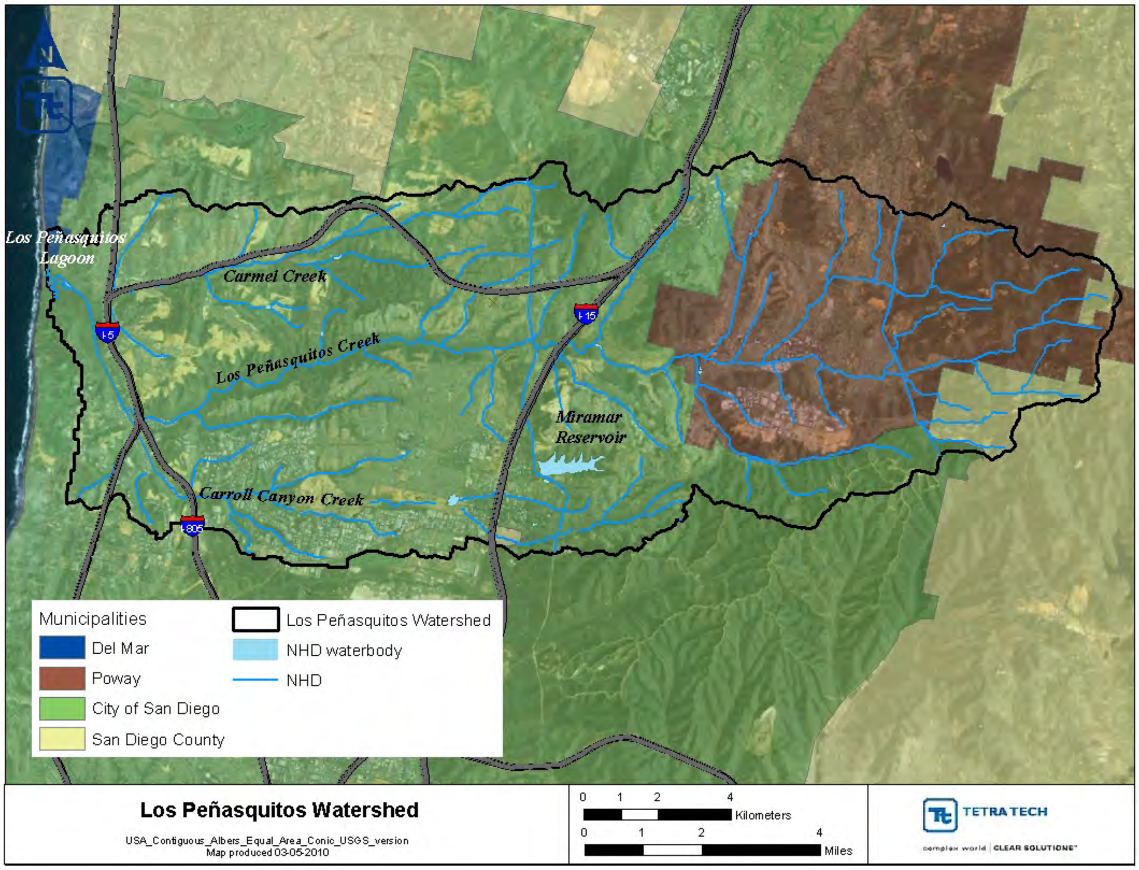

Figure 2. Municipalities within the Los Peñasquitos watershed

The climate in the Region is generally mild with annual temperatures averaging around 65°F near the coastal areas. Average annual rainfall ranges from nine to 11 inches along the coast. There are three distinct types of weather in the Region. The summer dry weather occurs from May 1 to September 30. The winter season occurs from October 1 to April 30 and has two types of weather; 1) winter dry weather when rain has not fallen for the preceding 72 hours, and 2) wet weather consisting of storms of 0.1 inches of rainfall (or greater) and the 72 hour period after the storm. 85 to 90 percent of the annual rainfall occurs during the winter season.

Three major streams drain the watershed and flow into the tidal Lagoon (Figure 2). Los Peñasquitos Creek is the largest catchment in the watershed draining 59 mi^2 (approximately 37,760 acres) through its central portion. Carroll Canyon Creek is the second largest catchment (approximately 18 mi^2 or 11,520 acres) and drains the southern portion of the watershed. Carmel Creek is located along the northern, coastal area and drains the remaining 16 mi^2 (approximately 10,240 acres). Los Peñasquitos Creek and Carroll Canyon Creek confluence together prior to entering the Lagoon.

There is one major dam in the Carroll Canyon Creek watershed, which drains approximately 1 mi^2 (approximately 640 acres) and forms Miramar Reservoir (retains imported drinking water; does not discharge downstream). Watershed elevation rises from sea level to 2,600 ft in the headwaters (Figure 3).

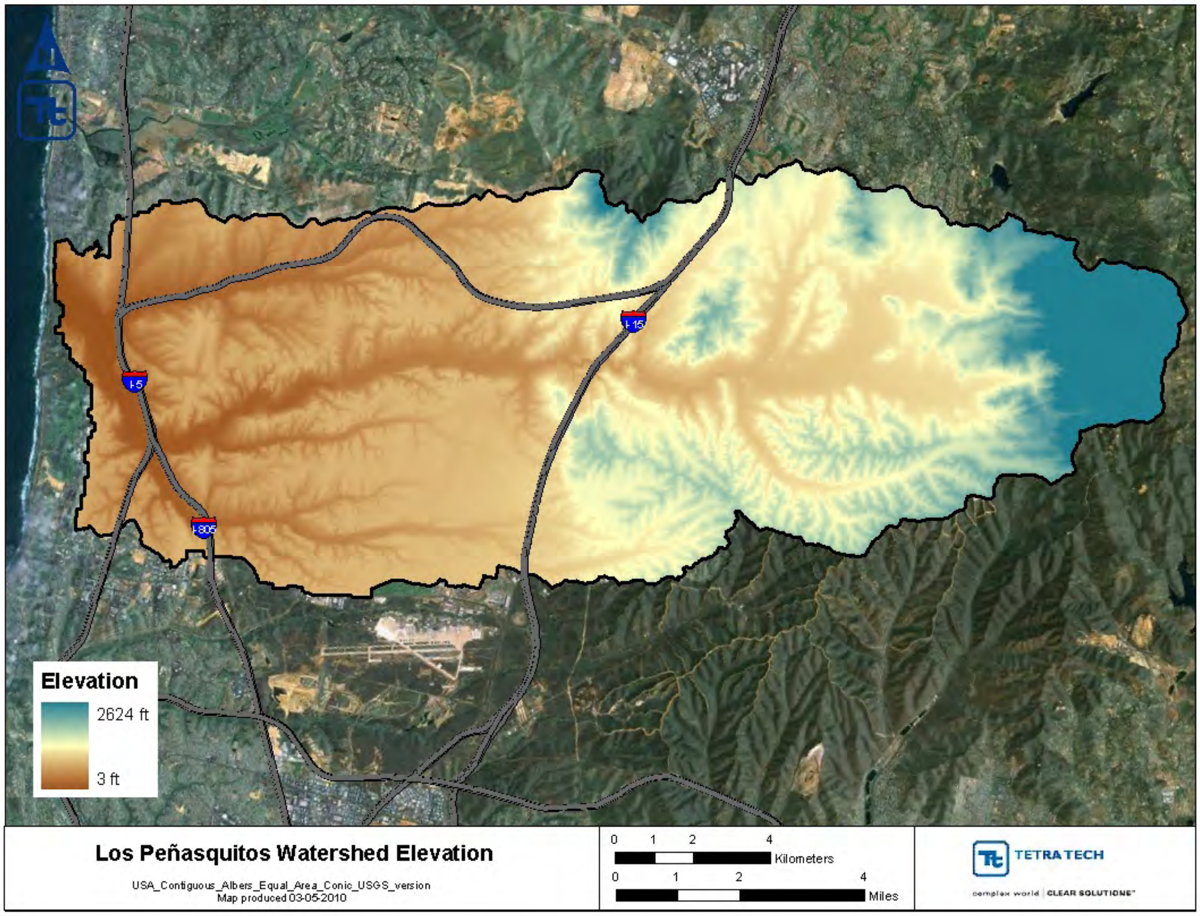

Figure 3. Los Peñasquitos watershed elevation

Data detailing land use in the Los Peñasquitos watershed is available through the San Diego Association of Governments 2000 land use coverage[2] and presented in (Figure 4). Approximately 54 percent of the watershed has been developed, with 46 percent of that area classified as impervious. The largest single land use type in the Los Peñasquitos watershed is open space (approximately 25,500 acres), followed by low density residential development (approximately 14,250 acres), and industrial/transportation (approximately 11,660 acres). The percent distribution of all land uses in the watershed is presented in Figure 5. Additional key watershed characteristics that are important for model configuration are described in later sections and within the modeling report (Appendix A).

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[2] http://www.sandag.org/resources/maps_and_gis/gis_downloads/downloads/zip/Land/CurrentLand/lu.zip

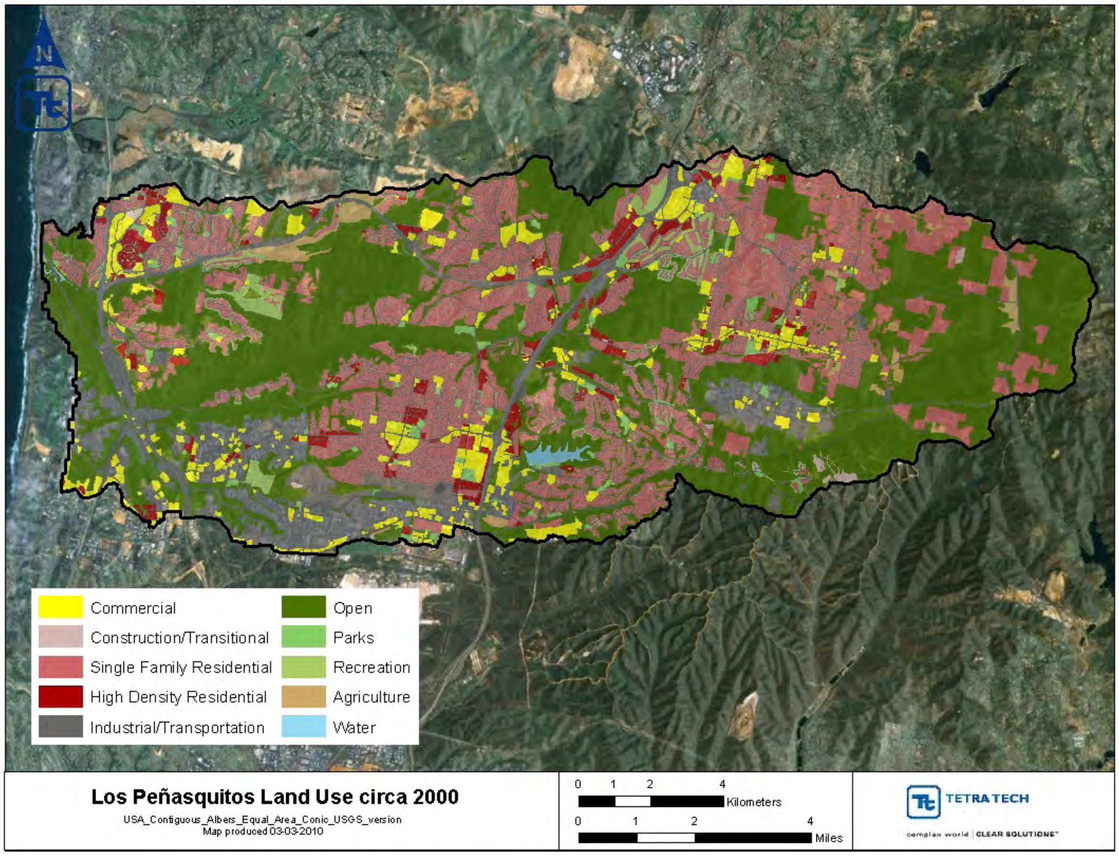


Figure 4. Land uses in the Los Peñasquitos watershed

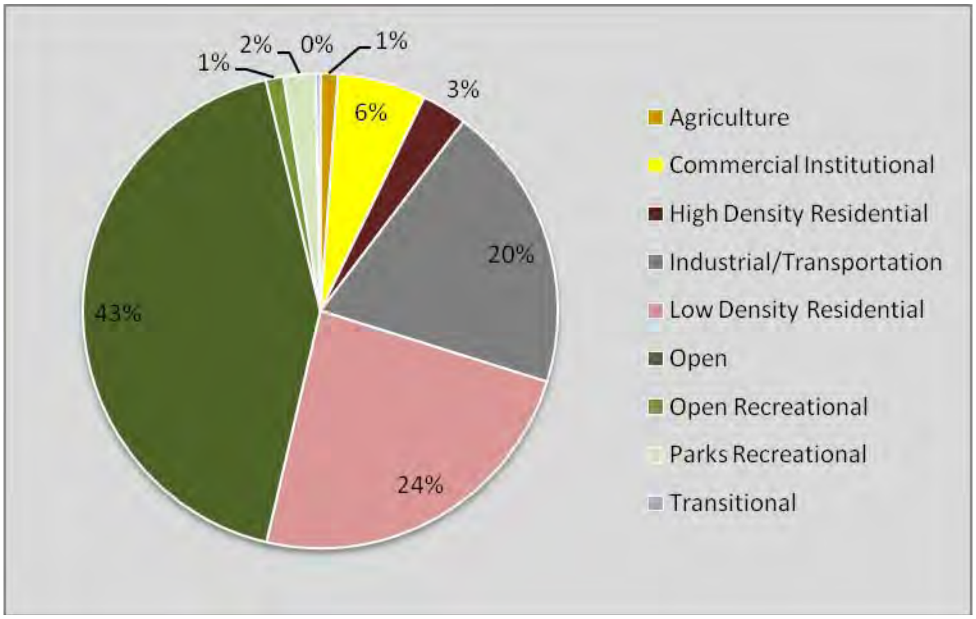


Figure 5. Land use distribution in the Los Peñasquitos watershed

3.2 Los Peñasquitos Lagoon Description

The Los Peñasquitos Lagoon is a relatively small estuarine system (approximately 0.6 mi^2 or 384 acres) that is part of the Torrey Pines State Natural Reserve (Figure 6). Given the status of "Natural Preserve" by the California State Parks, the Lagoon is one of the few remaining native salt marsh lagoons in southern California. The Lagoon is ecologically diverse, supporting a variety of plant species, and providing habitat for numerous bird, fish, and small mammal populations. The Lagoon also serves as a stopover for migratory birds and provides habitat for coastal marine and salt marsh species.

Figure 6. Photograph of Los Peñasquitos Lagoon

Tidal flows enter the Lagoon during periods when the Lagoon mouth is open to the ocean. Currently, the Lagoon mouth is open throughout most of the year. Mouth closures are typically caused by coastal processes (deposition of sand and cobble storms surges and wave action) and structures, such as the U.S. Highway 101 abutments. Mechanical dredging is used when needed to eliminate blockages and allow for tidal flow into the Lagoon in order to improve water quality conditions and support salt marsh species.

Most of the freshwater input flows through Los Peñasquitos Canyon into the Lagoon. Carroll Canyon Creek to the south and Carmel Creek to the north also contribute freshwater to the Lagoon. Historically, Los Peñasquitos Creek was the only tributary that flowed year-round, while Carroll Canyon and Carmel Creeks only flowed during significant rainfall events. Beginning in the 1990s, these drainages also began flowing year-round due to increasing urban development within the watershed. Carroll Canyon Creek confluences with Los Peñasquitos Creek upstream and the combined stream channel extends into the Lagoon along the western side of the railroad track berm. This berm acts as a barrier between the eastern and western portions of the Lagoon for much of its length. The railroad trestle along the northern side provides the main connection between eastern and western portions of the lagoon. The Lagoon channel that receives flow from Carmel Creek crosses through this area. In addition, there are two smaller bridges located in the southern portion of the Lagoon which allow flow from Carroll Canyon Creek to pass through to the eastern side of the Lagoon during high flow events.

3.3 Applicable Water Quality Standards

Water quality standards consist of WQOs, beneficial uses, and an anti-degradation policy. WQOs are defined under Water Code section 13050(h) as “limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water.” Under section 304(a)(1) of the CWA, the USEPA is required to publish water quality criteria that incorporate ecological and human health assessments based on current scientific information. WQOs must be based on scientifically sound water quality criteria, and be at least as stringent as those criteria.

The sediment WQO, as set forth in the Water Quality Control Plan for the San Diego Basin (Basin Plan), is narrative in nature and states “*The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses”* (Regional Board, 1994). To interpret the narrative nature of the sediment WQO, a numeric target was developed to establish the allowable sediment loading to the Lagoon. Section 4 presents the detailed information that was used to develop a numeric target for sediment.

The Basin Plan identifies the beneficial uses that are designated for Los Peñasquitos Lagoon (Regional Board, 1994) (Table 1). The narrative standard for sediment is applied to all beneficial uses. Compliance with WQOs must be assessed and maintained throughout the waterbody to protect all beneficial uses.

Table 1. Beneficial uses designated for Los Peñasquitos Lagoon

Beneficial Use	Beneficial Use Description
REC 1	Includes uses of water for recreation activities involving body contact with water, where ingestion of water is reasonable possible. These uses include, but are not limited to, swimming, wadding, water skiing, ski and SCUBA diving, surfing, white water activities, fishing, or use of natural hot springs. *Note that access to some areas is not permitted per California State Parks
REC 2	Includes the use of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonable possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beach combing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities. *Note that access to some areas is not permitted per California State Parks
BIOL	Includes uses of water that support designated area or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS), where the preservation or enhancement of natural resources requires special protection.
EST	Includes uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds)
WILD	Includes uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
RARE	Includes uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.
MAR	Includes uses of water that support marine ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
MIGR	Includes uses of water that support habitats necessary for migration, acclimatization, between fresh and salt water, or other temporary activities by aquatic organisms, such as anadromous fish.
SPWN	Includes uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish. This use is applicable only for the protection of anadromous fish.
SHELL	Includes uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters and mussels) for human consumption, commercial, or sport purposes.

3.4 Impairment Description

The Lagoon is listed as impaired on the CWA Section 303(d) list due to sediment/siltation impacts that originate from watershed sediment contributions. This impairment impacts several beneficial uses; however, the estuarine habitat use is the most sensitive to increased sedimentation. The Lagoon's wetland habitats consist of estuarine and riparian habitats, including coastal salt marsh habitat and wetland/upland buffer areas. The 303(d) listing indicates that an estimated area of 469 acres is impaired. Recent surveys by California State Parks indicate that greater than 180 acres of the 510 acres of coastal salt marsh has been impaired by sedimentation, converting coastal salt marsh to riparian habitat (California State Parks, 2009; California State Parks, 2010). .

As discussed in the problem statement, impacts associated with sedimentation include: reduced tidal mixing within Lagoon channels, degradation and (in some cases) net loss of wetland vegetation, conversion from saline to freshwater habitats, and turbidity associated with siltation in Lagoon channels. There are many potential sources that have influenced the accumulation of sediment within the Lagoon. Sources include erosion of canyon banks, bluffs, scouring stream banks, and tidal influx. Some of these processes are exacerbated by anthropogenic disturbances, such as urban development within the watershed. Urban development transforms the natural landscape and results in increased runoff due to hydromodifcation resulting in scouring of sediment, primarily below storm water outfalls that discharge into canyon areas. Sediment loads are transported downstream to the Lagoon during storm events causing deposits on the salt flats, and in Lagoon channels. These sediment deposits have gradually built-up over the years due to increased sediment loading and inadequate flushing, which directly and indirectly affects lagoon functions and salt marsh characteristics.

To address the impairment, and interpret the narrative WQOs, a historical watershed-based approach was used to calculate the acceptable sediment load to the Lagoon. The historical analysis focused on identifying an earlier time period that corresponds with natural sediment loading from the watershed which did not exceed the Lagoon’s assimilative capacity, as described in the following section (Section 4).

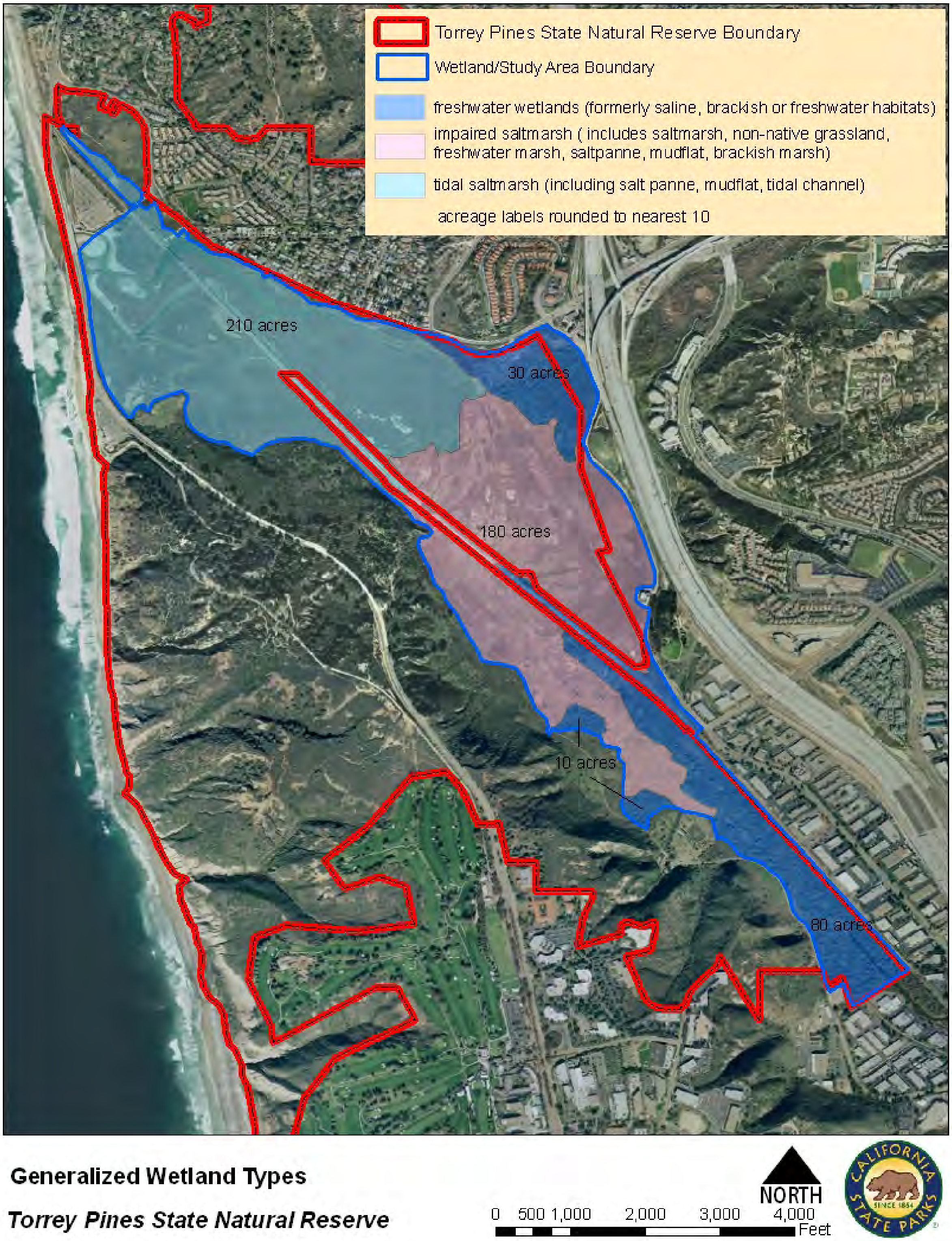


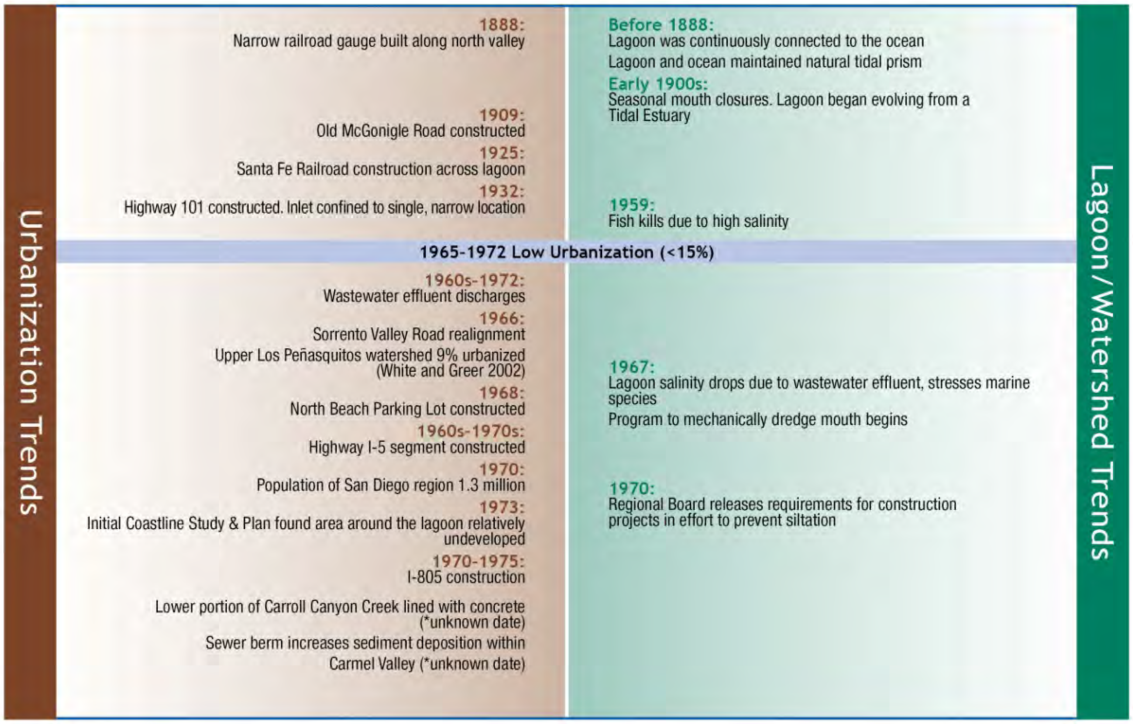
Figure 7. Wetland habitats within Los Peñasquitos Lagoon (California State Parks, 2010)

4 Numeric Targets

When calculating TMDLs, numeric targets are selected to meet the WQOs for a waterbody and subsequently establish measureable targets for the restoration and/or protection of beneficial uses. The sediment WQO, as set forth in the Basin Plan, is narrative and states:

> *The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses* (Regional Board, 1994).

Due to the narrative nature of the sediment/siltation WQO, this WQO must be interpreted through the development of a numeric target for TMDL and implementation planning purposes. A numeric target is needed to define the conditions that will result in the attainment of water quality conditions. For the sediment/siltation impairment of the Lagoon, a numeric target was derived using a ‘reference watershed approach’. The ‘reference watershed approach’ typically refers to the process of comparing the impaired waterbody to a similar-unimpaired waterbody to establish an acceptable loading capacity which would result in the attainment of water quality standards. Due to the unique characteristics of the Lagoon, it was determined that a historical analysis of the Lagoon and its watershed would provide the best information available for determining the conditions that support water quality standards. Available literature and past accounts of sedimentation impacts within the Lagoon were reviewed to understand the relationship between urbanization in the watershed and associated changes in Lagoon water quality conditions. A timeline of significant events and literature references was developed to document important changes in lagoon condition over time in relation to changes in land use (urbanization in particular) and other impacts (Figures 8 and 9). The linkage between these factors was evaluated using a weight of evidence approach (Sections 4.1 through 4.3) in order to identify an appropriate reference time period that could be used calculate the numeric target for sediment TMDL development (Section 4.4). Note that much of the background information presented below is also referenced in the historical timeline.



Urbanization Trends

1888:
Narrow railroad gauge built along north valley

1909:
Old McGonigle Road constructed

1925:
Santa Fe Railroad construction across lagoon

1932:
Highway 101 constructed. Inlet confined to single, narrow location

Lagoon/Watershed Trends

Before 1888:
Lagoon was continuously connected to the ocean
Lagoon and ocean maintained natural tidal prism

Early 1900s:
Seasonal mouth closures. Lagoon began evolving from a Tidal Estuary

1959:
Fish kills due to high salinity

1965-1972 Low Urbanization (<15%)

1960s-1972:
Wastewater effluent discharges

1966:
Sorrento Valley Road realignment
Upper Los Peñasquitos watershed 9% urbanized (White and Greer 2002)

1968:
North Beach Parking Lot constructed

1960s-1970s:
Highway I-5 segment constructed

1970:
Population of San Diego region 1.3 million

1973:
Initial Coastline Study & Plan found area around the lagoon relatively undeveloped

1970-1975:
I-805 construction

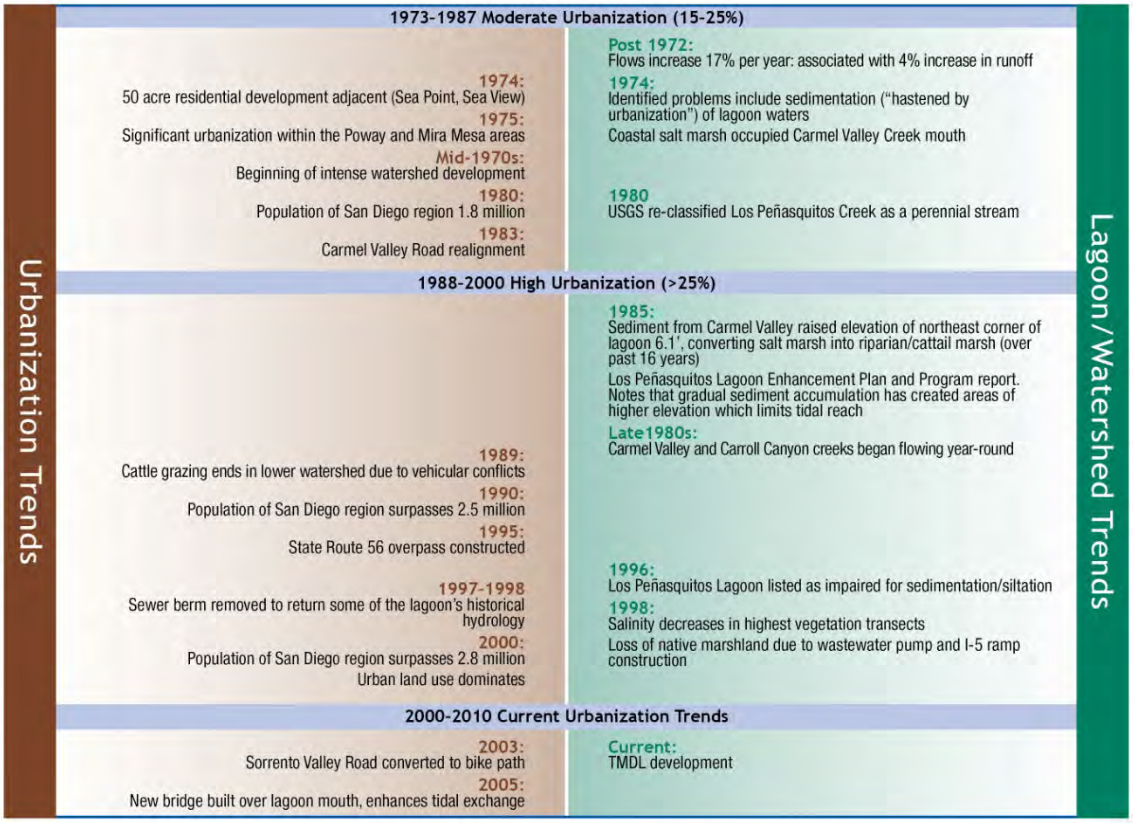
Lower portion of Carroll Canyon Creek lined with concrete (*unknown date)

Sewer berm increases sediment deposition within Carmel Valley (*unknown date)

1967:
Lagoon salinity drops due to wastewater effluent, stresses marine species
Program to mechanically dredge mouth begins

1970:
Regional Board releases requirements for construction projects in effort to prevent siltation

Figure 8. Timeline of urbanization and lagoon trends (1800s through early 1970s)



Urbanization Trends

Lagoon/Watershed Trends

1973-1987 Moderate Urbanization (15-25%)

1974:
50 acre residential development adjacent (Sea Point, Sea View)

1975:
Significant urbanization within the Poway and Mira Mesa areas

Mid-1970s:
Beginning of intense watershed development

1980:
Population of San Diego region 1.8 million

1983:
Carmel Valley Road realignment

Post 1972:
Flows increase 17% per year: associated with 4% increase in runoff

1974:
Identified problems include sedimentation ("hastened by urbanization") of lagoon waters
Coastal salt marsh occupied Carmel Valley Creek mouth

1980
USGS re-classified Los Peñasquitos Creek as a perennial stream

1988-2000 High Urbanization (>25%)

1989:
Cattle grazing ends in lower watershed due to vehicular conflicts

1990:
Population of San Diego region surpasses 2.5 million

1995:
State Route 56 overpass constructed

1997-1998
Sewer berm removed to return some of the lagoon's historical hydrology

2000:
Population of San Diego region surpasses 2.8 million
Urban land use dominates

1985:
Sediment from Carmel Valley raised elevation of northeast corner of lagoon 6.1', converting salt marsh into riparian/cattail marsh (over past 16 years)
Los Peñasquitos Lagoon Enhancement Plan and Program report. Notes that gradual sediment accumulation has created areas of higher elevation which limits tidal reach

Late1980s:
Carmel Valley and Carroll Canyon creeks began flowing year-round

1996:
Los Peñasquitos Lagoon listed as impaired for sedimentation/siltation

1998:
Salinity decreases in highest vegetation transects
Loss of native marshland due to wastewater pump and I-5 ramp construction

2000-2010 Current Urbanization Trends

2003:
Sorrento Valley Road converted to bike path

2005:
New bridge built over lagoon mouth, enhances tidal exchange

Current:
TMDL development

Figure 9. Timeline of urbanization and lagoon trends (mid 1970s through current)

4.1 Land Use Changes in the Los Peñasquitos Watershed

As the first Mexican land grant in California, land in the Los Peñasquitos watershed was historically maintained as a family homestead and livestock ranch throughout the 1800s and early 1900s. By the early 1900s, the City of San Diego and San Diego County began acquiring parcels of land surrounding the Lagoon. As the region began to develop, urban infrastructure, including construction of the railroad (1880s-1925), altered the natural drainage and restricted the mouth of the Lagoon. Later, the construction of U.S. Highway 101 in 1932 permanently confined the inlet to a single, narrow location and restricted the tidal prism and exchange between the ocean and Lagoon (Mudie et al., 1974). The North Beach Parking Lot was constructed in 1968 by California State Parks in historically tidal areas which further influenced hydrologic exchanges (LPL Foundation and the State Coastal Conservancy, 1985). Although there were significant alterations to the Lagoon's hydrology, the Initial Coastline Study and Plan released in 1973 found that the area surrounding the Lagoon remained relatively undeveloped (Duncan and Jones, 1973), but was at the threshold of rapid growth (Jet Propulsion, 1971).

In 1966 the Upper Los Peñasquitos subwatershed was 9% urbanized (White and Greer, 2002); however, by 1975, the watershed experienced significant urbanization with agricultural areas being converted to urban uses, specifically in the Poway and Mira Mesa areas (City of San Diego, 2005). In 1974, a California Fish and Game report expressed concerns associated with the anticipated completion of a 50 acre development along the shores of the Lagoon. The report also stated that within the following five years (1974 to 1979), the population surrounding the immediate lagoon environs was expected to increase by a factor of four to six over the 1972 level of approximately 1,000 people (Mudie et al., 1974). Urban runoff associated with the increased development had already been identified as the primary threat to water quality in the Lagoon (Jet Propulsion Lab, 1971); however, other factors existed including agriculture and grazing. In 1989, cattle grazing in the Los Peñasquitos Creek watershed ceased (White and Greer, 2002) primarily due to vehicular conflicts.

While development occurred sporadically before the 1970s, the mid-1970s appears to be the beginning of intense watershed development. Land use associated with this time period is illustrated in Figure 10. Land use/land cover data for the Los Peñasquitos watershed were not available for this period, therefore, a historical coverage was developed based on the location and type of structures that are shown in USGS topographic maps from the 1970s (primarily the La Jolla quadrangle – dated 1975). The most recent land use coverage (from SANDAG 2000 – refer to Section 3.1) was modified based on this information in order to create a uniform historical land use map for the watershed for comparison. Land use differences between the current and historical time periods are shown in Table 2.

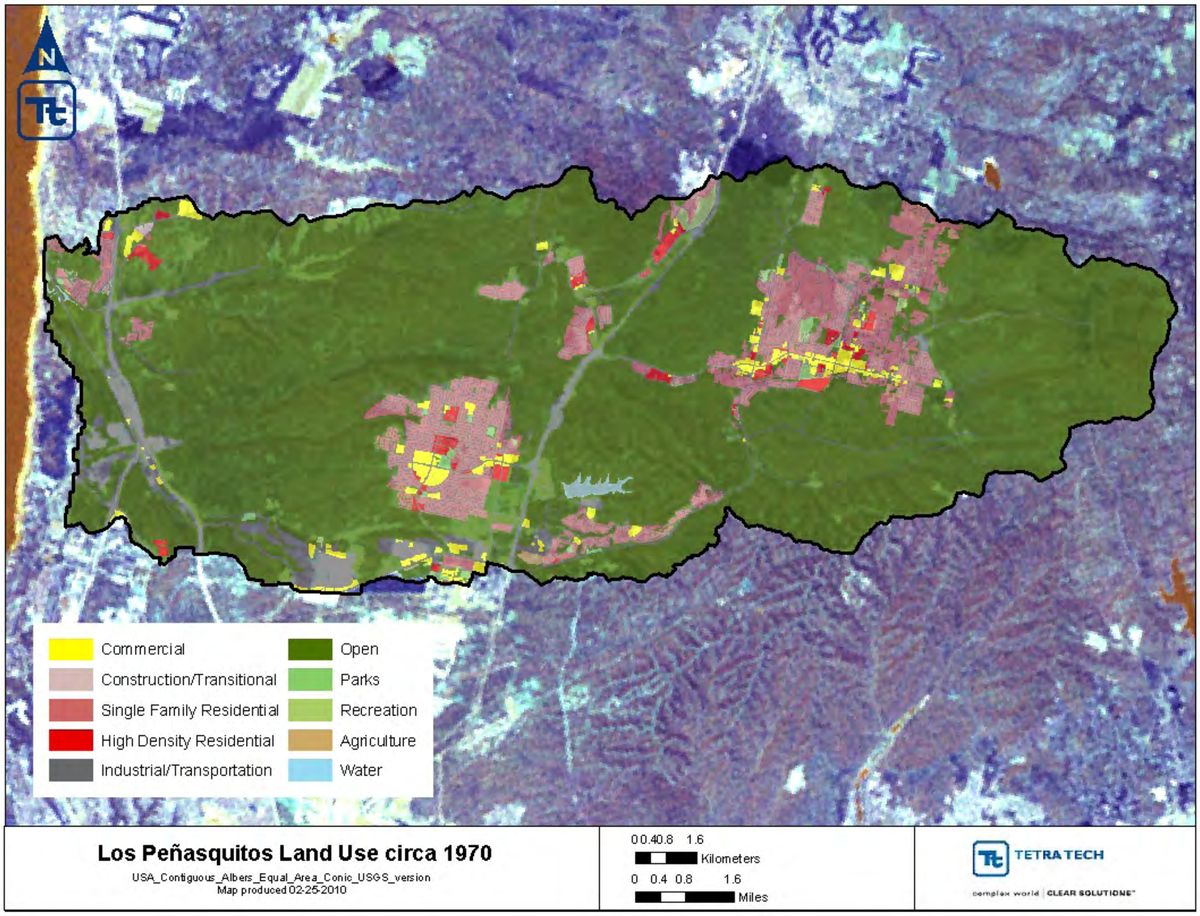


Figure 10. Historic land use in the Los Peñasquitos watershed (1970's)

Table 2. Current (SANDAG 2000) vs. historical land use comparison

Land Use	Current area (ac)	Current area (%)	Historic area (ac)	Historic area (%)	Relative Change (%)
Agriculture	741	1.24%	100	0.17%	1.07%
Commercial	3,591	6.00%	1,088	1.82%	4.18%
Construction/Transitional	169	0.28%	23	0.04%	0.24%
High Density Residential	1,840	3.07%	648	1.08%	1.99%
Industrial/Transportation	11,654	19.46%	4,830	8.07%	11.40%
Open	25,463	42.52%	47,445	79.23%	-36.71%
Parks	1,326	2.22%	2,884	0.48%	1.73%
Recreation	670	1.12%	139	0.23%	0.89%
Single Family Residential	14,258	23.81%	5,155	8.61%	15.20%
Water	161	0.27%	160	0.27%	0.00%
Total	59,879	100.00%	59,879	100.00%	

From 1966 to 1999, the acreage of urbanized land within the upper Los Peñasquitos Creek watershed increased by 290 percent (White and Greer, 2002) and by 2000, the Los Peñasquitos watershed was dominated by urban uses (City of San Diego, 2005). Additional highway infrastructure was built in and around the Los Peñasquitos watershed to accommodate increasing population growth. Realignment of Sorrento Valley Road (~1966) and Carmel Valley Road (1983) both impacted the surrounding watershed (Greer and Stow, 2003) as well as segments of the I-5 freeway (1994) and the State Route 56 overpass (1995). To decrease impacts from road infrastructure, Sorrento Valley Road was converted to a bike path in 2003 and a new U.S. Highway 101 bridge was constructed over the Lagoon mouth in August 2005, enhancing tidal exchange. Figure 11 shows the major roads within the watershed. Runoff from surrounding roads and highways ultimately reaches the Lagoon.

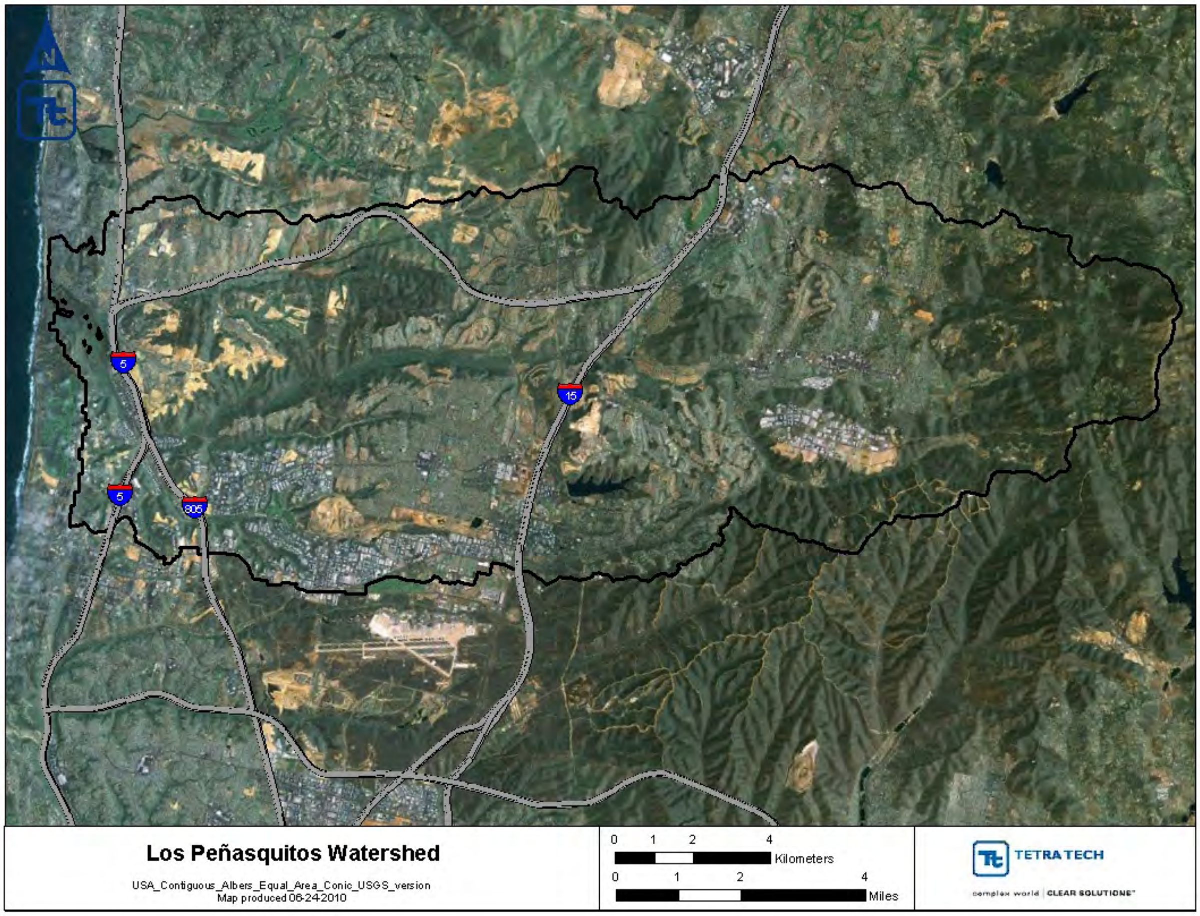


Figure 11. Major roads within the Los Peñasquitos watershed

To further characterize the land use changes, population trends in the San Diego region were evaluated. Population steadily increased from 1970 to 2010 in the San Diego region[3] as shown in Figure 12. This regional population analysis was used to evaluate general trends and includes surrounding areas. General trends show expansive population growth, resulting in intense development throughout the region.

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[3] www.sandag.org

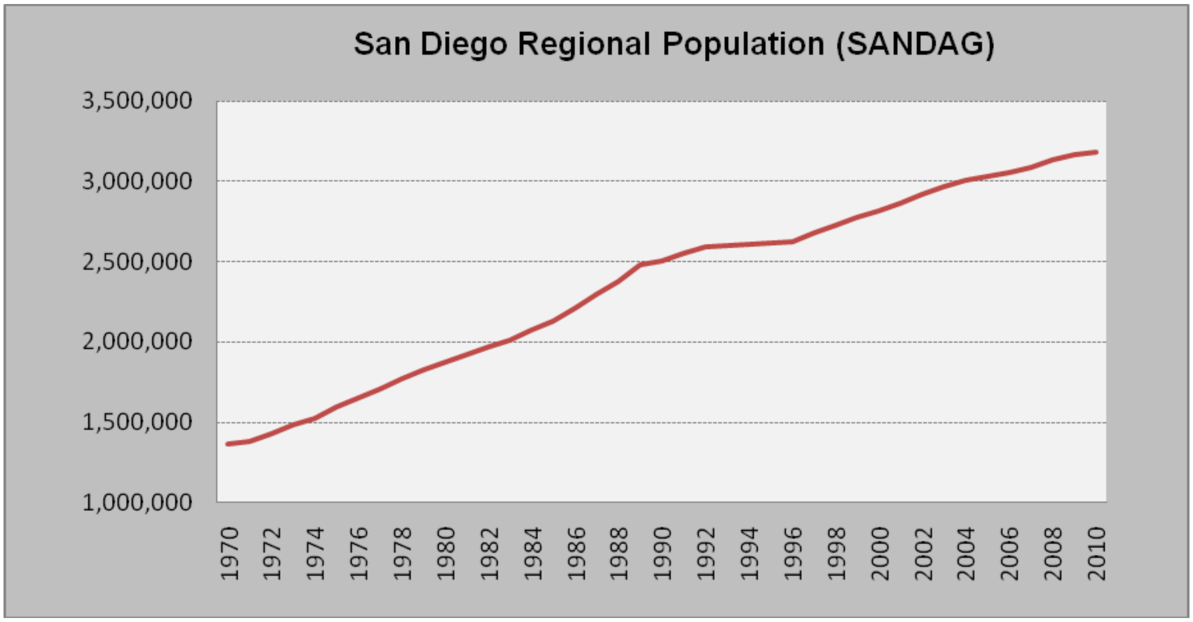

Figure 12. San Diego regional population trends (SANDAG, 2010)

4.1.1 Los Peñasquitos Lagoon Historical Water Quality Conditions

In the past 60 years, the Lagoon has evolved from a tidal estuary with an active connection to the ocean, to one that is closed to tidal action for long periods of time and requires mechanical excavation to reopen. The major factors that were responsible for degradation of the lagoon before the 1990s are: (1) the railroad embankment that cuts off lagoon channels; (2) construction of North Torrey Pines Road (part of U.S. Highway 101) along the barrier beach that restricted the location of the lagoon mouth; (3) construction of the North Beach Parking Lot in historic tidal areas; (4) increased sediment from changing land uses upstream; and, (5) decreased water quality from urban runoff and sewage effluent (LPL Foundation and State Coastal Conservancy, 1985). Hydromodification linked to urban development within the watershed and lagoon in the 1980s and 1990s played (and still plays) a major role in the degradation of the Lagoon. Water quality impacts to the Lagoon are primarily associated with a restricted tidal prism, historical discharge of wastewater effluent from 1962-1972; and more recently, hydromodification that has resulted in increased sedimentation and year-round freshwater inputs. Information that relates to each of these impacts is discussed below.

4.1.2 Tidal Prism Restriction

Maintaining a tidal prism, and proper exchange between the ocean and the Lagoon, is critical for maintaining adequate salt marsh salinity levels, and other water quality parameters. The Los Peñasquitos Enhancement Plan identifies mouth closures as one of the most important problems occurring in the Lagoon (Elwany, 2008). Tidal inflows and outflows of impounded water from large storm events help to keep the mouth open, whereas, wave-induced currents are responsible for the depositional processes which tend to close the lagoon entrance (LPL Foundation and State Coastal Conservancy, 1985). Sedimentation of lagoon environments is a natural process; research of the Lagoon determined that the volume of sand trapped in the inlet is a function of wave and flooding dynamics (Elwany, 2008). Although increased sediment loading from the watershed may increase the build-up rate of sand bar formation, this study also determined that the grain size distribution of accumulated sand at the inlet was comparable to the distribution of grain size on the beach, thus identifying significant marine sources (Elwany, 2008) rather than watershed sources affecting the western portion of the Lagoon.

Despite the natural process, historical evidence indicates that the lagoon was continuously connected to the ocean until at least 1888 and after this time period, the natural process within the Los Peñasquitos watershed was accelerated by disturbances (Mudie et al., 1974). For example, construction of the railroad and U.S. Highway 101 across the lagoon reduced the volume of water flowing in and out of the lagoon; this allows sand to build up at the entrance and can prevent tidal flow altogether (Duncan and Jones, 1973). In 1966, a program was initiated to restore the tidal prism by mechanically dredging and removing the accumulated sediment at the mouth of the Lagoon (LPL Foundation and State Coastal Conservancy, 1985). This effort was later refined in the mid 1980s and early 1990s to improve tidal mixing and reduce the frequency of mouth closures. Because of continued, sporadic mouth closures, a dredging program continues to date (Elwany, 2008). The program seeks to enhance tidal flushing, water quality, and marine habitats.

4.1.3 Wastewater Effluent Discharge

To accommodate increasing urban development within the watershed, two wastewater treatment plants operated from 1962-1972 and discharged effluent to the Lagoon or tributaries that ultimately reach the Lagoon. Although these facilities elevated minimum and median annual discharge values and assisted with maintaining the tidal prism, the effluent caused insect and odor problems (Mudie et. al., 1974), as well as elevated nutrients (Bradshaw and Mudie, 1972), and depressed salinity[4] concentrations. These problems continued until 1972 when surrounding areas were all connected to the San Diego Metropolitan sewer system.

4.1.4 Watershed Sedimentation

Several studies have documented the influx of sediment originating in the watershed to the Lagoon. Mudie and Byrne (1980) estimate that sedimentation rates have increased to 50 cm/100 years since European settlement of the area. Between 1968 and 1985,

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[4] (http://www.torreypine.org/parks/Peñasquitos-lagoon.html).

sediment from Carmel Valley has raised the elevation of the northeast corner of the lagoon by 6.1 feet, converting salt marsh vegetation into riparian and cattail marsh which helps retain sediment (LPL Foundation and State Coastal Conservancy, 1985). The main depositional areas in the lagoon are just downstream of the I-5 Carmel Valley Creek culverts and at the southern end of the Lagoon near Sorrento Valley. Deposition at the I-5 culvert, which is the outlet of Carmel Valley, was caused by a sewer berm located about 1000' west of I-5 (removed in the late 1980s). Storm flows from Carmel Valley pond behind the berm and allow coarse sediment to be deposited (LPL Foundation and State Coastal Conservancy, 1985). Gradual sediment accumulation in the lagoon has created areas of higher elevation which tidal water no longer reaches. The mouth of Carmel Valley Creek is the primary example of this process. In 1974, coastal salt marsh occupied the Carmel Valley Creek mouth; however, the ground elevation at the lower end of the Carmel Valley culverts rose 6.1 feet in the past 16 years, due to sedimentation from upstream (LPL Foundation and State Coastal Conservancy, 1985).

In an attempt to control the increasing sedimentation rate from development in the watershed, the Regional Board first approved a resolution (70-R26). This resolution established requirements for control of siltation from construction projects in areas that drain to the Lagoon in 1970 (Mudie et al., 1974). Despite these actions, a 1974 report by the California Department of Fish and Game expressed concerns associated with a significant increase in flow of urban runoff draining into the eastern channel. It was determined that the runoff was the result of intensive residential development of the mesas northeast of the lagoon. During the fall of 1973, this runoff volume amounted to approximately 1,500 gal/day (Mudie et al.,1974). Prestegaard (1978) concluded that unmitigated urbanization could double the annual sediment load within 30 years. More recently, the City of San Diego identified increasing urban development, resulting in alterations in hydrology and modified geomorphic conditions within the three main tributaries of the Lagoon's watershed, as a source of sedimentation (City of San Diego, 2005).

The regional climate is characterized by higher precipitation during winter months and lower precipitation, and corresponding high lagoon salinity, during the dry summer months (Williams, 1997). Storm events transport sediment into the lagoon which deposits on the salt flats and within lagoon channels. These sediment deposits have gradually built-up over the years due to increased sediment loading and inadequate flushing, which directly and indirectly affects lagoon functions and salt marsh characteristics.

4.1.5 Habitat alterations

Continued sedimentation and freshwater inputs, both resulting from urbanization, have resulted in significant alterations to habitat (White and Greer, 2002; Greer and Stowe, 2003; CE, 2003; Mudie et al, 1974; LPL Foundation and State Coastal Conservancy, 1985). In 1985, the Los Peñasquitos Lagoon Enhancement Plan estimated that sedimentation had removed 25 acres from the coastal salt marsh inventory. The encroachment of freshwater wetlands and reduction of saltwater marsh is evident in the National Wetland Inventory (NWI) maps from 1985 and 2009 (Figures 13 and 14). The location of different wetland types is also shown in maps that were included in the Los Peñasquitos Lagoon Enhancement Plan (1985) and in the Mudie et al. 1974 report (Figures 15 and 16). Although there are differences in the depiction of wetland areas from each study and time period, these maps show an encroachment of riparian, freshwater, and upland vegetation types in the eastern portion of the lagoon that is likely related to sediment accumulation and impediments to tidal flow. As discussed in Section 3.4, California State Parks estimated that 180 acres of the 390 to 570 acres of coastal salt marsh has been impaired by sedimentation, converting coastal salt marsh to more riparian habitat.

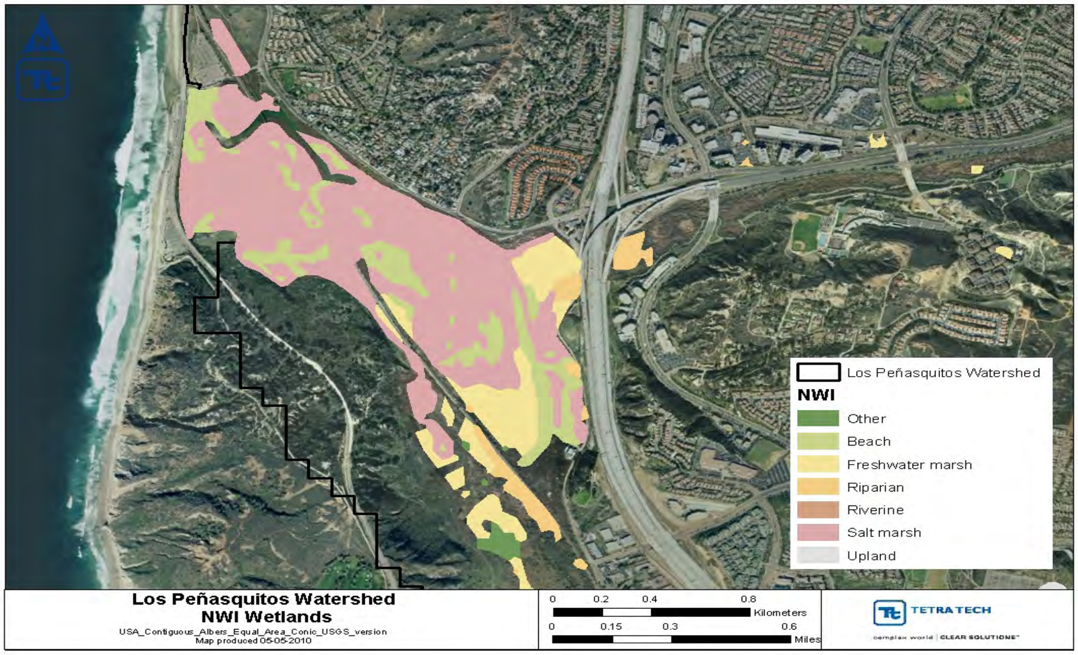

Figure 13. National Wetland Inventory (NWI) - 1985

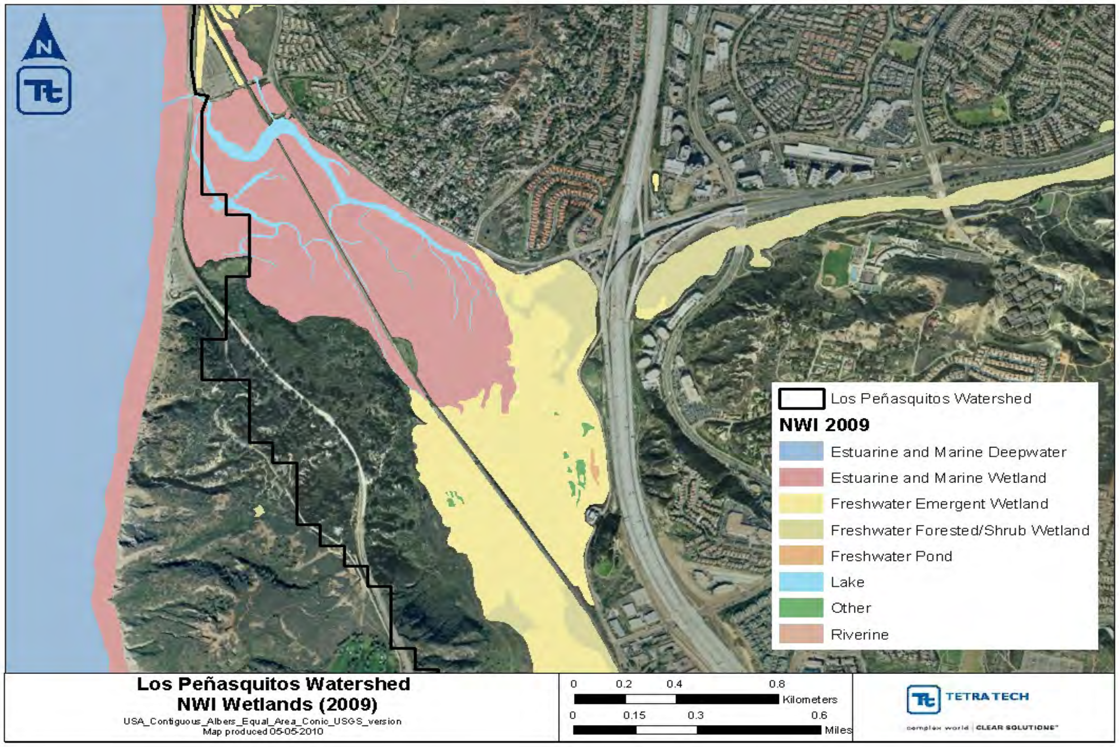

Figure 14. National Wetland Inventory (NWI) - 2009

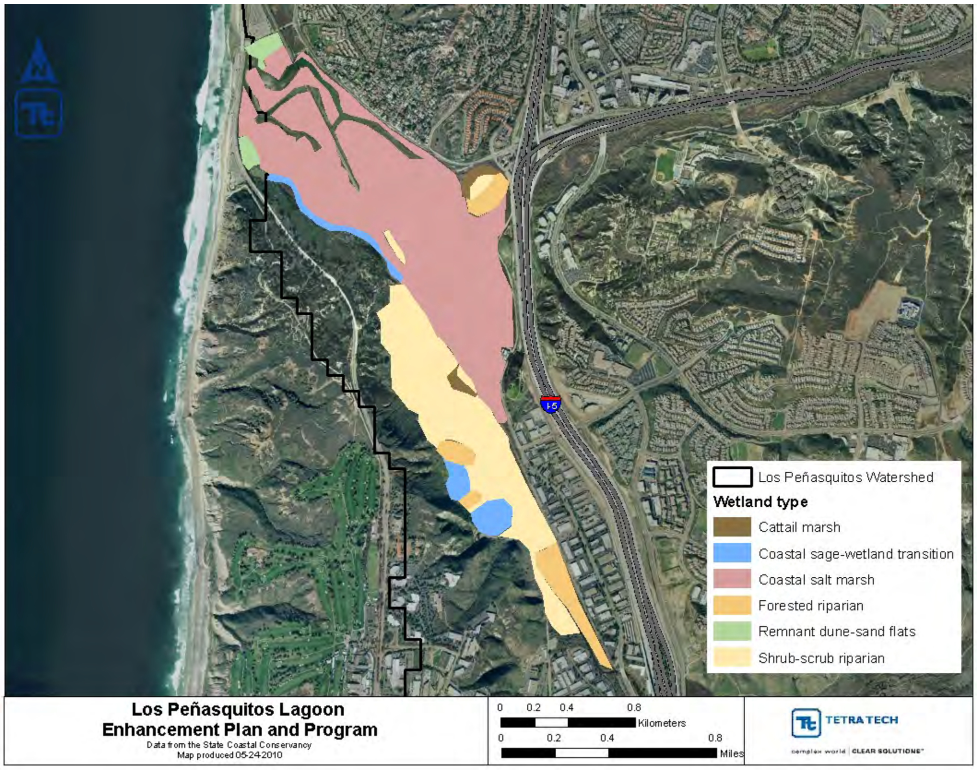

Figure 15. LPL Enhancement Plan – 1985 wetland types

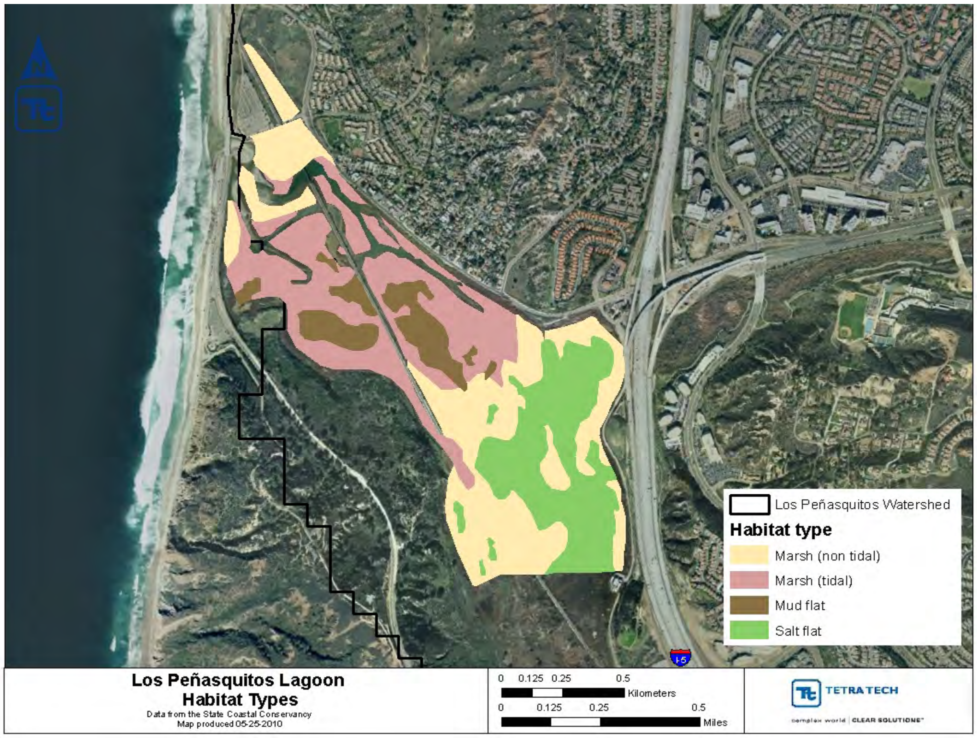

Figure 16. Historical lagoon wetland types (Mudie et al. 1974)

4.2 Impacts of Urbanization on Water Quality

Rapid urbanization of the watershed directly affects the natural drainage, pollutant loads and hydrologic characteristics such as peak flow rates, flow volumes, flow durations, and flow velocities (City of San Diego, 2005). Increased development has resulted in year-round flow in the main tributaries to the Lagoon (White and Greer, 2002; Greer and Stow, 2003). In addition to pollutant loading associated with specific land use practices, urbanization changes the landscape from pervious to impervious. Recent research has shown that impervious surfaces represent the imprint of land development on the landscape and is directly related to runoff (Burton and Pitt, 2002; Scheuler, 1994). Furthermore, impervious cover has been identified as the 'unifying theme' in stream degradation (USEPA, 1999); with stream degradation occurring with as little as ten percent imperviousness of the watershed (Scheuler, 1994).

The concerns associated with urban development are multifaceted. Land development typically results in increased erosion and runoff rates; accounting for up to 50 percent of sediment loads in urban areas (Burton and Pitt, 2002). In addition, urbanization increases imperviousness, resulting in alteration of the volume, velocity, duration, and timing of runoff events. Lowered infiltration rates speed surface runoff which leads to increased surface erosion and gullying. Ultimately, increased erosion destabilizes streambanks and washes sediment into surface waters. Freshwater runoff from adjacent and upstream urban development also reduces salinity, and brackish and freshwater plant species have encroached upon the area, reducing the salt marsh acreage (CE, 2003).

Previous studies which focused on the Lagoon and the surrounding watershed provide additional information on historical conditions and hydrologic changes associated with urbanization. For example, White and Greer (2002) classified three distinct periods of urbanization within the upper Los Peñasquitos Creek watershed: 1965-1973 was classified as low urbanization (<15 percent), 1973-1987 as moderate urbanization (15-25 percent), and 1988-2000 as high urbanization (>25%). Across the entire time period, the 1-2 year flood interval increased from 229 cubic feet per second (cfs), to 745 cfs, to 1,272 cubic feet per second in each respective period. Flow duration curves indicate increased baseflow, such that discharges above 1.7 cfs occurred more often during the period between 1973 to1987 than the earlier period (White and Greer, 2002). This study also estimated a four percent increase in runoff since 1972, with an increase in minimum flows throughout the study equivalent to 17 percent per year (2002). These findings are supported by a recent review of flow data in Los Peñasquitos Creek (Figure 17), which demonstrates a steady increase in monthly mean flows since the 1970s. These analyses illustrate the general urbanization trends throughout the watershed that impact the Lagoon and assist with identifying a period in time when development, and increased sediment delivery from the watershed, was not the primary concern.

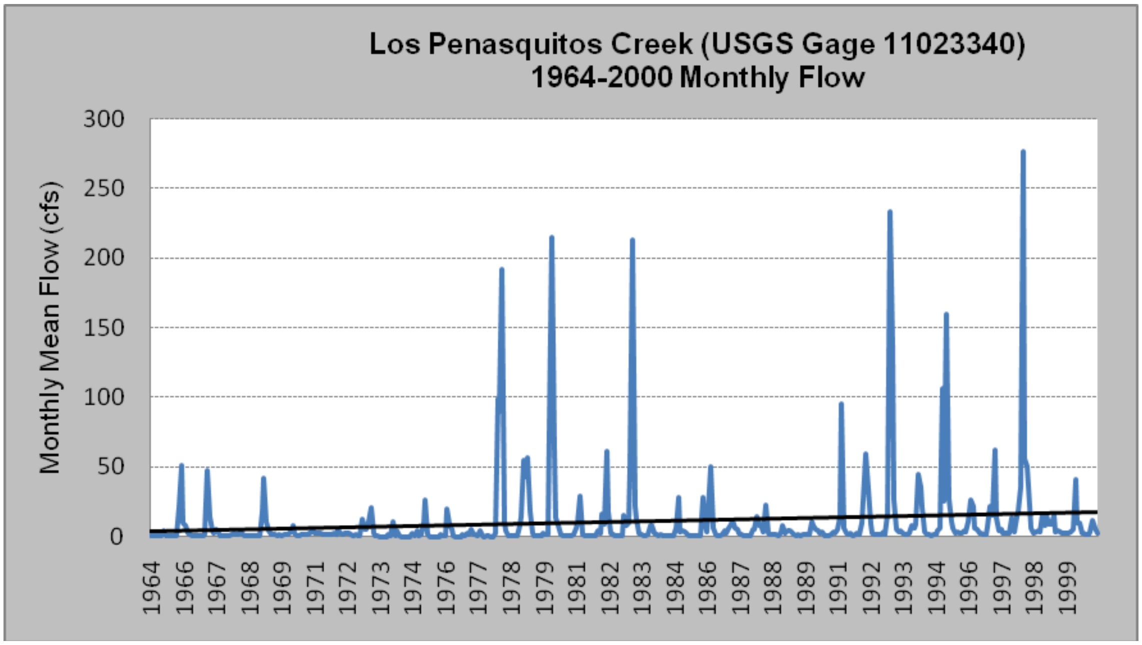

Figure 17. Hydrograph for Los Peñasquitos Creek

4.3 Selection of TMDL Numeric Target

A numeric sediment TMDL target was established through the historical analysis of land use and lagoon conditions using a ‘weight of evidence’ approach. The numeric target provides the link to the narrative WQO for sediment and defines the conditions that will result in the attainment of WQS for the Lagoon. Available data and literature studies of the Lagoon and watershed were evaluated to help identify the general time period when sedimentation impacts were likely minimal. This time period defines the reference condition upon which the numeric sediment target load was calculated. This approach was needed because numeric criteria are not specified in California’s water quality standards and available data for the Lagoon does not specifically define a sediment loading rate or other measure of natural background sediment loading that can be used for TMDL development.

Several lines of evidence were considered when evaluating the watershed and Lagoon conditions in order to determine an appropriate reference time period for TMDL development. These lines of evidence include:

- **Urbanization trends**: A review of historical literature that describes urbanization in the watershed (Section 4.1) indicates that intensive development began in the in the mid-1970s. Land use data shows a nearly 37% decrease in open space in the watershed beginning in the mid 1970s.
- **Population data**: Trend analysis of population data (Section 4.1) indicates that the population of the San Diego region has been steadily increasing since 1970.
- **Flow data**: Review of historical streamflow data from the USGS gage on Los Peñasquitos Creek and the conclusions drawn by White and Greer (2002) indicate that flow has increased substantially since the 1970s. White and Greer (2002) associated these flow increases with urbanization trends in the watershed.
- **Evaluation of Lagoon conditions** (Section 4.1.1). As described above, Lagoon conditions have been influenced by several factors, which can be separated into watershed impacts and problems associated with the lagoon mouth. Salt marsh habitat loss is primarily associated with long-term sedimentation impacts, reduced tidal flushing, and year-round freshwater input. Watershed impacts to the Lagoon include sediment delivery associated with urban development, which increased substantially in the mid-1970s. The wastewater treatment plants impacted water quality in the Lagoon until 1972 when the area was connected to the city sewer system, making it difficult to differentiate between the wastewater impacts and development-associated impacts during this time period (pre-1972). Available literature indicates that sediment deposition from the watershed is not adequately flushed out of the system due to problems at the lagoon mouth caused by the railroad berm (and other physical alterations) and sediment build-

up at the ocean inlet. Note that the Highway 101 bridge abutments were recently replaced and have resulted in improved tidal exchange through the area. As discussed above, reductions in the tidal prism have resulted in increased sediment build-up at the ocean inlet. Sediment impacts at the ocean inlet are primarily a function of littoral forces (Elwany, 2008) and other factors that are largely separate from the sedimentation problems that originate from the watershed. These factors are important to understand in order to effectively manage and improve conditions within the Lagoon, but are outside the scope of the sediment TMDL analysis.

Consideration of these various lines of evidence indicates that the Lagoon was likely achieving WQS for sediment before the mid-1970s; therefore the numeric target was calculated based on the historic mid-1970s land use distribution for the watershed (Figure 10). Existing and historic land use areas and the calculated percent change by land use category are shown in Table 2. This table indicates that open space decreased by nearly 37% between the mid-1970s and existing conditions (based on SANDAG 2000 land use data). The percent impervious associated with the historic land use cover was also determined. Overall, in the mid-1970s the Los Peñasquitos Lagoon watershed was approximately 9.4% percent impervious, which is just below the threshold of stream degradation that occurs at 10 to 15 percent of watershed imperviousness (Scheuler, 1994), thereby further justifying use of this historic time period.

The historic land use coverage was used to calculate the sediment load to the Lagoon using the LSPC watershed model (see Appendix A). This historic sediment load represents the sediment TMDL numeric target.

5 Data Inventory and Analysis

Multiple data sources were used to characterize the watershed and Lagoon, in particular stream flow and water quality conditions. Much of this information was recently collected by watershed stakeholders to assist with TMDL model development. Data describing the watershed's topography, land use, soil characteristics, meteorological data, and irrigation needs along with available bathymetric survey information and data sondes analyzing pressure and salinity were used to calibrate the watershed and Lagoon models. This section summarizes stream flow and total suspended sediment data; refer to the Modeling Report (Appendix A) for additional details.

5.1 Streamflow Data Summary

Available streamflow data collected within the watershed were compiled for model calibration and validation. The United States Geological Survey (USGS) maintains a long term flow gage (11023340) in the upper Los Peñasquitos watershed (Figure 18). Daily data from 1990 through 2008 were downloaded for calibration of model hydrologic parameters. Total suspended solids (TSS) data were also collected at this location and a downstream USGS sediment monitoring station (325423117124501) (see Section 5.2). Additional streamflow data were collected at the base of Los Peñasquitos, Carroll Canyon, and Carmel Creeks as part of the Los Peñasquitos TMDL monitoring study (City of San Diego, 2009) as described in the Modeling Report (Appendix A) (Figure 18).

Los Peñasquitos Creek drains the largest area within the watershed and, accordingly, recorded the highest measured flows and runoff volume (Figure 19). Review of recent data (2007-2008) shows that median flows in Los Peñasquitos Creek were roughly twice those in Carmel Creek and two orders of magnitude greater than in Carroll Canyon Creek. A continual increase in cumulative volume for Los Peñasquitos Creek and Carmel Creek indicated consistent baseflows. By contrast, streamflow data collected on Carroll Canyon Creek included periods with little change in cumulative volume, flashy response time, and low baseflow. Low flows at this station were within the tenth percentile. Additional stream flow data, including a discussion of data from the mass loading station (MLS) and location-specific challenges to flow monitoring are presented in Appendix A.

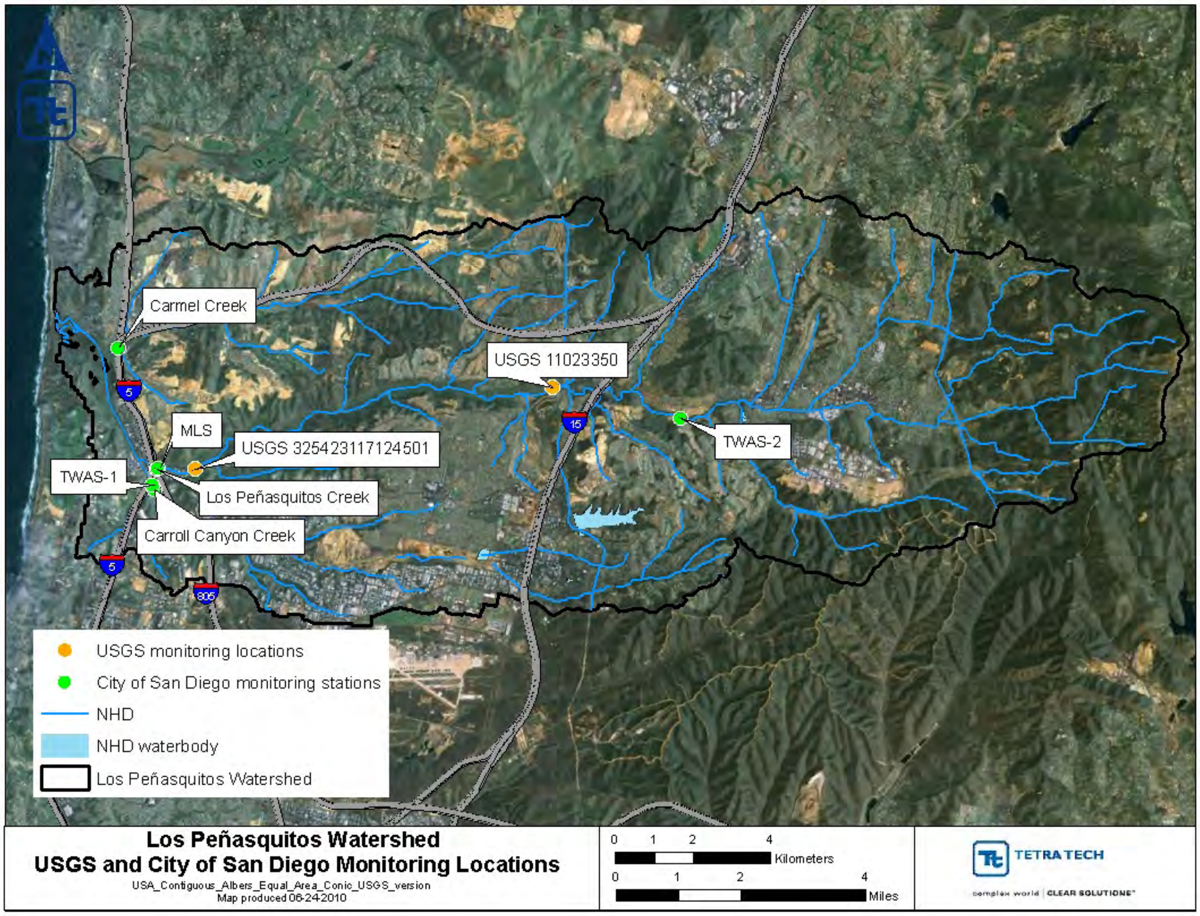

Figure 18. Monitoring locations in the Los Peñasquitos watershed

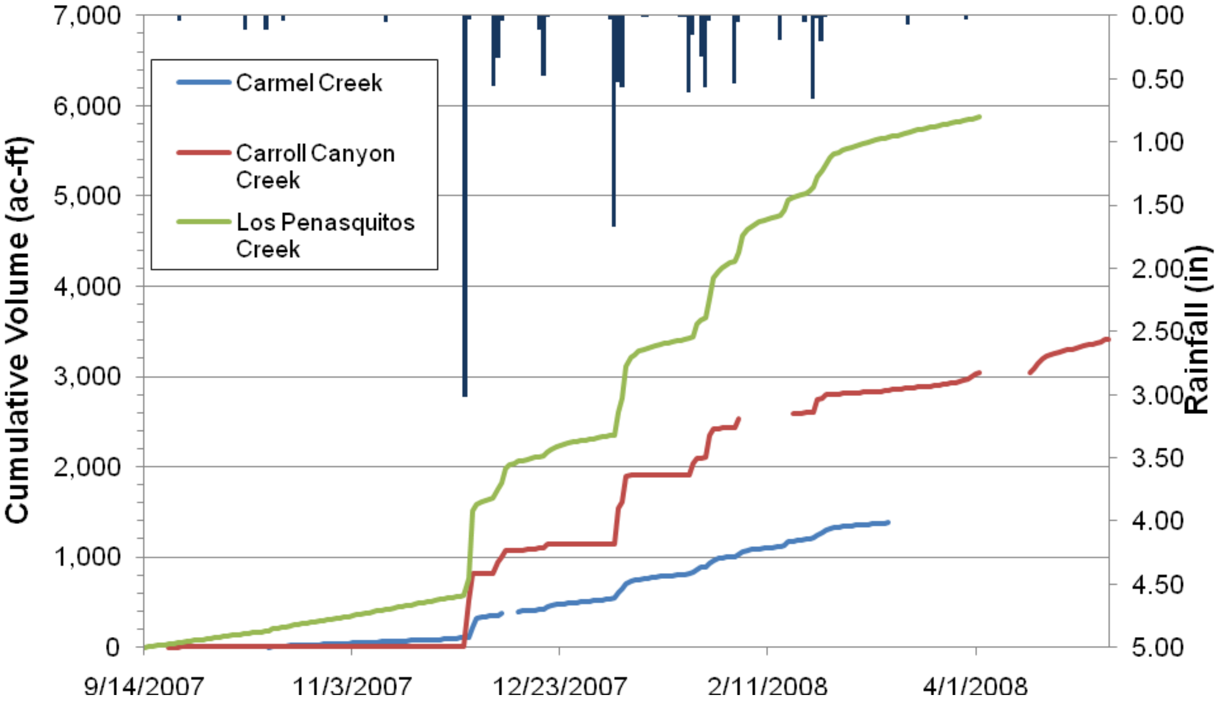

Figure 19. Cumulative flow volumes at TMDL monitoring locations

5.2 Suspended Sediment Data Summary

Total suspended solids and particle size data were collected by the City of San Diego (in accordance with Regional Board requirements) at several locations within the Los Peñasquitos watershed and used to develop and calibrate the watershed model (Figure 18). The USGS collected samples at gage 11023340 as well as at gage 325423117124501 (USGS, 2009). Event mean concentrations (EMCs) from storm water and dry weather runoff were collected at the MLS on Los Peñasquitos Creek near the confluence with Carroll Canyon Creek . Storm water and dry weather runoff events were also monitored at this station since 2001, in accordance with NPDES permit requirements. In addition, two Temporary Watershed Assessment Stations (TWAS) are located within the watershed on Los Peñasquitos Creek upstream (TWAS-2) and on Carroll Canyon Creek (TWAS-1). Collectively, these data were used to better understand the relationship between flow and sediment loading for model development purposes.

Pollutograph samples characterizing suspended sediment concentration changes throughout a storm were collected during three storms in the 2007-2008 storm season as part of the TMDL monitoring study. Samples were collected from the three major streams flowing into the lagoon: Los Peñasquitos, Carroll Canyon, and Carmel Creeks.

Longer-term datasets were also available for comparison (MLS and USGS stations). TSS concentrations recorded at the MLS on Los Peñasquitos Creek since 2001 were more than five times lower than the data collected by the USGS at both stations, possibly due to the presence of cattails upstream of the Los Peñasquitos MLS and the presence of the El Cuervo Norte wetland diverting flows from Los Peñasquitos Creek (Figure 20). When comparing just the pollutographs for the three major streams, TSS EMCs at Carroll Canyon Creek were consistently higher than those at Los Peñasquitos and Carmel Creeks (Figure 20). Additional details on sediment data, including particle size distribution, further comparison of the pollutographs and EMCs, and correlations with rainfall are presented in Appendix A.

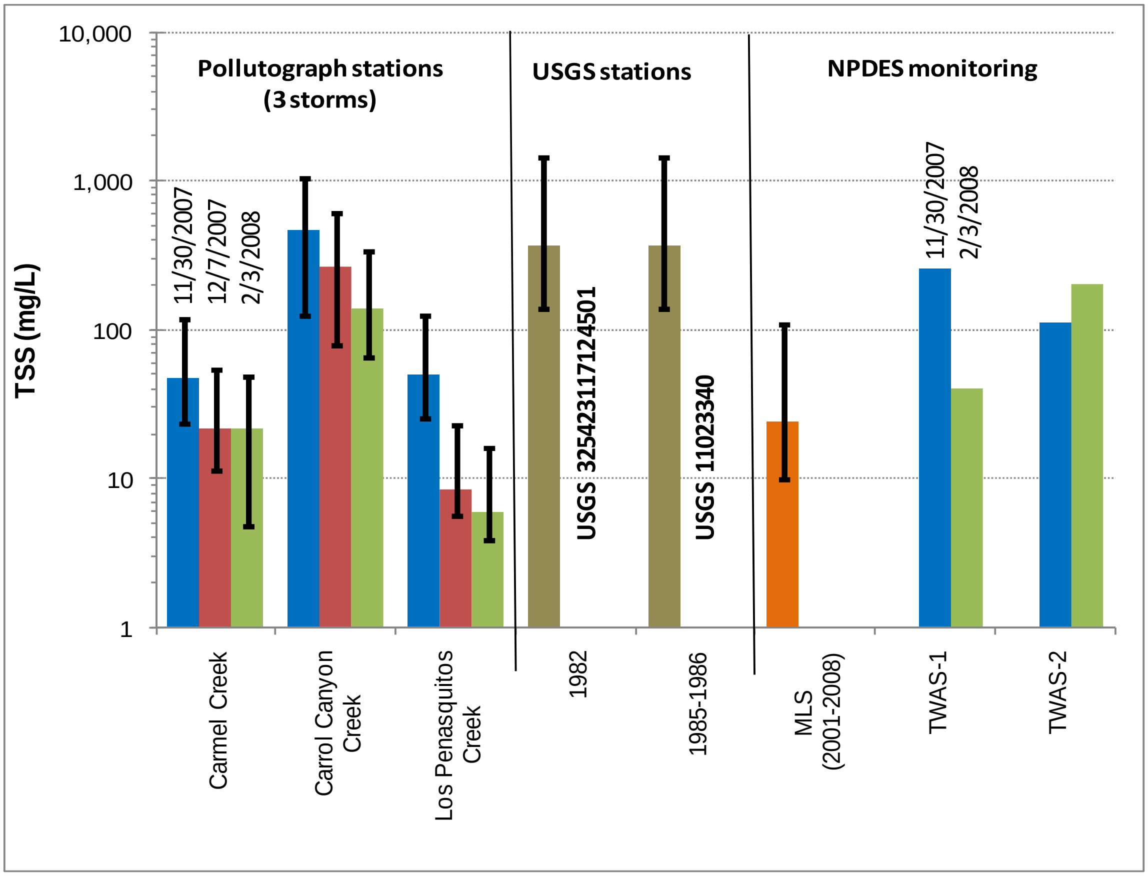

Figure 20. EMC/Median TSS and 95th percentile confidence intervals for all sampling events

6 Source Assessment

The purpose of the source assessment is to identify and quantify the sources of sediment to the Los Peñasquitos Lagoon. Sediment can enter surface waters from both point and nonpoint sources. Point sources typically discharge at a specific location from pipes, outfalls, and conveyance channels from, for example, municipal wastewater treatment plants or municipal separate storm sewer systems (MS4s). These discharges are regulated through waste discharge requirements (WDRs) that implement federal NPDES regulations issued by the State Water Board or the Regional Board through various orders. Nonpoint sources are diffuse sources that have multiple routes of entry into surface waters. Some nonpoint sources, such as agricultural and livestock operations are regulated under the Basin Plan’s waste discharge requirement waiver policy (Waiver Policy). The source assessment quantification is measured as an annual or daily load, which is then used to separate the load allocations or wasteload allocations for the TMDL. The following sections discuss the sediment sources that contribute to Los Peñasquitos Lagoon.

6.1 Land Use / Sediment Source Correlation

Sources of sediment are generally the same under both wet weather and dry weather conditions; however, storm events can cause significant erosion and transport of sediment downstream (especially from canyon areas below storm water outfalls). Dry weather loading is dominated by nuisance flows from urban land use activities such as car washing, sidewalk washing, and lawn over-irrigation, which pick up and transport sediment into receiving waters. Wet weather loading is dominated by episodic storm flows that wash off sediment that has built up on land surfaces during dry periods and from canyon areas below storm water outfalls. Due to the higher runoff potential associated with wet weather conditions, emphasis was placed on characterizing wet weather watershed loading.

Sediment sources were quantified by land use group since sediment loading can be highly correlated with land use practices. For example, land disturbance may occur from construction or agricultural practices, disturbing native vegetative cover and leaving the soil susceptible to erosion. With the native cover disturbed, a rainfall event can cause soil detachment and further erosion of the land due to overland flow. For impervious areas, a different process occurs where sediment builds up over time to a maximum amount for each impervious land use type. For both pervious and impervious land uses, the amount of sediment that can be transported is a function of runoff. Scouring of stream banks can also occur in un-protected areas.

Since several land use types share hydrologic or pollutant loading characteristics, many were grouped into similar classifications, resulting in a subset of nine categories for modeling. Selection of these land use categories was based on the availability of monitoring data and literature values that could be used to characterize individual land use contributions and critical sediment-contributing practices associated with different land uses. For example, multiple urban categories were represented independently (e.g., high density residential, low density residential, and commercial/institutional), whereas other natural categories were grouped. The three major land use sources in the watershed are open space, low density residential, and industrial/transportation.

The sediment load contributed by each land use type was calculated using the LSPC model. Modeling parameters varied by land use to provide the correlation between sediment loading and land use type. The amount of runoff and associated sediment concentrations are highly dependent on land use.

6.2 Point Sources

Storm water runoff is regulated through the following NPDES permits: the San Diego County Phase I municipal separate storm sewer system (MS4) permit, the Phase II MS4 permit for small municipal dischargers, and the statewide storm water permit issued to Caltrans. The permitting process defines these discharges as point sources because storm water is discharged from the end of a storm water conveyance system, as described below. NPDES permits are also issued for construction and industrial sites that are enrolled in the statewide General Storm Water permit program. These sites are located within areas controlled by the San Diego County Phase I MS4 permit and are, therefore, not specifically included in the TMDL analysis.

6.2.1 Phase I Municipal Separate Storm Sewer System (MS4)

In 1990, the USEPA developed rules establishing Phase I of the NPDES storm water program, designed to prevent harmful pollutants from being washed by urban runoff into MS4s or from being discharged directly into MS4s, and then local receiving waters. Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or more) to implement an urban runoff management program as a means to control polluted discharges from MS4s.

Approved urban runoff management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipally owned operations and hazardous waste treatment. More specifically, large and medium operators are required to develop and implement Urban Runoff Management Plans that address, at a minimum, the following elements:

- Structural control maintenance;
- Areas of significant development or redevelopment;
- Roadway runoff management;
- Flood control related to water quality issues;
- Municipally owned operations such as landfills, wastewater treatment plants, etc.;
- Hazardous waste treatment, storage, or disposal sites, etc.;
- Application of pesticides, herbicides and fertilizers;
- Illicit discharge detection and elimination;
- Regulation of sites classified as associated with industrial activity;
- Construction site and post-construction site runoff control; and
- Public education and outreach.

Twenty one entities are identified in Regional Board Order R9-2007-0001 (NPDES No. CAS0108758) and are responsible for addressing water quality concerns for the MS4 (Regional Board, 2007). Responsible Municipal Dischargers within the Los Peñasquitos watershed are San Diego County, the City of San Diego, the City of Del Mar, and the City of Poway.

During wet weather events, significant erosion can occur along canyon walls below storm water outfalls. Sediment also builds up on the land surface from various sources and associated management practices and is then washed off the surface during rainfall events. The amount of runoff and associated concentrations are, therefore, highly dependent on the nearby land management practices. Note that the redistribution of sediment to other areas of the Lagoon can be caused by both anthropogenic and natural processes; however, most of the sediment is contributed by point sources in the watershed so this resuspension is associated with and quantified in the MS4 load calculations.

All land uses were classified as generating point source loads because, although the sediment sources on these land use types may be diffuse in origin, the pollutant loading is transported and discharged to receiving waters through the MS4. Sediment loads that are attributed to point sources are discharged via the MS4 from all land uses. Note that several construction and industrial sites regulated under the General Statewide Storm Water Permit program are located within the Phase 1 MS4 permitted area. Additional information would be needed to estimate the sediment load contribution from these sites.

6.2.2 Phase II Municipal Separate Storm Sewer System (MS4)

In 1999, the USEPA developed rules establishing Phase II of the NPDES storm water program, extending the regulations to storm water discharges from small MS4s located in “urbanized areas” and construction activities that disturb 1 to 5 acres of land. Small MS4 systems are not permitted under the municipal Phase I regulations, and are owned or operated by the United States, a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity.

The General Permit for the Discharge of Storm Water from Small MS4s, Water Quality Order No. 2003-0005-DWQ (Small MS4 General Permit) regulates discharges of storm water from “regulated Small MS4s.” A “regulated Small MS4” is defined as a Small MS4 that discharges to a water of the United States or to another MS4 regulated by an NPDES permit. The General Permit requires that Small MS4 Dischargers develop and implement a Storm Water Management Program (SWMP) that reduces the discharge of pollutants through their MS4s to the Maximum Extent Practicable (MEP). The SWMP must describe the best management practices (BMPs), measurable goals, include time schedules of implementation, and assign responsibility of each task.

Non-traditional Small MS4s may also require coverage by the permit. The non-traditional Small MS4s include those located within or discharge to a permitted MS4, and that pose significant water quality threats. In general, these are storm water systems serving public campuses (including universities, community colleges, primary schools, and other publicly owned learning institutions with campuses), military bases, and prison and hospital complexes within or adjacent to other regulated MS4s, or which pose significant water quality threats. The State Water Board considered designating non-traditional small MS4s when adopting this General Permit.

Entities that enroll in Order No. 2003-0005-DWQ are responsible for addressing water quality concerns from their small MS4s. In the San Diego Region, the non-traditional small MS4s that are subject to the Order include the San Diego Unified School District (SDUSD) and others, as applicable, in the watershed.

As with Phase I MS4s, pollutants build up on land surfaces and then are washed off during rainfall events. The amount of runoff and associated concentrations are highly dependent on the nearby land uses and management practices.

6.2.3 Caltrans MS4s

Caltrans is regulated by a statewide storm water discharge permit that covers all municipal storm water activities and construction activities (State Board Order No. 99-06-DWQ; CAS000003). The Caltrans storm water permit authorizes storm water discharges from Caltrans properties such as the state highway system, park and ride facilities, and maintenance yards. The storm water discharges from most of these Caltrans properties and facilities eventually ends up in either a city or county storm drain system.

6.3 Nonpoint Sources

A nonpoint source is a source that discharges via sheet flow or natural discharges. Additionally, storm surges and ocean tides can be a source of sediment to the mouth of the Lagoon; however, a recent study found that accumulated sediment at the Lagoon's ocean inlet was similar to beach sediment and tidal sources (Elwany, 2008). For this reason, watershed loading was assumed to have a less significant contribution to sediment build-up at the inlet. Beach erosion processes cannot be modeled with the existing model configuration which lacks wave, wave-breaking, and wave-current interaction components; therefore, sediment modeling used a reduced grid which sets the open ocean boundary immediately outside of the ocean inlet (see Appendix A for a more detailed discussion).

7 Linkage Analysis

The technical analysis of the relationship between pollutant loading from identified sources and the response of the waterbody to this loading is referred to as the linkage analysis. The purpose of the linkage analysis is to quantify the maximum allowable sediment loading that can be received by an impaired waterbody and still attain the WQOs of the applicable beneficial uses. This numeric value is represented by the TMDL.

The linkage analysis for this TMDL is based on computer models that were developed to represent the physical processes within the impaired receiving waterbody and the associated watershed. The models provide estimation of sediment loadings from the watersheds based on rainfall events, and simulation of the response of the receiving water to these loadings. The following sections provide more detailed discussion regarding model selection and linkage analyses.

7.1 Model Selection Criteria

In selecting an appropriate approach for TMDL calculation, technical and regulatory criteria were considered. Technical criteria include the physical system, including watershed or receiving water characteristics and processes and the constituents of interest. Regulatory criteria include water quality objectives or procedural protocol. The following discussion details the considerations in each of these categories. Based on these considerations, appropriate models were chosen to simulate watershed and receiving water conditions.

7.2 Technical Criteria

Technical criteria were divided into four main topics. Consideration of each topic was critical in selecting the most appropriate modeling system to address the types of sources and the numeric target associated with the impaired waterbody.

Physical Domain

Representation of the physical domain is perhaps the most important consideration in model selection. The physical domain is the focus of the modeling effort—typically, either the receiving water itself or a combination of the contributing watershed and the receiving water. Selection of the appropriate modeling domain depends on the constituents and the conditions under which the waterbody exhibits impairment. For a waterbody dominated by point source inputs that exhibits impairments under only low-flow conditions, a steady-state approach is typically used. If the system includes tidal influences, quasi-steady-state simulation is typically performed that assumes steady-state inputs, but includes diurnal variability in hydrodynamics associated with tidal effects. The steady-state and quasi-steady-state modeling approaches primarily focus on receiving water processes during a user-specified condition.

For waterbodies affected additionally or solely by nonpoint sources or primarily rainfall-driven flow and pollutant contributions, a dynamic approach is recommended. Dynamic models consider time-variable nonpoint source contributions from a watershed surface or subsurface, as well as a hydrodynamic response of the receiving water. Some models consider monthly or seasonal variability, while others enable assessment of conditions immediately before, during, and after individual rainfall events. Dynamic models require a substantial amount of information regarding input parameters and data for calibration purposes.

Source Contributions

Primary pollutant sources must be considered in the model selection process. Accurately representing contributions from nonpoint sources and point sources is critical in properly representing the system and ultimately evaluating potential load reduction scenarios.

Water quality monitoring data were not sufficient to fully characterize all sources of sediment to the Lagoon, however, available data indicate that the main controllable sources are watershed runoff and streambank erosion. As a result, the models selected to develop a sediment TMDL for the Los Peñasquitos Lagoon need to address the major source categories during conditions considered controllable for TMDL implementation purposes.

Critical Conditions

The goal of the TMDL analysis is to determine the assimilative capacity of the waterbody and to identify potential allocation scenarios that will enable that waterbody to achieve WQOs. The critical condition is the set of environmental conditions for which controls designed to protect water quality will ensure attainment of objectives for all other conditions. This is typically the period of time in which the waterbody exhibits the most vulnerability. For the Lagoon and its watershed there is a high degree of variability in when sediments are deposited at the mouths of each creek. This variability is due to the nature of wet weather events that represent the critical condition for sediment deposition.

Constituents

Another important consideration in model selection and application is the constituent(s) to be assessed. Choice of state variables is a critical part of model implementation. The more state variables included, the more difficult the model will be to apply and calibrate.

However, if key state variables are omitted from the simulation, the model might not simulate all necessary aspects of the system and might produce unrealistic results. A delicate balance must be met between minimal constituent simulation and maximum applicability.

7.3 Regulatory Criteria

A properly designed and applied model provides the source-response linkage component of the TMDL and enables accurate assessment of assimilative capacity and allocation distribution. The receiving water's assimilative capacity is determined by assuming adherence to WQOs. For all waters in the San Diego Region, the Basin Plan establishes the beneficial uses for each waterbody to be protected and the WQOs that protect those uses. In the case of narrative objectives, interpretation is required to develop a numeric target for TMDL development (refer to Section 4). The modeling framework must enable direct comparison of model results to the selected numeric target and allow for the analysis of the duration of those conditions. For the watershed loading analysis and implementation of required reductions, it is also important that the modeling framework allow for the examination of gross land use loading.

7.4 Model Selection and Overview

Establishing the relationship between the receiving water quality target and source loading is a critical component of TMDL development. This allows for the evaluation of management options that will help achieve the desired source load reductions. This can be established through a number of techniques, ranging from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. The objective of this section is to present the approach taken to develop the linkage between sources and receiving water responses for TMDL development in the Lagoon.

In addition, to assist in TMDL development and to provide decision support for watershed management, the models can be used to simulate various scenarios and may require future modifications to address specific management and environmental factors. Such scenarios may result from the augmentation of input data to be collected in ensuing monitoring efforts, future implementation of various management strategies or best management practices (BMPs), or adaptation and linkage to additional models developed in subsequent projects. Therefore, model flexibility is a key attribute for model selection.

The modeling system was divided into two components representative of the processes essential for accurately modeling hydrology, hydrodynamics, and water quality. The first component of the modeling system is a watershed model that predicts runoff and external pollutant loading as a result of rainfall events. The second component is a hydrodynamic and water quality model that simulates the complex water circulation and pollutant transport patterns in the Lagoon.

The models selected for the Lagoon sediment TMDL are components of USEPA's TMDL Modeling Toolbox (Toolbox), which was developed through a joint effort between USEPA and Tetra Tech, Inc. (USEPA, 2003). The Toolbox is a collection of models, modeling tools, and databases that have been utilized over the past decade to assist with TMDL development and other environmental studies. The Loading Simulation Program in C++ (LSPC) is the primary watershed hydrology and pollutant loading model and the Environmental Fluids Dynamic Code (EFDC) is the receiving water hydrodynamic and water quality model in the Toolbox modeling package. Both the LSPC and EFDC models are summarized below and described in detail in the Modeling Report (Appendix A).

7.4.1 Watershed Model: Loading Simulation Program in C++ (LSPC)

LSPC was selected for simulation of land-use based sources of sediment and the hydrologic and hydraulic processes that affect delivery (Shen et al., 2004; Tetra Tech and USEPA, 2002; USEPA, 2003). LSPC was specifically used to simulate watershed hydrology and transport of sediments in the streams and storm drains flowing to the impaired Lagoon. LSPC is a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) (Bicknell et al., 1997) algorithms for simulating hydrology, sediment, and general water quality on land, as well as a simplified stream fate and transport model. Since its original public release, the LSPC model has been expanded to include additional GQUAL components for sorption/desorption of selected water quality constituents with sediment, enhanced temperature simulation, and the HSPF RQUAL module for simulating dissolved oxygen, nutrients, and algae.

The hydrologic (water budget) process is complex and interconnected within LSPC. Rain falls and lands on various constructed landscapes, vegetation, and bare soil areas within a watershed. Varying soil types allow the water to infiltrate at different rates while evaporation and plant matter exert a demand on this rainfall. Water flows overland and through the soil matrix. There may also be point source discharge and water withdrawals/intakes. The land representation in the LSPC model environment considers three flowpaths; surface, interflow, and groundwater outflow. The sediment routine in LSPC represents the general detachment of sediment due to rainfall, overland and instream transport, attachment when there is no rainfall, and scour.

The model can simulate sediment loadings from specific source areas (i.e., subwatershed or land use areas). This is important in terms of TMDL development and allocation analysis. For this TMDL, the LSPC model was used to calculate both historic and existing conditions within the watershed to establish the TMDL numeric target and required load reductions from existing conditions. The LSPC model output was incorporated as an input to the receiving water model for the Lagoon, as described below.

7.4.2 Lagoon Model: Environmental Fluid Dynamics Code (EFDC)

The Los Peñasquitos Lagoon was simulated using the EFDC model. The LSPC watershed model was linked to EFDC and provided all freshwater flows and loadings as model input. EFDC is a public domain, general purpose modeling package for simulating one-dimensional (1-D), two-dimensional (2-D), and three-dimensional (3-D) flow, sediment transport, and biogeochemical processes in surface water systems including rivers, lakes, estuaries, reservoirs, wetlands, and coastal regions. The EFDC model was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications (Hamrick, 1992). This model is now being supported by the USEPA and has been used extensively to support TMDL development throughout the country. In addition to hydrodynamic, salinity, and temperature transport simulation capabilities, EFDC is capable of simulating cohesive and noncohesive sediment transport, near-field and far-field discharge dilution from multiple sources, eutrophication processes, the transport and fate of toxic contaminants in the water and sediment phases, and the transport and fate of various life stages of finfish and shellfish. The EFDC model has been extensively tested, documented, and applied to environmental studies worldwide by universities, governmental agencies, and other entities.

The EFDC model includes four primary modules: (1) a hydrodynamic model, (2) a water quality model, (3) a sediment transport model, and (4) a toxics model. The hydrodynamic model predicts water depth, velocities, and water temperature. The water quality portion of the model uses the results from the hydrodynamic model to compute the transport of the water quality variables. The water quality model then computes the fate of up to 22 water quality parameters including dissolved oxygen, phytoplankton (three groups), benthic algae, various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria (Cerco and Cole 1994). The sediment transport and toxics modules use the hydrodynamic model results to calculate the settling of suspended sediment and toxics, resuspension of bottom sediments and toxics, and bed load movement of noncohesive sediments and associated toxics. For this project, the hydrodynamics and sediment transport models were used. The hydrodynamics model simulated the circulation, water temperature, and salinity in the lagoon driven by ocean tides and watershed inflows. The sediment transport model simulated the transport of sand, silt as non-cohesive sediments, and clay as cohesive sediment. Details of the EFDC model's hydrodynamic and eutrophication components are provided in Hamrick (1992) and Tetra Tech (2002, 2006a, 2006b, 2006c, 2006d).

The EFDC model was configured to simulate hydrodynamics and sediment transport in the Los Peñasquitos Lagoon for both existing and historic conditions. Specifically, water temperature and salinity were both modeled for hydrodynamics. Sediment fractions considered in the model include sand, silt, and clay. Sand and silt were modeled using the non-cohesive sediment module and clay was modeled using the cohesive sediment module in EFDC.

7.5 Model Application

A complete discussion, including model configuration, hydrologic and hydrodynamic calibration and validation, and water quality calibration and validation, of the LSPC and EFDC models is provided in the Modeling Report (Appendix A). These models provide the technical analysis framework that will be used to make regulatory and management decisions for the Lagoon and its watershed.

The models were initially calibrated to observed hydrologic and water quality data to characterize existing conditions in the watershed and Lagoon (required load reductions are based on these existing loads). In addition, the models were used to establish a TMDL numeric target for sediment. As described in Section 4, a historical review of available literature regarding urbanization trends and Lagoon impacts was used to identify an appropriate time period (mid 1970s) for calculating the numeric target that represents the sediment WQO. Conditions present at this time were associated with loads that met WQOs and did not adversely impact the Lagoon. To characterize this historical period, a historic land use coverage for the watershed was developed and model simulations were performed. The resulting historical net annual sediment load was identified as the TMDL numeric target and represents the loading (assimilative) capacity for the lagoon (i.e. the TMDL). Percent reductions were calculated based on the difference between the TMDL load and the sediment load that corresponds with existing conditions.

8 Identification of Load Allocations and Reductions

The calibrated models were used to simulate historical and existing sediment loads to the Los Peñasquitos Lagoon from which numeric targets and load reductions were established. Point sources were then assigned a wasteload allocation (WLA) while nonpoint sources were assigned a load allocation (LA). This section discusses the methodology used for TMDL development and the results in terms of loading capacities and required load reductions for the Los Peñasquitos Lagoon. Other TMDL components are also discussed including the margin of safety (MOS), seasonality and critical conditions, and a daily load expression.

8.1 Loading Analysis

The calibrated LSPC model was used to estimate existing sediment loads to the Lagoon, with the receiving water simulated based on the EFDC model (see Appendix A). Using the EFDC model, the assimilative capacity of the Lagoon was assessed and compared to the historical numeric target for evaluation of sediment quality.

8.2 Application of Numeric Targets

As discussed in Section 4, the narrative WQO for sediment was interpreted using a weight of evidence approach to determine a reference condition to define the TMDL numeric target (i.e., a historical period when the Lagoon was not impaired for sedimentation). Several lines of evidence used to establish a numeric sediment target include: urbanization trends, population data, flow data, and evaluation of Lagoon conditions over time.

8.3 Load Estimation

Estimation of current watershed loading to the impaired Lagoon required use of the LSPC model to predict flows and pollutant concentrations. The dynamic model-simulated watershed processes, based on observed rainfall data as model input, provided temporally variable load estimates for the critical period. These load estimates were simulated using calibrated, land use-specific processes associated with hydrology and sediment transport (see Appendix A).

8.4 Identification of Critical Conditions

Due to the higher transport potential of sediment during wet weather, the 1993 El Nino time period was selected as the critical period for assessment. The wet season that includes the 1993 El Nino storm events (10/1/92 – 4/30/93) is one of the wettest periods on record over the past several decades. Statistically, 1993 corresponds with the 93rd percentile of annual rainfall for the past 15 years measured at the San Diego Airport (Lindbergh Field). Selection of this year was also consistent with studies performed by the Southern California Coastal Water Research Project (SCCWRP). An analysis of rainfall data for the Los Angeles Airport from 1947 to 2000 shows that 1993 was the 90th percentile year; meaning 90 percent of the years between 1947 and 2000 had less annual rainfall than 1993 (Los Angeles Water Board, 2002).

8.5 Critical Locations for TMDL Calculation

For TMDL calculation, a critical location within the impaired waterbody is selected for comparison to the numeric target in order to determine the required pollutant load reductions needed to meet the WQOs. The selection of a critical location (or locations) represents a conservative assessment of water quality conditions, as these areas typically display the worst water quality conditions and are the most vulnerable to pollution impacts. Although, a critical location is used for water quality assessment in the TMDL analysis, compliance with WQOs must be assessed and maintained throughout a waterbody in order to protect beneficial uses.

Due to the variability and dynamic nature of conditions within the Lagoon (e.g., mouth closures, tidal fluctuations, sediment fate and transport, etc.), the entire modeled Lagoon area was assessed as the critical location. Load reductions for sediment were based on achieving the numeric TMDL target across the Lagoon.

8.6 Calculation of TMDLs and Allocation of Loads

Load calculations for sediment were developed using land use-based generation rates and meteorological conditions from the critical wet period (10/1/92 – 4/30/93). The TMDL was divided among point sources as a WLA and nonpoint sources as a LA. The point sources identified in the Los Peñasquitos watershed are Phase I MS4 co-permittees (San Diego County and the cities of San Diego, Poway, and Del Mar), Phase II MS4s, and Caltrans. The USEPA's permitting regulations require municipalities to obtain NPDES requirements for all storm water discharges from MS4s. The existing loads estimated were solely the result of watershed runoff (land-use based) and streambank erosion and not other types of point sources.

8.7 Margin of Safety

A margin of safety (MOS) is incorporated into a TMDL to account for uncertainty in developing the relationship between pollutant discharges and water quality impacts (USEPA, 1991). The MOS can be incorporated in the TMDL either explicitly or implicitly. Reserving a portion of the loading capacity provides an explicit MOS, whereas, the use of conservative assumptions in the modeling and TMDL analysis provides an implicit

MOS. In either case, the purpose of the MOS is to ensure that the beneficial uses that are currently impaired will be restored, given the uncertainties in the TMDL analysis.

For this TMDL, an implicit MOS was included through the application of conservative assumptions throughout TMDL development. The following list describes several key assumptions that were used.

- **Critical condition** - The wet season that includes the 1993 El Nino storm events (10/1/92 – 4/30/93) was selected as the critical condition time period for TMDL development. This is one of the wettest periods on record over the past several decades. Because of the large amount of rainfall, sediment loads were significant higher during this period than in other years with less rainfall.

- **Soil composition** - Soils that are more easily transported typically have higher proportions of smaller particles sizes (silt and clay fractions), as compared to local parent soils, because of differences in settling rates and other sediment transport characteristics. To account for these differences in the model, soils transported by surface runoff were assumed to be composed of 5 percent sand, twice as much clay as the percentage of clay within each hydrologic soil group, and the remainder assigned to the silt fraction.

- **Numeric target** - The historical analysis involved an extensive literature search and technical analysis in order to identify an appropriate time period for development of the numeric sediment target. This comprehensive ‘weight of evidence’ analysis considered all available information regarding urbanization and lagoon impacts over time in order to identify a conservative reference condition.

- **Critical location** - TMDL load reductions are based on meeting the numeric target across the entire Lagoon (lagoon channels and marsh areas). This approach ensures protection of beneficial uses throughout the lagoon. .

It was determined that an explicit MOS was not needed because of use of conservative assumptions and the overall predictive capability of the modeling framework that was developed for this study.

8.8 Seasonality

The federal regulations at 40 CFR 130.7 require that TMDLs include seasonal variations. Sources of sediment are similar for both dry and wet weather seasons (the two general seasons in the San Diego region). Despite the similarity of wet/dry sources, transport mechanisms can vary between the two seasons. Throughout the TMDL monitoring period, the greatest transport of sediment occurred during rainfall events. It is recognized that dry weather will contribute a deminimus discharge of sediment;

however, model calibration and TMDL development focused on wet weather conditions as sediment transport is dramatically higher during wet weather. Model simulation was completed for the 10/1/92 – 4/30/93 wet period to account for the much greater sediment loading and associated impacts to the Lagoon during this time period.

8.9 Daily Load Expression

The load allocations for the Lagoon are presented in Section 9. Load allocations are expressed in terms of net sediment load for the critical period (tons) because sediment delivery to streams is highly variable on a daily and annual basis. Loads were also divided by the number of days in the critical period (211) to derive daily loading rates (tons/mi^2/day). EPA expects the load allocations to be evaluated using a long-term rolling average period (e.g. 15-year), because of the natural variability in sediment delivery rates. In addition, EPA does not expect each square mile within a particular source category throughout the watershed to necessarily meet the load allocation; rather, EPA expects the watershed average for the entire source category to meet the load allocation for that category.

9 Total Maximum Daily Loads and Allocations

The TMDL is the total amount of pollutant that can be assimilated by the receiving waterbody while still achieving the numeric target. Allowable loadings from pollutant sources that cumulatively amount to no more than the TMDL must be established; this provides the basis to establish water quality-based controls. TMDLs can be expressed on a mass loading basis (e.g., net sediment amount per year) or as a concentration in accordance with 40 CFR 130.2(l).

A TMDL for a given pollutant and waterbody is comprised of the WLA for point sources and LA for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and water quality in the receiving waterbody. Conceptually, this definition is represented by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

A TMDL was established for the Lagoon using the methodology described above (Section 6). The WLA portion of this equation is the total loading assigned to point sources. The LA portion is the loading assigned to nonpoint sources. The MOS is the portion of loading reserved to account for any uncertainty in the data and computational methodology, as described in Section 8. An implicit MOS was incorporated for this TMDL.

9.1 Wasteload Allocations

Federal regulations (40 CFR 130.7) require TMDLs to include a WLA for point source discharges regulated under a discharge permit. The Los Peñasquitos watershed includes several MS4 municipalities and other permitted dischargers. The total sediment contribution from all dischargers in the watershed is presented as the WLA.

Twenty entities are identified in Regional Board Order R9-2007-0001 (NPDES No. CAS0108758) and are responsible for addressing water quality concerns for the MS4 (Regional Board, 2007). The Phase I MS4 municipal dischargers within the Los Peñasquitos watershed are the County of San Diego, the City of San Diego, the City of Del Mar, and the City of Poway. Sediment loads generated from land use activities within MS4 boundaries were included in the WLA. The total WLA includes the contribution from Phase II MS4 facilities within the watershed and highway areas regulated under the Caltrans MS4 permit. Permittees enrolled under the General

Statewide Construction and Industrial Storm Water Permit program are located within the permitted area of the Phase 1 MS4 municipalities and are, therefore, included in the total WLA. Additional information may be needed in the future to help determine the contribution from construction areas and industrial facilities in the watershed to assist with implementation planning. No other individual NPDES permits for point sources are located in the watershed.

9.2 Load Allocations

According to federal regulations (40 CFR 130.2(g)), load allocations are best estimates of the nonpoint source or background loading. For the Los Peñasquitos watershed, land use contributions to MS4 systems are included in the WLAs described above. A LA was assigned to sediment contributions from storm surges and wave action along the ocean boundary (ocean sediment contributions).

9.3 Summary of TMDL Results

The overall TMDL and its component loads are presented in Table 3. Daily loads are established by dividing the modeled loads by the number of days within the critical wet period (211 days). Current loads, historical loads, and required reductions are presented in Table 4. Existing loads were estimated based on modeling of current land use conditions (from the SANDAG 2000 land use coverage) and meteorological conditions from the critical wet period (10/1/92 – 4/30/93). As described in Section 4, the numeric target was calculated based on modeling of historical (mid-1970s) land use conditions and the same meteorological data in order to accurately compare the watershed and Lagoon response to the same weather conditions. Historic loads define the allowable load; therefore, required load reductions represent the difference between current sediment loads and historic (allowable) loads. Note that sediment dynamics within the Lagoon are dependent on a number of factors, including runoff volumes and the amount of sediment that is transported to the lagoon from the watershed. These factors are important components in determining the timing and magnitude of erosion and depositional processes within the Lagoon. The Lagoon model shows that a reduction in watershed sediment loading affects the amount of sediment that can deposit throughout the lagoon from oceanic inputs (considering a constant input of sediment from the ocean boundary under current and historical conditions). The model analysis for historical conditions indicates that a greater proportion of sediment that deposits in the Lagoon originates from tidal inputs during lower watershed loading periods, therefore, the TMDL results show that a net increase in oceanic loads occurs during the critical wet period under historical landuse conditions. To meet the TMDL, the total load reduction required from the watershed is approximately 67%. Tidal input from the ocean boundary represents natural background loads, therefore, no reduction is required for this source category.

Table 3. TMDL summary

Source	Critical Wet Period Load (tons)	Daily Load (tons)
TMDL	12,360	59
Watershed contribution (WLA)	2,580	12
Ocean boundary (LA)	9,780	46
MOS	Implicit	Implicit

Table 4. Current vs. historical loads and percent reduction

Source	Current Load (tons)	Historical Load (tons)	Load Reduction (tons)	Percent Reduction Required
TMDL	13,663	12,360	1,303	10%
Watershed contribution (WLA)	7,719	2,580	5,139	**67%**
Ocean boundary (LA)	5,944	9,780	+3,836 (increase)	+39% (increase)

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Attachment 2

Modeling Report

Los Peñasquitos Lagoon Sediment TMDL Modeling - Final

Referenced as Attachment 2 to the Staff Report for the Los Peñasquitos Lagoon Sediment/Siltation TMDL.

Also referenced as Appendix A to the Technical Support Document for the Los Peñasquitos Lagoon Sediment/Siltation TMDL.

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October 12, 2010

Contents

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Introduction

The Los Peñasquitos watershed and lagoon are located in central San Diego County (Figure 1). Both the watershed and lagoon are included in the Los Peñasquitos Hydrologic Unit (906), which also includes Mission Bay and several coastal tributaries[1]. The lagoon was included in the Clean Water Act's (CWA) Section 303(d) list for sediment/siltation and is the primary focus of this study. Increasing urban development has altered hydrology within the watershed and modified the geomorphic conditions of the three main tributaries that feed into the lagoon. These conditions have resulted in sedimentation in the lagoon-watershed interface and within lagoon channels (City of San Diego, 2009).

Tetra Tech (Tt) is supporting the City of San Diego and stakeholders by developing and calibrating models to support ongoing sediment TMDL development efforts for Los Peñasquitos Lagoon. Water quality simulation models are needed to link potential sources of sediment loading to lagoon impacts for TMDL development and analysis of management scenarios. The linked watershed and lagoon models were developed based on models that were previously configured for the U.S. Environmental Protection Agency (EPA) and the Regional Water Quality Control Board. These models were refined with additional calibration and validation based on monitoring data that were recently collected by the watershed stakeholders.

This report describes the approach that was used to develop and refine the Los Peñasquitos watershed and lagoon models. Model calibration/validation results are also presented and discussed. The watershed model used information on watershed soils, land use, topography, and stream networks to simulate the hydrology and sediment input to the lagoon. The lagoon model incorporates watershed inputs and oceanic forcings (tidal flooding) to mimic the circulation and sediment transport within the lagoon. This modeling framework will eventually be used to simulate existing (baseline) conditions within the watershed and lagoon, calculate the numeric TMDL target, identify required sediment load reductions, and evaluate possible management actions.

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[1] http://www.projectcleanwater.org/html/ws_penasquitos.html

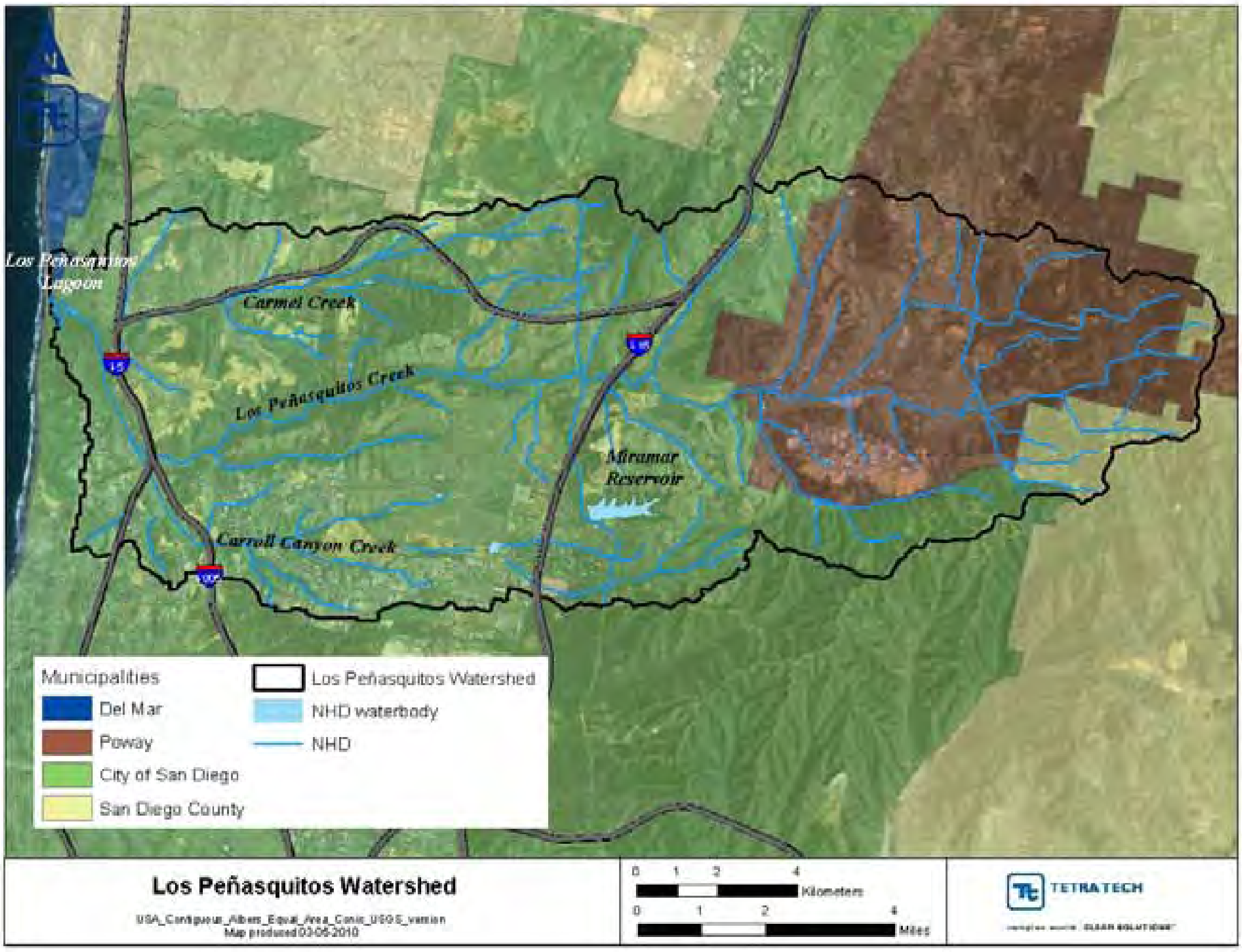

Figure 1. Location of the Los Peñasquitos watershed and lagoon

Watershed Description

The Los Peñasquitos Lagoon watershed is a 93 mi^2 coastal watershed located in central San Diego County. The watershed includes portions of the cities of San Diego, Poway, and Del Mar. In addition, a small portion of San Diego County is located in the eastern headwaters area. Three major streams drain the watershed and flow into the tidal lagoon. Los Peñasquitos Creek is the largest catchment in the watershed draining 59 mi^2 through its central portion. Carroll Canyon Creek is the second largest catchment (18 mi^2) and drains the southern portion of the watershed. Carmel Creek is located along the northern, coastal area and drains the remaining 16 mi^2. Los Peñasquitos Creek and Carroll Canyon Creek confluence together prior to entering the lagoon. There is one major dam in the Carroll Canyon Creek watershed, which drains approximately 1 mi^2 and forms Miramar Reservoir. Key watershed characteristics, including land use, soils, and other features that are important for model representation are described in later sections.

Lagoon Description

The Los Peñasquitos Lagoon is a relatively small salt marsh lagoon (0.6 mi^2) that is part of the Torrey Pines State Reserve. Given the status of “Natural Preserve” by the California State Parks, the lagoon is one of the few remaining native salt marsh lagoons in California and provides a home to several endangered species. The lagoon is ecologically diverse, supporting a variety of plant species, and providing habitat for numerous bird, fish, and small mammal populations. The lagoon also serves as a stopover for migratory birds and provides habitat for coastal marine and salt marsh species.

The lagoon is listed as impaired on the CWA's Section 303(d) list due to sediment/siltation impacts that originate from watershed sediment contributions. Tidal flows enter the lagoon during periods when the lagoon mouth is open to the ocean. Currently, the lagoon mouth is open throughout most of the year. Mouth closures are typically caused by coastal processes (deposition of sand and cobble from nearshore sources) and structures, such as the Highway 101 abutments. Mechanical dredging is used when needed to eliminate blockages and allow for tidal flow into the lagoon in order to improve water quality conditions and support salt marsh species. Most of the freshwater input flows through Los Peñasquitos Canyon into the lagoon. Carroll Canyon Creek to the south and Carmel Creek to the north also contribute freshwater to the lagoon. Historically, Los Peñasquitos Creek was the only tributary that flowed year-round, while Carroll Canyon and Carmel Creeks only flowed during significant rainfall events. Beginning in the 1980's, these drainages also began flowing year-round due to increasing urban development within the watershed. Carroll Canyon Creek confluences with Los Peñasquitos Creek upstream and the combined stream channel extends into the lagoon along the western side of the railroad track berm. This berm acts as a barrier between the eastern and western portions of the lagoon for much of its length. The railroad trestle along the northern side provides the only connection between eastern and western portions of the lagoon. The lagoon channel that receives flow from Carmel Creek crosses through this area.

The regional climate is characterized by higher precipitation during winter months and lower precipitation (and corresponding high lagoon salinity) during the dry summer months (Williams, 1997). Storm events transport sediment into the lagoon which deposits on the salt flats and within lagoon channels. These sediment deposits have gradually built-up over the years due to increased sediment loading and inadequate flushing, which directly and indirectly affects lagoon functions and salt marsh characteristics.

Data Inventory and Analysis

Multiple data sources were used to characterize the watershed and lagoon, in particular flow and water quality conditions. Much of this information was recently collected by the watershed stakeholders to assist with model development. Data describing the watershed's topography, land use, and soil characteristics were compiled and used to develop the watershed model. Stream flows and total suspended sediment concentrations were used to calibrate both the lagoon and watershed model components. The lagoon was also characterized using available bathymetric survey information, data sondes analyzing pressure and salinity, and sediment grab samples.

Land Use

Land use information was used in the model to characterize watershed imperviousness and the amount of sediment that washes off land surfaces, depending on land use type. Data detailing land use in the Los Peñasquitos watershed was based on the San Diego Association of Governments 2000 land use coverage[2] (Figure 2). The largest single land use type in the Los Peñasquitos watershed is open space. Approximately 54 percent of the watershed has been developed, with 46 percent of that area classified as impervious. The area and percent distribution of land uses within the watershed is presented in Table 1.

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[2] http://www.sandag.org/resources/maps_and_gis/gis_downloads/downloads/zip/Land/CurrentLand/lu.zip

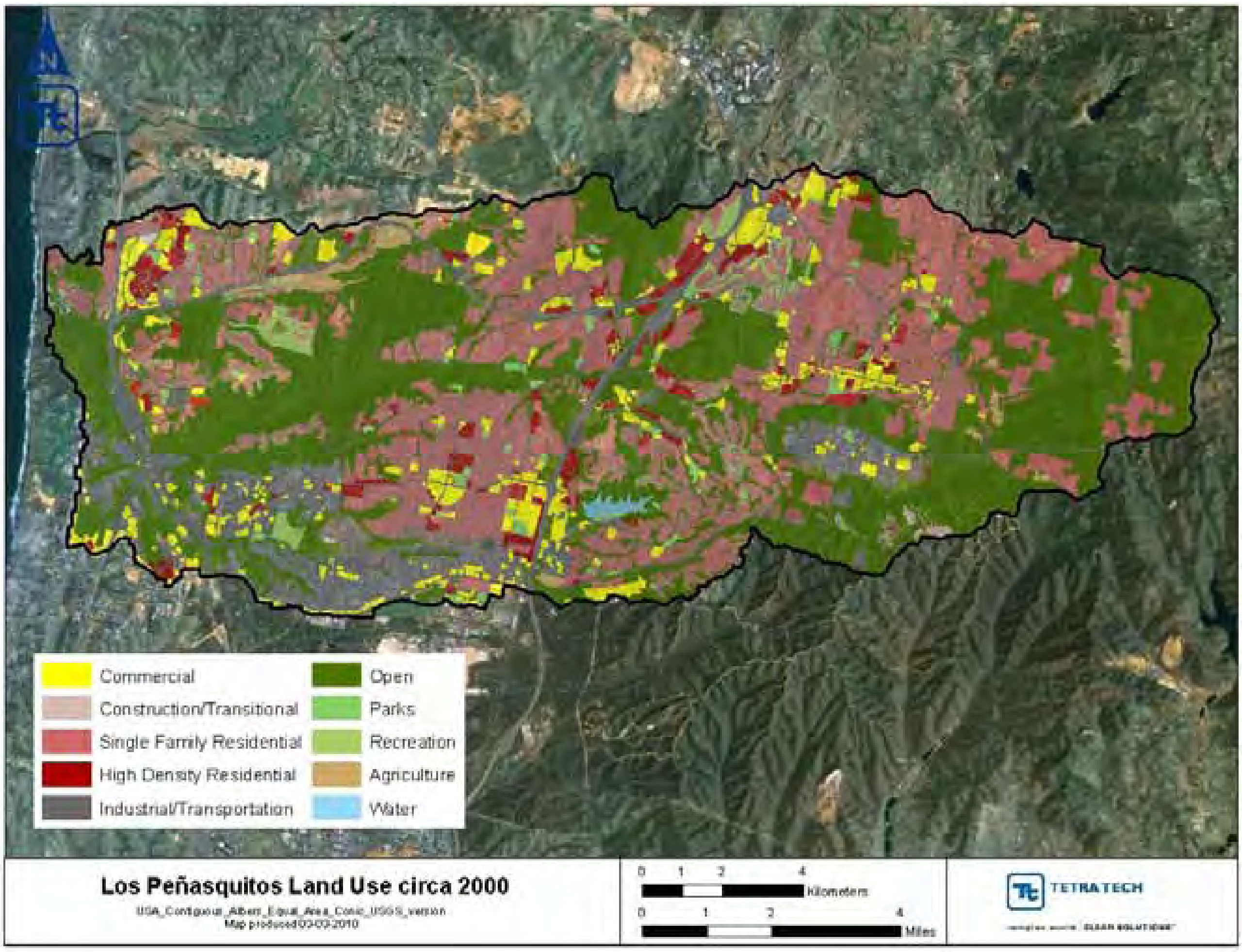

Figure 2. Land use distribution in the Los Peñasquitos watershed

Table 1. Area and percent land use distribution

Land Use Group	Land Use area (acres)	Percent Total
Agriculture	741	1.2%
Commercial Institutional	3,596	6.0%
High Density Residential	1,855	3.1%
Industrial/Transportation	11,658	19.5%
Low Density Residential	14,254	23.8%
Open	25,497	42.6%
Open Recreational	713	1.2%
Parks Recreational	1,335	2.2%
Transitional	171	0.3%

Topography

Topographical information was primarily used to describe the slope of the main tributaries within the watershed. Ten meter elevation data were obtained from the San Diego Association of Governments[3]. Elevation within the watershed rises from sea level to 2,600 ft in the headwaters (Figure 3).

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[3] http://www.sandag.org/resources/maps_and_gis/gis_downloads/downloads/zip/elev10grd.zip

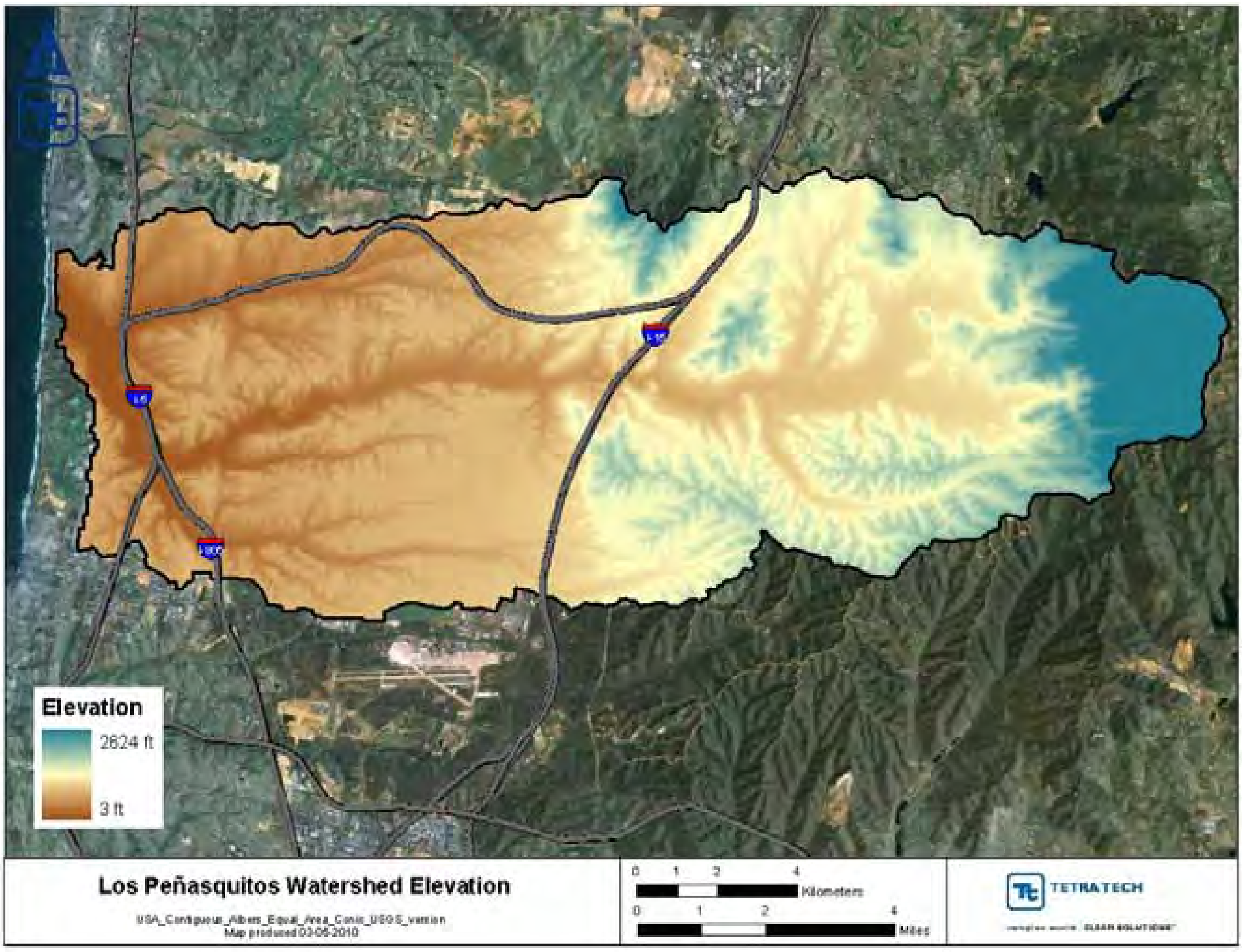

Figure 3. Topography in the Los Peñasquitos watershed

Soil Characteristics

Soils data for the Los Peñasquitos watershed were used to group watershed catchments based on differing infiltration rates. The Soil Survey Geographic (SSURGO) Database[4] was used to characterize the soils. The majority of the watershed is located within hydrologic soil group D, which is indicative of a low infiltration rate and a high potential for surface runoff (Figure 4). As a result, Group D soils are more susceptible to erosion and can contribute significant sediment loads.

Soil erodibility values (K factor) were obtained from the SSURGO database and used in conjunction with slope information to calculate the coefficient in the soil detachment equation (KRER) for each land use/hydrologic soil group combination. The proportion of sand, silt and clay within each hydrologic soil group (particle size distribution) was also extracted from the SSURGO database. Soils that are more easily transported typically have higher proportions of smaller particles sizes (silt and clay fractions), as compared to local parent soils, because of differences in settling rates and other sediment transport characteristics. To account for these differences, soils transported by surface runoff were assumed to be composed of 5 percent sand, twice as much clay as the percentage of clay within each hydrologic soil group, and the remainder assigned to the silt fraction (Table 2).

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[4] http://soils.usda.gov/survey/geography/ssurgo/. National Resources Conservation Service. Accessed September 2008

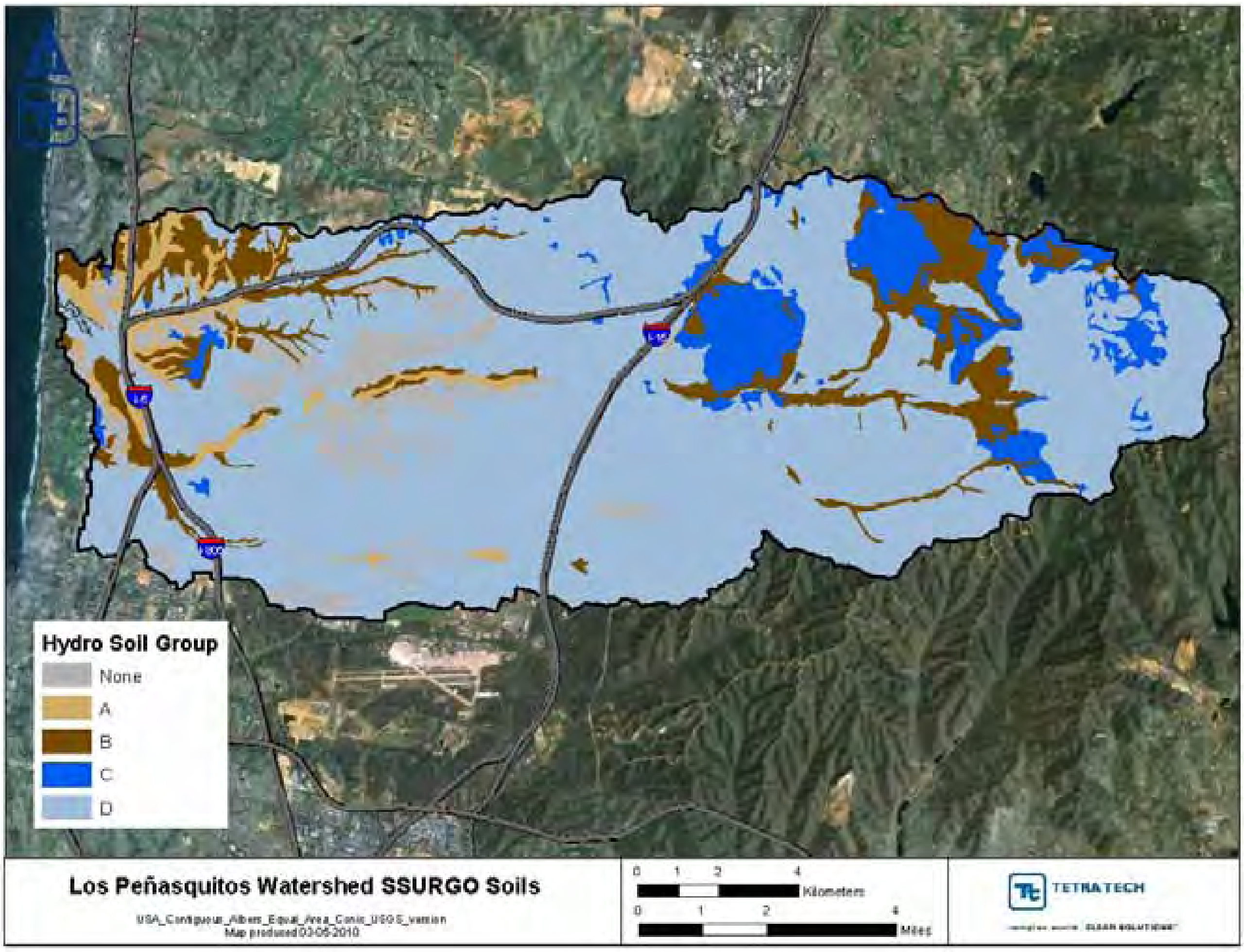

Figure 4. Hydrologic soil groups in the Los Peñasquitos watershed

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Table 2. Sand, silt, and clay distribution by hydrologic soil group

	drologic Soils Group		
	B	C	D
SSURGO Soil Fractionation			
SAND	60 %	26 %	14 %
SILT	67 %	19 %	14 %
CLAY	47 %	32 %	21 %
Surface Soil Runoff Fractionation			
SAND	5 %	5 %	5 %
SILT	67 %	67 %	54 %
CLAY	28 %	28 %	41 %

Meteorological Data

Surface runoff and associated pollutant transport is dependent on the water balance, including precipitation inputs and evapotranspiration outputs. Meteorological data describing rainfall and potential evapotranspiration (PET) were compiled to describe the hydrologic cycle of the watershed. Precipitation data were obtained from two local Alert weather stations: 24 and 22 (available from the San Diego County Flood Control District) (Figure 5). Rainfall from Alert station 24 was used to represent the upper portion of the watershed and Alert station 22 the lower portion. Data collected at these stations were available from 1/1/1990 through 6/30/2008 (Table 3). Additional rainfall data were collected by the City of San Diego (2009) at three flow monitoring stations between 9/13/2007 and 6/16/2008.

The PET time series was developed from nearby California Irrigation Management Information System (CIMIS) stations[5] (Figure 5). CIMIS station 74 was primarily used to assign hourly PET values to each weather station. For days when the station did not record PET, a secondary station (CIMIS 62) was used to patch the missing dates (Table 4). CIMIS station 62 is located 30 miles to the northwest of the watershed in Temecula. A ratio of the average annual PET over the simulation period was used to scale the secondary PET values, as needed.

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[5] http://wwwcimis.water.ca.gov/cimis/welcome.jsp

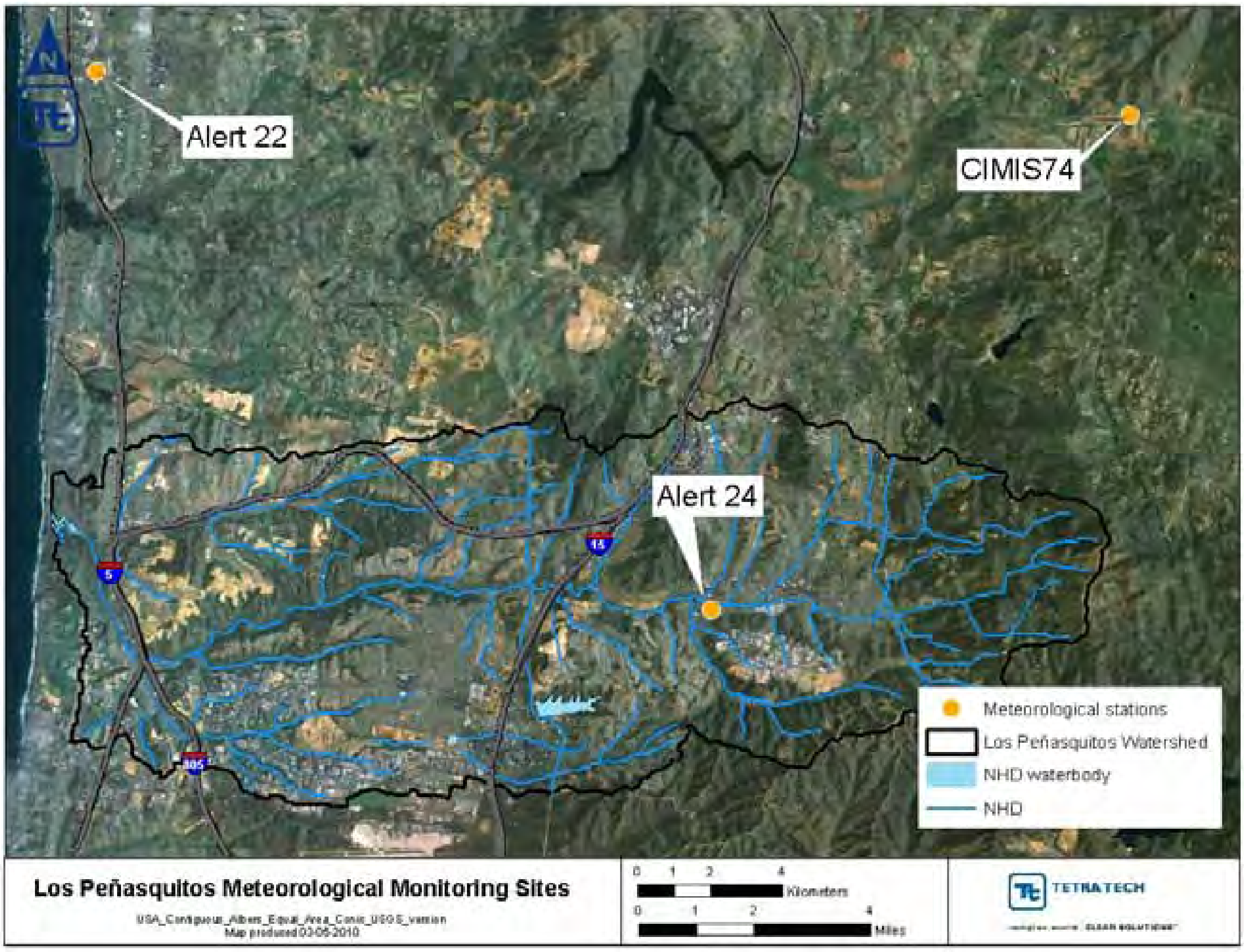

Figure 5. Meteorological stations within and near the Los Peñasquitos watershed

Table 3. Hourly rainfall gages

Station Name	Elevation (ft)	Data Collection Period		Precipitation (in/yr)
		Start	End	
Alert 24	446	1/1/1990	6/30/2008	8.14
Alert 22	250	1/1/1990	6/30/2008	6.96

Table 4. Potential evapotranspiration (PET) stations

Station Name	Elevation (ft)	Data Collection Period		Percent Missing
		Start	End	
CIMIS 74	450	1/1/1990	12/20/1998	48%
CIMIS 62	1420	1/1/1990	6/30/2008	3%

Streamflow Data

Available streamflow data collected within the watershed were compiled for model calibration and validation. The United States Geological Survey (USGS) maintains a long term flow gage (11023340) in the upper Los Peñasquitos watershed (Figure 6). Daily data from 1990 through 2008 were downloaded for calibration of model hydrologic parameters[6]. Total suspended solids (TSS) data were also collected at this location and a downstream USGS sediment monitoring station (325423117124501). Sediment monitoring data are described in the following section.

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[6] http://waterdata.usgs.gov/nwis/dv/?site_no=11023340&referred_module=sw

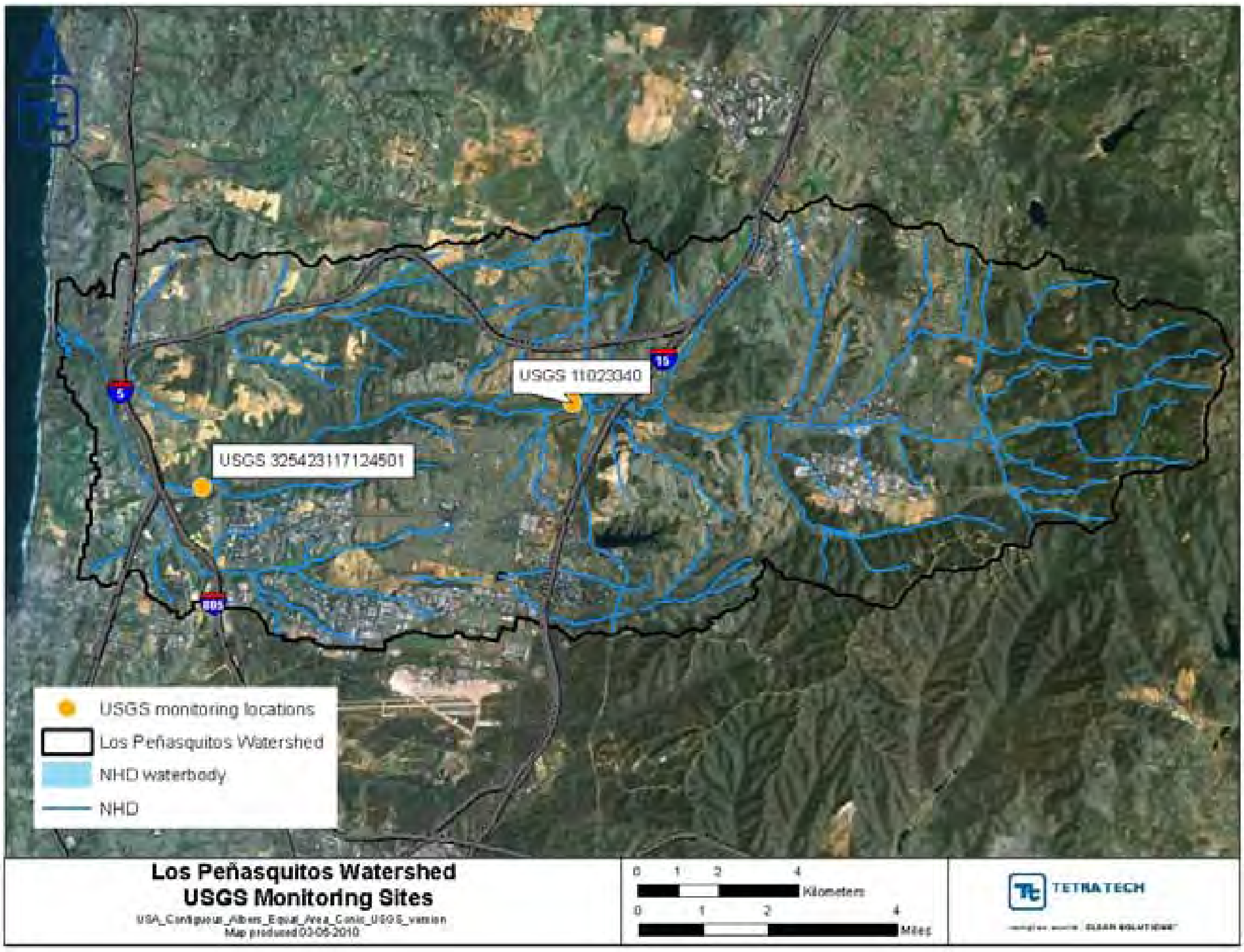


Figure 6. USGS monitoring locations in the Los Peñasquitos watershed

Additional streamflow data were collected at the base of Los Peñasquitos, Carroll Canyon, and Carmel Creeks as part of the Los Peñasquitos TMDL monitoring study (City of San Diego, 2009) (Figure 7). The Los Peñasquitos TMDL monitoring station was co-located with the long term Los Peñasquitos Creek Mass Loading Station (MLS) that undergoes routine water quality monitoring. Note that two additional monitoring stations within the watershed (LPC-TWAS-1 and LPC-TWAS-2) are shown in Figure 7 and are described in the following section. Flows were determined by applying the Manning's Equation to data collected with Sigma 950 or 920 flow meters with area velocity meters and pressure transducers. Sampling frequency ranged from 5 to 15 minute intervals. Instruments were deployed on 9/13/2007 and retrieved on 6/16/2008.

Los Peñasquitos Creek drains the largest area within the watershed and, accordingly, recorded the highest measured flows and runoff volume (Figure 8). Median flows in Los Peñasquitos Creek were roughly twice those in Carmel Creek and two orders of magnitude greater than in Carroll Canyon Creek. A continual increase in cumulative volume for Los Peñasquitos Creek and Carmel Creek indicated consistent baseflows. By contrast, streamflow data collected on Carroll Canyon Creek included periods with little change in cumulative volume, which indicates low baseflow. Low flows at this station were within the tenth percentile (Figure 8).

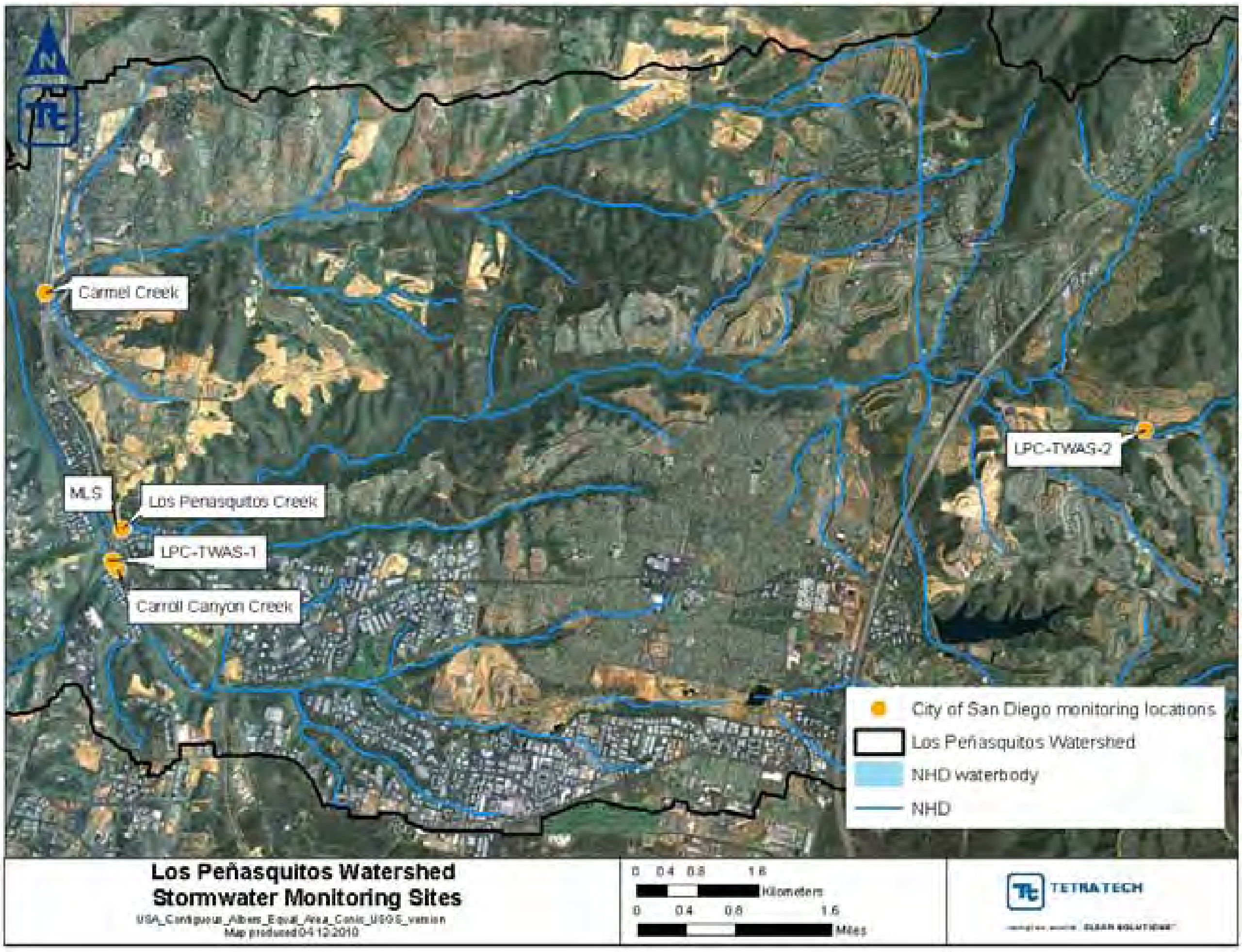


Figure 7. Stormwater monitoring locations in the Los Peñasquitos watershed

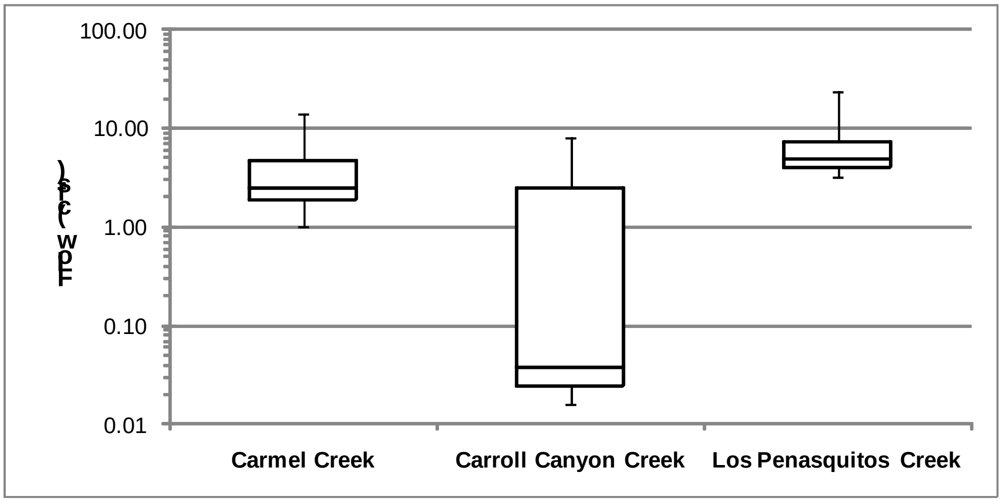


Figure 8. Measured flows at TMDL monitoring locations

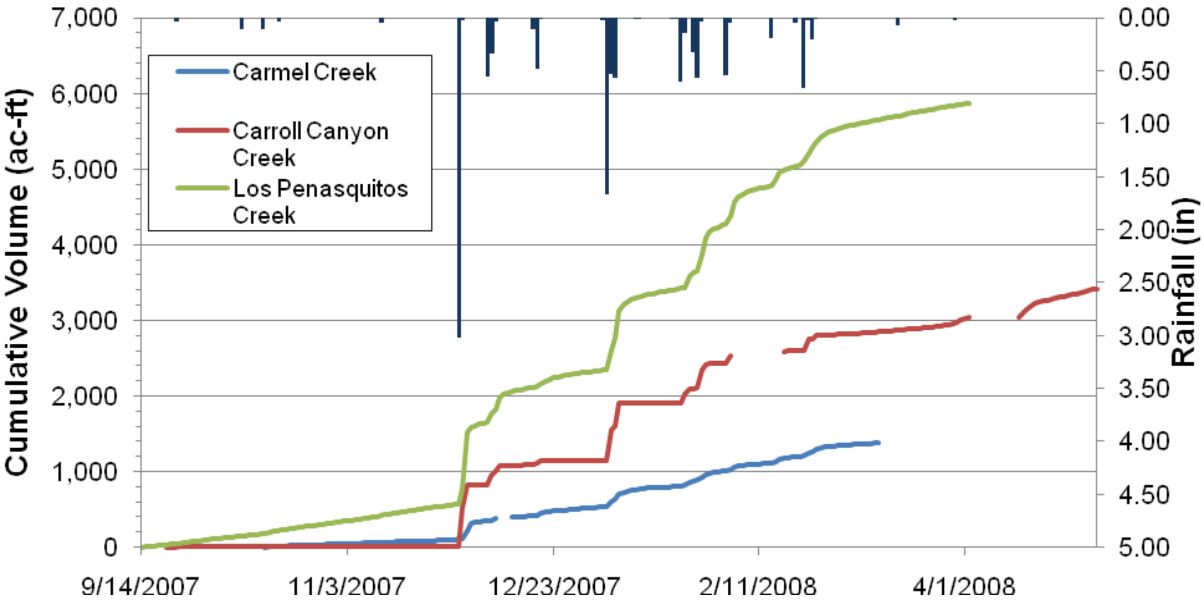


Figure 9. Cumulative volumes at TMDL monitoring locations

Measuring streamflow in the Los Peñasquitos watershed presents difficulties that are common to urban, arid watersheds. The Los Peñasquitos and Carmel Creek monitoring locations were both natural channels with heavy vegetation. During monitoring, cross section measurements were taken at each station at regular intervals with flows estimated using Manning's equation. The Carmel Creek location had ponded conditions due to a flow control structure located downstream of the box culvert. The Carroll Canyon Creek monitoring location is a concrete lined trapezoidal channel. Median depths in Los Peñasquitos, Carmel, and Carroll Canyon Creeks were 7.0, 4.8, and 0.95 inches, respectively. Because of shallow water depths, variability in natural channel cross sections, and water not distributed uniformly across the concrete channel in Carroll Canyon Creek, flows are difficult to accurately monitor over a long period (Figures 10 and 11). Also, small differences in depths or depth homogeneity across the channel can result in large differences in flows at the lower end of the station rating tables.

Figure 10. Photos near the Carroll Canyon Creek monitoring station

Figure 11. Photo at the Los Peñasquitos Creek monitoring station

Comparison of the flow record at the Los Peñasquitos Creek MLS and the USGS gaging station upstream (11023340) shows a distinct difference in recorded flows. There was small difference in average daily flow throughout the common period of record (9/13/2007 – 3/31/2008) (Figure 12). However, when cumulative volumes are compared (Figure 13), the total volume measured at the USGS station (8,000 ac-ft) is greater than the volume measured downstream at the MLS (5,870 ac-ft). An estimate of the water volume that would need to be infiltrated by the creek over the 200 days of record, assuming an average creek width of 8 ft, results in an infiltration rate of 0.6 in/hr. This estimated infiltration rate is higher than expected and may indicate an error in the rating table at the MLS station, especially at higher flows. It is difficult to develop a rating table at the MLS, or any of the monitoring locations, during storm flows because of the high velocities in the creek and safety concerns for monitoring staff. Possible data limitations were considered during model development and calibration.

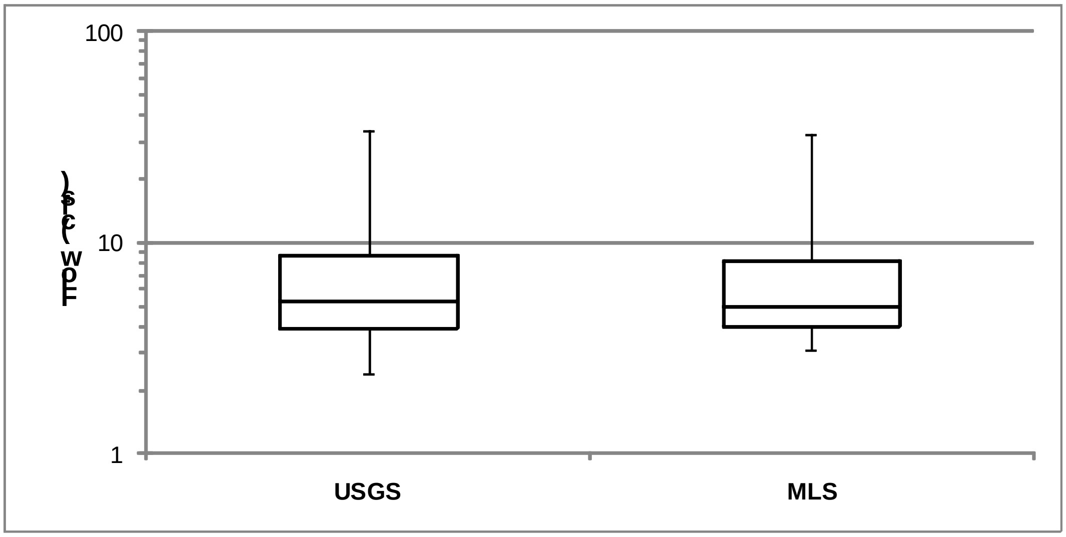


Figure 12. Comparison of flows at the MLS and USGS gaging station (11023340)

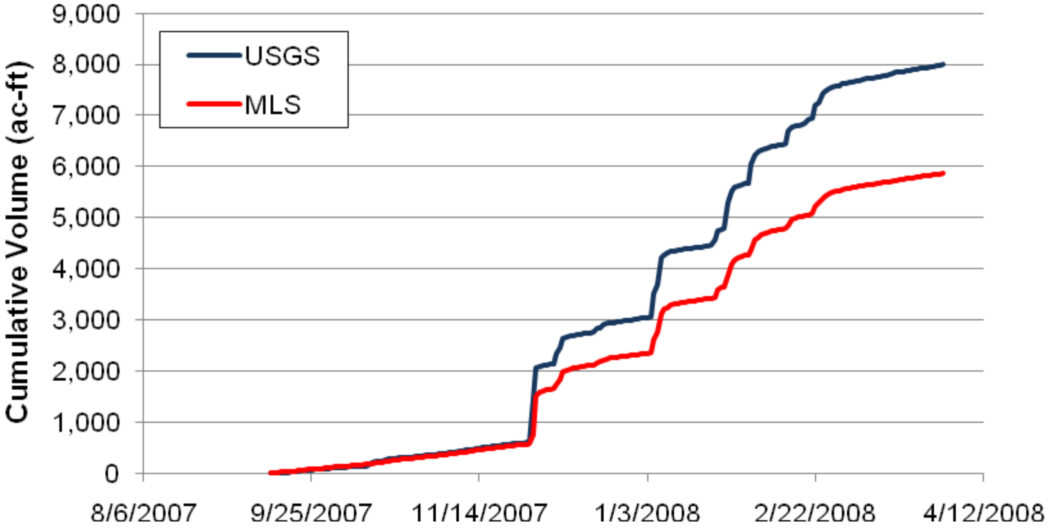


Figure 13. Comparison of cumulative volumes at the MLS and USGS gaging stations

Suspended Sediment Data

Suspended sediment and particle size data were collected at several locations within the Los Peñasquitos watershed and used to develop and calibrate the watershed model. Total suspended sediment (TSS) data were collected in the watershed by three different agencies. The USGS collected 19 samples at gage 11023340 between 11/12/1985 and 10/25/1986 and five samples at gage 325423117124501 from 1/20/1982 to 3/18/1982 (USGS, 2009) (Table 5). Event mean concentrations (EMCs) from stormwater and dry weather runoff were collected at the MLS on Los Peñasquitos Creek near the confluence with Carroll Canyon Creek. Stormwater and dry weather runoff events were also monitored at this station since 2001, in accordance with NPDES permit requirements. In addition, two Temporary Watershed Assessment Stations (TWAS) are located within the watershed on Los Peñasquitos Creek upstream (TWAS-2) and on Carroll Canyon Creek (TWAS-1). These stations were monitored on 11/30/2007 and 2/3/2008 (Figure 7 above; Table 6). The relationship between rainfall and flow at the MLS is shown in Figure 14. Collectively, these data were used to better understand the relationship between flow and sediment loading for model development purposes.

Table 5. TSS measurements at USGS stations on Los Peñasquitos Creek

USGS 11023340			USGS 325423117124501		
Date Time	Flow (cfs)	TSS Concentration (mg/L)	Date Time	Flow (cfs)	TSS Concentration (mg/L)
11/12/1985 10:00	70	362	1/20/1982 15:15	4.87	222
11/12/1985 10:30	70	365	1/21/1982 10:20	7.9	1060
11/12/1985 15:15	93	321	3/15/1982 8:40	4.33	1070
11/12/1985 16:00	100	321	3/17/1982 11:05	6.71	366
11/25/1985 13:00	460	1640	3/18/1982 16:50	10.9	245
11/25/1985 13:45	432	1400			
11/26/1985 13:00	32	252			
11/30/1985 10:30	162	605			
12/3/1985 12:30	180	570			
1/30/1986 14:40	39	120			
2/8/1986 10:15	136	436			
2/8/1986 14:00	209	334			
2/15/1986 14:30	639	1390			
2/16/1986 9:15	146	201			
3/10/1986 12:15	130	437			
3/10/1986 13:15	93	432			
3/16/1986 8:15	375	800			
9/25/1986 12:45	75	172			
10/25/1986 12:45	75	172			

Table 6. Rainfall and TSS measurements at the MLS and TWAS stations on Los Peñasquitos Creek

Date	Station	Rain (in)	TSS (mg/L)
11/29/01	MLS	0.10	<20
2/17/02	MLS	0.14	<20
3/17/02	MLS	0.35	<20
11/8/02	MLS	0.11	35
12/16/02	MLS	0.33	58
2/11/03	MLS	0.43	38
11/12/03	MLS	0.28	27
2/3/04	MLS	0.20	<20
2/18/04	MLS	0.12	<20
10/17/04	MLS	0.16	<20
2/11/05	MLS	0.52	<20
2/18/05	MLS	0.28	108
10/17/05	MLS	0.16	20
2/20/06	MLS	0.16	30
2/28/06	MLS	0.28	182
12/10/06	MLS	0.08	22
1/30/07	MLS	0.20	<20
2/19/07	MLS	1.10	81
11/30/07	MLS	3.03	130
11/30/07	TWAS-1	3.03	260
11/30/07	TWAS-2	3.03	113
2/3/08	MLS	0.59	26
2/3/08	TWAS-1	0.59	40
2/3/08	TWAS-2	0.59	200

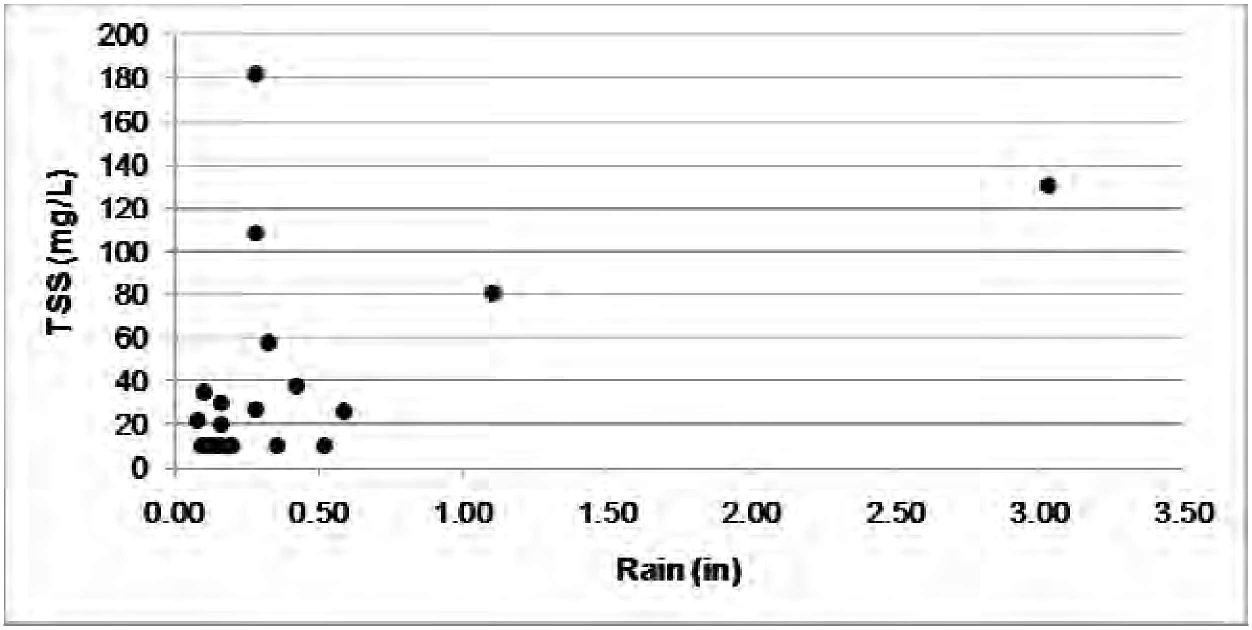


Figure 14. Relationship between rainfall and TSS measured at the MLS

Pollutograph samples characterizing suspended sediment concentration changes throughout a storm were collected during three storms in the 2007-2008 storm season as part of the TMDL monitoring study. Samples were collected from the three major streams flowing into the lagoon: Los Peñasquitos, Carroll Canyon, and Carmel Creeks (see Figure 7). The Los Peñasquitos Creek location was co-located with the MLS, which had EMC monitoring data. Pollutograph samples consist of multiple individual samples collected throughout a storm which are individually analyzed. Typically, EMCs are calculated for each monitored storm using the following equation:

$$EMC = \frac{\sum V_i * C_i}{\sum V}$$

where V is volume and C is concentration. Pollutograph samples are superior to volume- or time-weighted sampling because multiple samples provide insight into how concentrations change throughout a monitored event. The 95th percent confidence interval (1.96 * standard error of the mean) was calculated for each pollutograph sampling event and was used to compare to the median concentrations of the other sampling efforts.

$$CI = 1.96\sqrt{\frac{\sum\left[\left(c_i - \bar{c}\right)v_i\right]^2}{\left(\sum v_i\right)^2}}$$

Pollutograph TSS concentrations recorded during each storm event at the Los Peñasquitos, Carroll Canyon, and Carmel Creek TMDL stations are shown in Table 7 through 9.

Table 7. Pollutograph measurements of TSS (mg/L) at Carmel Creek

11/30/07 Storm		12/7/07 Storm		2/3/08 Storm	
Date Time	TSS	Date Time	TSS	Date Time	TSS
11/30/07 9:40	91	12/7/07 4:40	34	2/3/08 7:01	123.9
11/30/07 10:40	180	12/7/07 5:40	11	2/3/08 7:48	0.7*
11/30/07 11:40	56	12/7/07 6:40	8.5	2/3/08 8:18	4.3*
11/30/07 11:40	56	12/7/07 8:06	15.5	2/3/08 8:48	16
11/30/07 14:40	83	12/7/07 8:36	15.5	2/3/08 9:18	30
11/30/07 15:40	38	12/7/07 9:06	12	2/3/08 10:01	44
11/30/07 20:40	15	12/7/07 9:06	11.1	2/3/08 10:18	9.5
11/30/07 23:40	32	12/7/07 10:06	11	2/3/08 11:48	7.3
12/1/07 1:40	19.5	12/7/07 10:06	12.3	2/3/08 12:01	33.3
12/1/07 3:20	14	12/7/07 11:06	12.3	2/3/08 12:40	8.7
12/1/07 4:40	16	12/7/07 11:36	16	2/3/08 12:40	10
		12/7/07 13:06	14	2/3/08 13:01	32
		12/7/07 15:40	13	2/3/08 13:01	30.7
		12/7/07 21:02	38.3	2/3/08 13:40	10.7
				2/3/08 15:01	31.3
				2/3/08 15:10	14
				2/3/08 16:40	7
				2/3/08 17:01	62
				2/3/08 18:40	3.7*
				2/3/08 18:40	3.7*
				2/3/08 19:01	28.7
				2/3/08 20:10	4.7*
				2/3/08 21:15	15.3
				2/4/08 1:15	40
				2/4/08 1:15	2.7*
				2/4/08 5:15	21.3
				2/4/08 11:15	32
				2/4/08 15:15	24.7

* Less than reporting limit (RL)

Table 8. Pollutograph measurements of TSS (mg/L) at Carroll Canyon Creek

11/30/07 Storm		12/7/07 Storm		2/3/08 Storm	
Date Time	TSS	DateTime	TSS	DateTime	TSS
11/30/07 12:35	488	12/7/07 5:30	222	2/3/08 7:10	ND
11/30/07 13:36	340	12/7/07 7:10	130	2/3/08 7:10	1*
11/30/07 14:35	716	12/7/07 8:10	237	2/3/08 8:35	30.3
11/30/07 14:35	716	12/7/07 8:40	558	2/3/08 9:05	7.7
11/30/07 15:35	596	12/7/07 9:10	476	2/3/08 10:14	30
11/30/07 16:44	396	12/7/07 9:40	404	2/3/08 11:21	148
11/30/07 17:40	144	12/7/07 10:10	380	2/3/08 12:13	221
11/30/07 18:35	116	12/7/07 10:40	312	2/3/08 13:07	241
11/30/07 20:30	60	12/7/07 11:10	206	2/3/08 14:07	178
11/30/07 21:30	568	12/7/07 11:40	224	2/3/08 15:07	117.5
11/30/07 22:40	760	12/7/07 12:40	66	2/3/08 16:07	100
		12/7/07 15:31	29	2/3/08 17:07	106
				2/3/08 17:07	96
				2/3/08 21:37	31

* Less than reporting limit (RL)

Table 9. Pollutograph measurements of TSS (mg/L) at Los Peñasquitos Creek

11/30/07 Storm		12/7/07 Storm		2/3/08 Storm	
Date Time	TSS	Date Time	TSS	Date Time	TSS
11/30/07 11:14	53	12/7/07 7:52	3.7*	2/3/08 8:13	2*
11/30/07 14:14	35	12/7/07 11:52	5.3	2/3/08 8:13	3.3*
11/30/07 18:14	140	12/7/07 13:22	13.7	2/3/08 10:13	1.5*
11/30/07 18:14	134	12/7/07 15:01	22.3	2/3/08 12:13	ND
11/30/07 19:14	170	12/7/07 16:01	26.3	2/3/08 14:13	1*
11/30/07 21:14	68	12/7/07 17:01	23.3	2/3/08 16:13	6.7
11/30/07 22:14	60	12/7/07 18:01	17	2/3/08 17:13	12.7
12/1/07 1:14	40	12/7/07 19:01	15.7	2/3/08 19:13	17.3
12/1/07 4:14	23.3	12/7/07 22:01	5.7	2/3/08 21:13	12.7
12/1/07 6:14	78	12/8/07 1:01	4.3*	2/3/08 22:27	12.65
12/1/07 10:14	30	12/8/07 3:01	3.7*	2/4/08 0:27	7.3
		12/8/07 8:01	2.7*	2/4/08 6:27	3*
				2/4/08 6:27	1*
				2/4/08 12:16	4*

* Less than reporting limit (RL)

TSS data collected through all sampling efforts within the Los Peñasquitos watershed were compared (Figure 15). TSS concentrations recorded at the MLS on Los Peñasquitos Creek since 2001 were more than five times lower than the data collected by the USGS at both stations. There were no significant difference in TSS between the two USGS stations/sampling periods. A small difference in the TSS EMC was observed between TWAS-2 and the MLS during the first sampled storm (11/30/2007), which was a storm of 3.03 in. The second monitored storm was only 0.59 in, where TWAS-2 recorded TSS concentrations nearly an order of magnitude higher than the MLS.

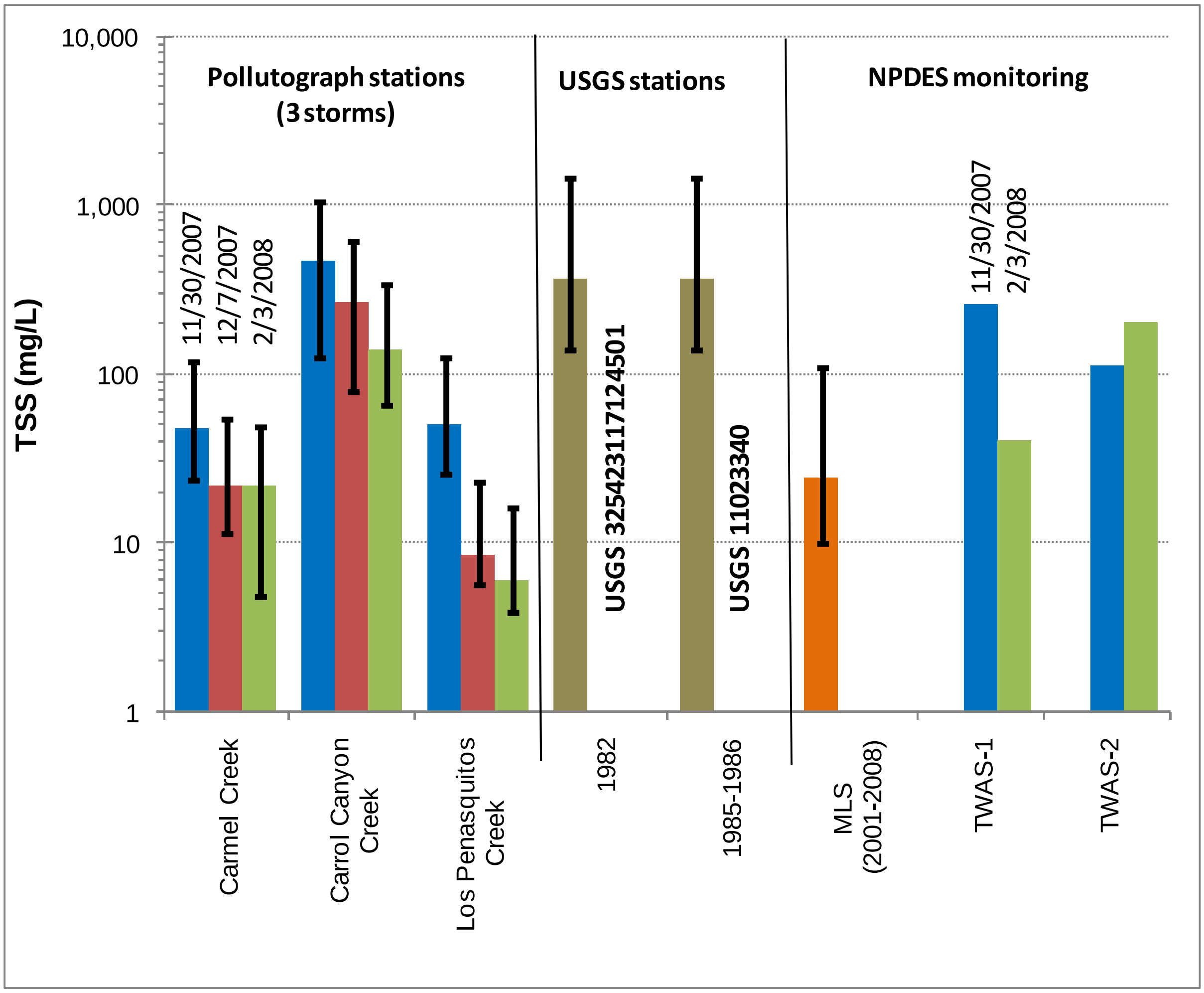


Figure 15. EMC/Median TSS and 95th percentile confidence intervals for all sampling events

Los Peñasquitos Creek was sampled using flow weighting and pollutograph sampling methods for two storms. These data showed considerable variability between the two sampling methods (Table 10). TSS EMCs were two to four times greater using the flow weighted sampling, as compared to the pollutograph sampling. The two stations were co-located and samples were collected using the same methods. Figure 11 shows this monitoring location had considerable vegetation within the creek, which may have caused significant differences in suspended particles considering depth and distance.

Table 10. TSS (mg/L) EMCs for the pollutograph and MLS stations on Los Peñasquitos Creek

	12/7/2007 Storm	2/3/2008 Storm
MLS	130	26
Pollutograph station	49.65	6.04

TSS particle size distribution was measured at the three pollutograph monitoring sites for two storms. A single composite sample was used to characterize the particle size distribution for each event. Samples were packed on ice, sent to the sample processing laboratory and analyzed with a Coulter Counter LS200. Samples from the first storm (11/30/2007) were shipped to the laboratory on 12/5/2007 and samples from the second storm (12/7/2007) were shipped on 12/11/2007. Particle size distributions for the pollutograph monitoring locations are shown in Figure 16 and 17. Note that the particle size distributions likely do not characterize the finer particles well because they likely flocculated in the days between sampling and analysis. Li et al (2005) have shown that particles tend to flocculate together within six hours, which can affect the particle size distribution.

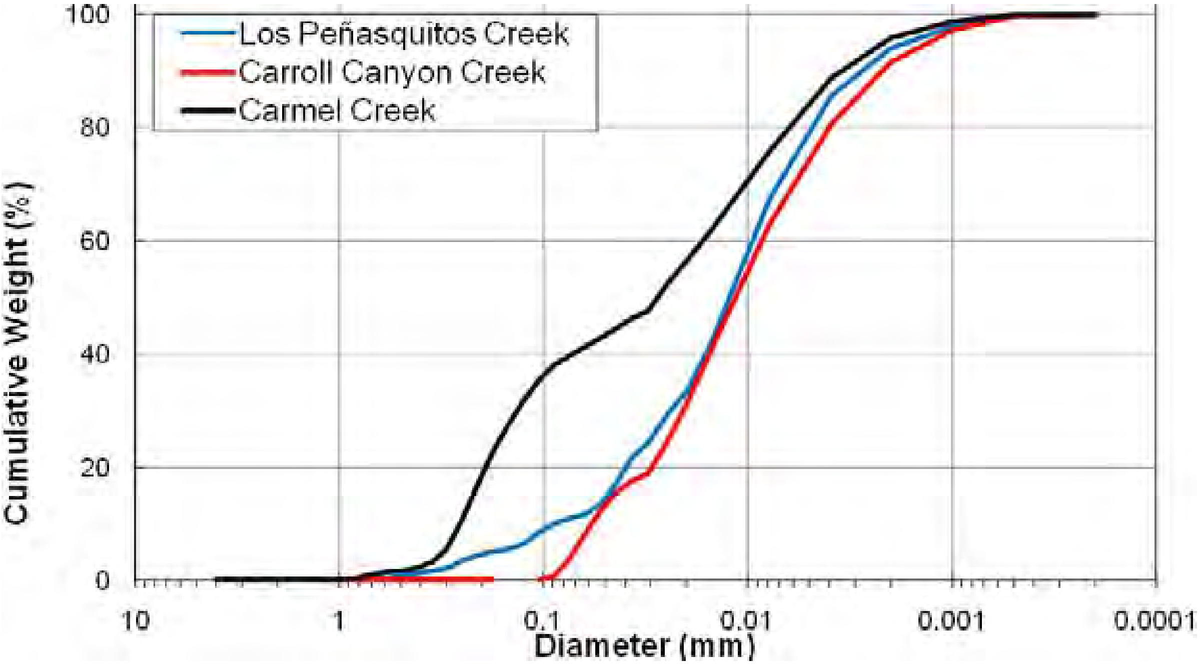


Figure 16. Particle size distribution for the 11/30/2007 storm event

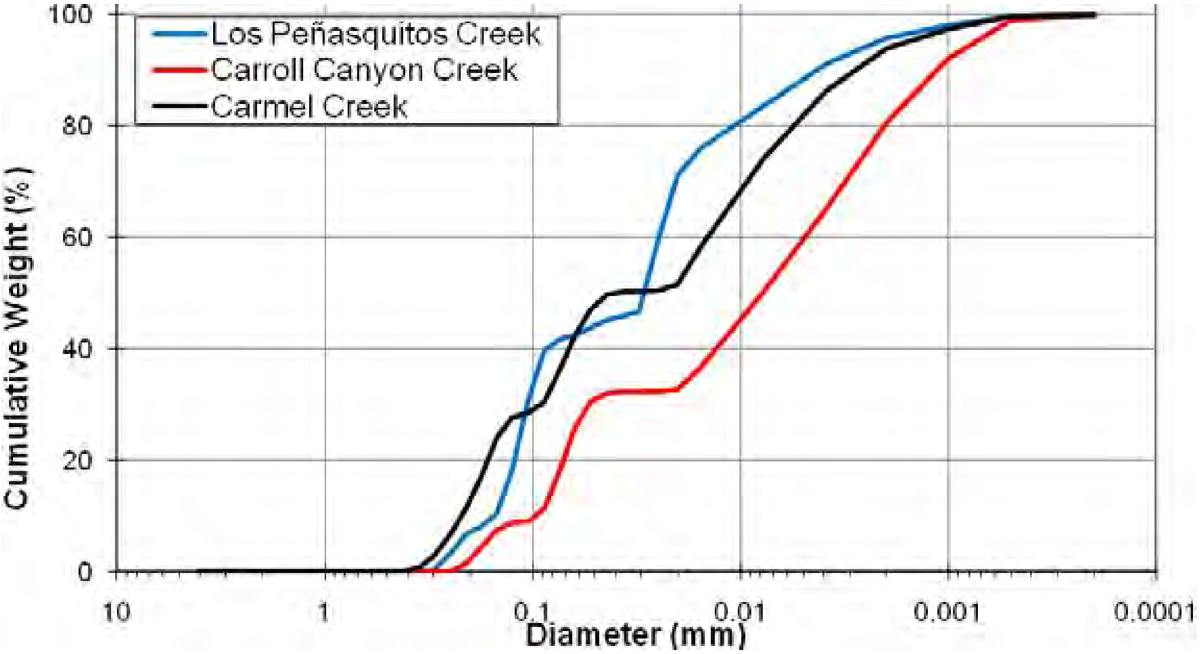


Figure 17. Particle size distribution for the 12/7/2007 storm event

Overview of Modeling Approach

The Los Peñasquitos watershed was modeled using the Loading Simulation Program in C++ (LSPC) model. The watershed model primarily uses information that details soil characteristics, land use distribution, topography, weather data, and the stream network to simulate hydrology and sediment contributions to the lagoon. Key data sources were compiled to support development of the watershed model (as described in previous sections). The Los Peñasquitos lagoon was modeled using the Environmental Fluid Dynamics Code (EFDC) model. The EFDC model incorporates meteorological data, watershed inputs, and oceanic forcings (tidal flooding). The watershed model is linked to the lagoon model through input of the LSPC results directly into the EFDC model for simulation of hydrodynamic and water quality conditions within the lagoon. Watershed model output was used to define the terrestrial inputs to the lagoon (flow and pollutant loads). Hourly watershed model flow and TSS concentrations (fractionated as sand, silt, and clay) were output for catchments 1401-1404 and 1411 and included as inputs to the EFDC lagoon model.

Watershed Model Description

LSPC (Shen et al., 2004; Tetra Tech and USEPA, 2002; USEPA, 2003) is a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) (Bicknell et al., 1997) algorithms for simulating hydrology, sediment, and general water quality on land, as well as a simplified stream fate and transport model. Since its original public release, the LSPC model has been expanded to include additional GQUAL components for sorption/desorption of selected water quality constituents with sediment, enhanced temperature simulation, and the HSPF RQUAL module for simulating dissolved oxygen, nutrients, and algae. LSPC has also been customized to address simulation of other pollutants such as nutrients and fecal coliform bacteria.

The hydrologic (water budget) process is complex and interconnected within LSPC (Figure 18). Rain falls and lands on various constructed landscapes, vegetation, and bare soil areas within a watershed. Varying soil types allow the water to infiltrate at different rates while evaporation and plant matter exert a demand on this rainfall. Water flows overland and through the soil matrix. There may also be point source discharge and water withdrawals/intakes. The land representation in the LSPC model environment considers three flowpaths; surface, interflow, and groundwater outflow.

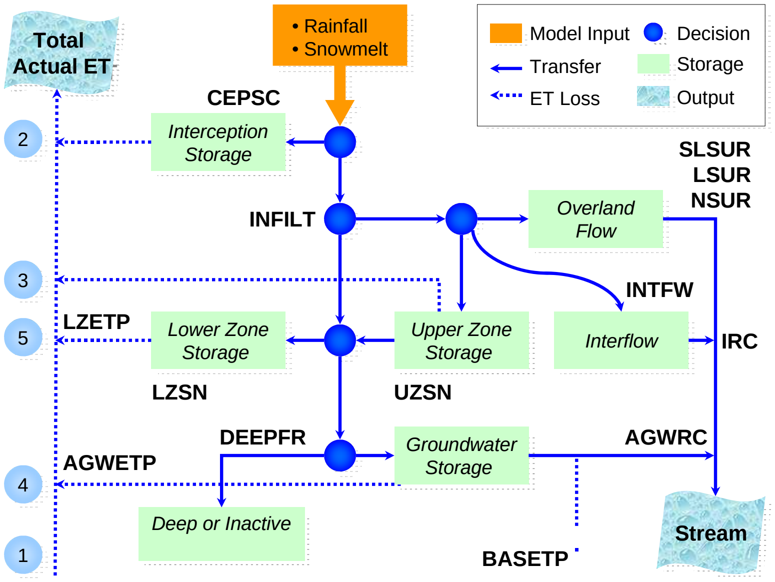


Figure 18. Schematic of LSPC Hydrology Components

The sediment routine in LSPC represents the general detachment of sediment due to rainfall, overland and instream transport, attachment when there is no rainfall, and scour. Land disturbance may occur from construction or agricultural practices, disturbing native vegetative cover and leaving the soil susceptible to erosion. With the native cover disturbed, a rainfall event may not only cause detachment, but can also provide sufficient rainfall in combination with the lack of vegetative cover to cause scour and further erosion as the overland flow proceeds to a defined channel. From impervious areas, a different process occurs where sediment builds up over time to a maximum value for each impervious land use type. For both pervious and impervious land uses, the amount of sediment that can be transported is a function of runoff. Sediment carried by runoff is fractionated into sand, silt, and clay portions depending on the underlying soil types. Once the sediment is in the stream channel, it is transported downstream where it can flow through the reach or settle out. If the stream velocity is sufficient, additional sediment can be mobilized via high shear stresses.

Watershed Model Setup

The Los Peñasquitos watershed model was developed to provide continuous sediment input to the EFDC lagoon model. Many data sources were used to develop the LSPC model of the Los Peñasquitos watershed. Smaller catchments within the watershed were delineated using available elevation data. Information about the soils and land use within each of those catchments was used to develop model parameters describing flow and sediment transport characteristics within the watershed.

Catchment Delineation

The Los Peñasquitos watershed was divided into smaller catchments for modeling efficiency based on 10 meter resolution digital elevation model (DEM) and hydrography. Catchment sizes ranged from 0.43 to 16.56 mi^2 with a median size of 7.19 mi^2 (Figure 19). The size of the catchments was determined to be adequate based on the accuracy needed for model predictions and linkage to the lagoon model. Delineation was based on several factors including, land use and soil information, stream channel characteristics, and the location of monitoring stations throughout the watershed for calibration purposes. Catchment 1404 receives flow from both Los Peñasquitos and Carroll Canyon Creeks. The lagoon is represented by Catchment 1402 and receives flow from Catchments 1401 (small direct drainage to the north), 1403 (Carmel Creek), and 1404 (Los Peñasquitos and Carroll Canyon Creeks).

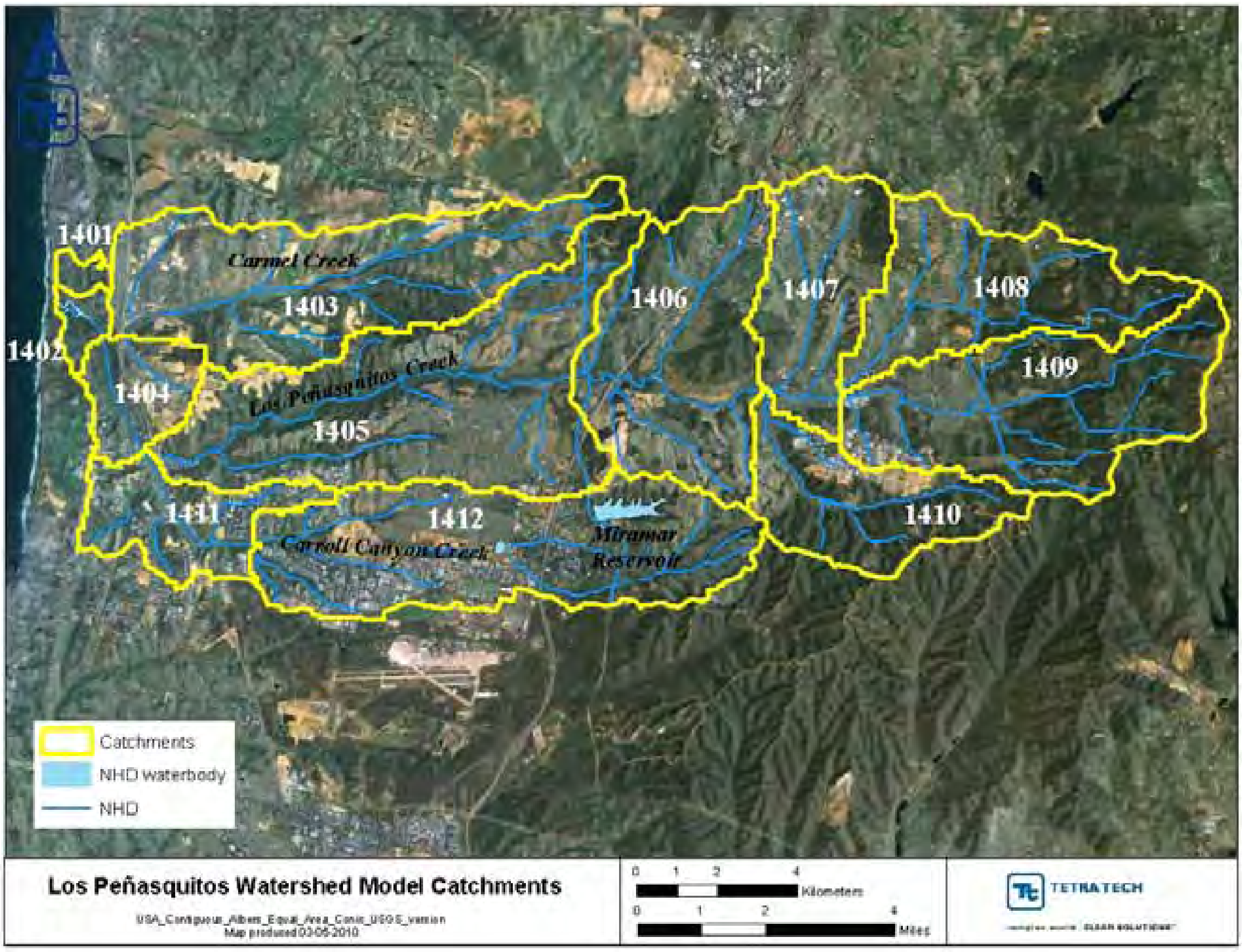


Figure 19. Catchment delineation in the Los Peñasquitos watershed

Streams

Each delineated catchment is represented with a single stream segment, as depicted in the National Hydrography Dataset (NHD), and assumed to be a completely mixed, one-dimensional segment with a trapezoidal cross-section. Once the representative reaches were identified, slopes were calculated based on elevation data (10 m DEM) and stream lengths measured from the original NHD stream coverage. In addition to stream slope and length, mean depths and channel widths are required to route flow and pollutants. Detailed cross section information did not exist for the watershed, therefore, mean stream depth and channel width were estimated using regression curves that relate upstream drainage area to stream dimensions available in the LSPC model setup spreadsheet that is described in the LSPC manual (Tetra Tech and USEPA, 2002). Manning’s n values ranging from 0.03 to 0.2 reflected very different stream types, including streams with concrete channels to heavily vegetated channels.

Land Use

LSPC algorithms require land use in each catchment to be divided into pervious and impervious categories. The overall watershed land use distribution is shown above in Table 1. The estimated impervious fraction for each land use type was calculated by multiplying the total area by an impervious factor (Table 11).

Table 11. Impervious fraction by land use type

Land Use	Percent Impervious
Agriculture	0 %
Commercial Institutional	85 %
High Density Residential	65 %
Industrial/Transportation	72 %
Low Density Residential	15 %
Open	0 %
Open Recreational	0 %
Parks Recreational	12 %
Transitional	0 %

Soils

Soil characteristics within each catchment were calculated using SSURGO data, as described previously. The average soils class within each catchment was calculated. The majority of the catchments were within hydrologic soil group D areas, which typically have high surface runoff rates and low infiltration.

Irrigation

Irrigation is an important component of the water balance in Southern California. Through changes in soil moisture storages, irrigation can affect storm runoff, as well as baseflow conditions.

The irrigation demand for the Los Peñasquitos watershed model was calculated based on information presented in “A Guide to Estimating Irrigation Water Needs of Landscape Plantings in California” (University of California Cooperative Extension, 2000). This guide recommends comparing daily precipitation to water demand to determine the amount of irrigation water.

The estimated hourly PET was based on data collected at the nearby California irrigation measurement station, CIMIS 74 (Figure 5). Hourly values were summed over each day to determine the daily PET depth in inches. To convert PET depth to the water demand for a specific crop or vegetation type, a crop-specific coefficient is multiplied by the PET. The University of California Cooperative Extension (2000) suggests a crop coefficient of 0.6 for lawns planted with warm season grasses and 0.65 for agricultural citrus production. For the purposes of this analysis, a crop coefficient of 0.8 was used to estimate the daily water demand for residential and commercial lawns and 0.85 for agricultural areas.

The difference between daily water demand and daily precipitation was calculated for each day. If precipitation exceeded water demand, then the irrigation demand was set to zero. Precipitation was used to offset water demand from the following days until all of the precipitation was lost from the system. To estimate the amount of irrigation water applied, the University of California Cooperative Extension (2000) suggests dividing the irrigation demand by the efficiency of the irrigation system. An efficiency factor of 80 percent was used for both the lawn and agricultural irrigation systems in order to estimate the depth of irrigation water applied. Finally, the irrigation water applied was added to the water balance in the LSPC simulation. The daily amount applied was assumed distributed evenly over time. The LSPC model also uses demand-based irrigation values based on the PET time series.

Sediment Fractionation

SSURGO data were used to estimate the fraction of total sediment contributed from the land within each particle size class and hydrologic soil group (Table 12). Adjustments were made to account for deposition during runoff periods based on the assumption that 50 percent of the sand fraction and 30 percent of silt is deposited using watershed delivery ratios presented in Vanoni, 1975. The resulting particle size fractions used for modeling are shown in Table 13

Table 12. Sediment fractions by hydrologic soil group

Hydrologic Soils Group	Sand	Silt	Clay
B	65 %	23 %	12 %
C	68 %	19 %	14 %
D	54 %	21 %	24 %

Table 13. Sediment fractions adjusted for watershed delivery

Hydrologic Soils Group	Sand	Silt	Clay
B	33 %	16 %	51 %
C	34 %	13 %	53 %
D	27 %	15 %	58 %

Configuration of Key Model Components

The initial basis for model parameterization was derived from “Hydrology: San Diego Region TMDL Model” (CARWQCB and USEPA, 2005). Final model hydrologic parameters are provided in Appendix A. Model calibration and validation focused on accurate characterization of precipitation in the watershed. Precipitation data from Alert gages 22 and 24 provided long term rainfall records for the lower watershed. Two catchments in the upper watershed (1408 and 1409) had increased rainfall due to higher elevation which was greater than observed at the Alert gage. Proportionally scaling the rainfall data using median rainfall from the CIMIS 74 gage and Alert 24 provided a better representation of rainfall in those catchments. Little adjustment of model parameters from the regional calibration was required once good rainfall records were established.

Sediment calibration focused on maintaining sediment balance in the streams. Sediment land use model parameters were developed following BASINS Technical Note 8 (USEPA, 2006) and Ackerman and Weisberg (2006). Sediment shear stress thresholds for deposition and scour were adjusted independently for each reach to maintain a dynamic steady state bed for silt and clay during a decadal simulation. Sand in the reaches was simulated using the average velocity power function in the reach, again, maintaining a dynamic balance throughout the decadal simulation. Several parameters were adjusted during calibration to achieve reasonable loading rates by land use type and to improve model fit to observed data collected in the Los Peñasquitos watershed.

Lagoon Model Description

The Los Peñasquitos Lagoon was simulated using the EFDC model. EFDC is a public domain, general purpose modeling package for simulating one-dimensional (1-D), two-dimensional (2-D), and three-dimensional (3-D) flow, sediment transport, and biogeochemical processes in surface water systems including rivers, lakes, estuaries, reservoirs, wetlands, and coastal regions. The EFDC model was originally developed at the Virginia Institute of

Marine Science for estuarine and coastal applications. This model is now being supported by the USEPA and has been used extensively to support TMDL development throughout the United States. In addition to hydrodynamic, salinity, and temperature transport simulation capabilities, EFDC is capable of simulating cohesive and noncohesive sediment transport, near-field and far-field discharge dilution from multiple sources, eutrophication processes, the transport and fate of toxic contaminants in the water and sediment phases, and the transport and fate of various life stages of finfish and shellfish. The EFDC model has been extensively tested, documented, and applied to environmental studies worldwide by universities, governmental agencies, and other entities.

The EFDC model includes four primary modules: (1) a hydrodynamic model, (2) a water quality model, (3) a sediment transport model, and (4) a toxics model. The hydrodynamic model predicts water depth, velocities, and water temperature. The water quality portion of the model uses the results from the hydrodynamic model to compute the transport of the water quality variables. The water quality model then computes the fate of up to 22 water quality parameters including dissolved oxygen, phytoplankton (three groups), benthic algae, various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria (Cerco and Cole 1994). The sediment transport and toxics modules use the hydrodynamic model results to calculate the settling of suspended sediment and toxics, resuspension of bottom sediments and toxics, and bed load movement of noncohesive sediments and associated toxics. For this project, the hydrodynamics and sediment transport models were used. The hydrodynamics model simulated the circulation, water temperature, and salinity in the lagoon driven by ocean tides and watershed inflows. The sediment transport model simulated the transport of sand, silt as non-cohesive sediments, and clay as cohesive sediment. Details of the EFDC model's hydrodynamic and eutrophication components are provided in Hamrick (1992) and Tetra Tech (2002, 2006a, 2006b, 2006c, 2006d).

The EFDC model was configured to simulate hydrodynamics and sediment transport in the Los Peñasquitos Lagoon. Specifically, water temperature and salinity were both modeled for hydrodynamics. Sediment fractions considered in the model include sand, silt, and clay. Sand and silt were modeled using the non-cohesive sediment module and clay was modeled using the cohesive sediment module in EFDC.

Lagoon Model Setup

Various data sources were used to develop the EFDC model for the Los Peñasquitos Lagoon. Model development requires defining the computation domain and boundary conditions. The general steps to set up the EFDC model for the Los Peñasquitos Lagoon included generating the modeling grid, defining metrological conditions, estimating oceanic inputs, and linking the watershed (LSPC) model to EFDC. Key data sources were compiled to support development of the lagoon model. Model development steps and data used to identify initial conditions, boundary assignments, and calibration of key model parameters are further discussed below.

Grid Generation

The Los Peñasquitos Lagoon is composed of both deep and shallow channels and salt marsh areas. The lagoon connects with the ocean through a narrow inlet. Grid generation was primarily based on available bathymetry data, shoreline data, DEM data, and satellite imagery. The EFDC grid for the lagoon includes two portions—the lagoon itself and the ocean. During model development, hydrodynamic calibration was conducted first to ensure accurate exchange of salt and freshwater in the lagoon. A model grid was developed to include the ocean shoreline for hydrodynamic calibration. The grid including the ocean shoreline allowed for the use of tide elevation data for hydrodynamic calibration.

After the hydrodynamic calibration, a reduced grid was used to simulate sediment transport. The reduced grid set the ocean inlet, which is the location where the lagoon connects with the ocean, as the open boundary and does not include the ocean cells that were incorporated for hydrodynamic calibration. This was done because sediment, especially sand in the water column, are at relatively low levels in the ocean and sediment entering the lagoon are mainly due to beach erosion caused by various processes such as wave-breaking. Beach erosion processes cannot be modeled with the existing configuration which lacks wave, wave-breaking, and wave-current interaction components; therefore, sediment modeling used a reduced grid which sets the open ocean boundary immediately outside of the ocean inlet. The ocean part of the grid was not used for the sediment modeling. Note that for sediment modeling, the predicted tide elevations, water temperature, and salinity from the hydrodynamic calibration were assigned. In addition, bank erosion within lagoon channels was not simulated; therefore sediment erosion and resuspension are assumed to occur only with respect to the bottom sediment.

There are 374 computation cells in the full model grid, which includes the ocean cells, and 259 cells in the reduced grid that was used for modeling sediment transport. Lagoon channels near the ocean inlet are wider than upstream channels and have a finer resolution. Because of the complicated channel and salt marsh shapes, several grids were generated for each of the individual sections. The individual grids were then combined together to form one composite model grid for running EFDC. The full grid is shown in Figure 20. The grid includes the salt marsh area and two major channels. Two vertical layers were also included within the grid to better represent differences between upper and lower sections.

The channel that receives the flow and sediment loadings from Carmel Creek is called the Carmel Branch in this report. The channel that receives the flow and sediment from the merged Los Peñasquitos Creek and Carroll Canyon Creek is called the Los Peñasquitos Branch in this report. The small channels are coarsely represented together with the salt marsh area. In addition, the railroad track that bisects the lagoon was represented as a continuous berm that blocks flow and separates eastern and western portions of the lagoon, except for the railroad trestle (bridge) that crosses Carmel Branch. The model grid includes an opening at this location and allows flow through.

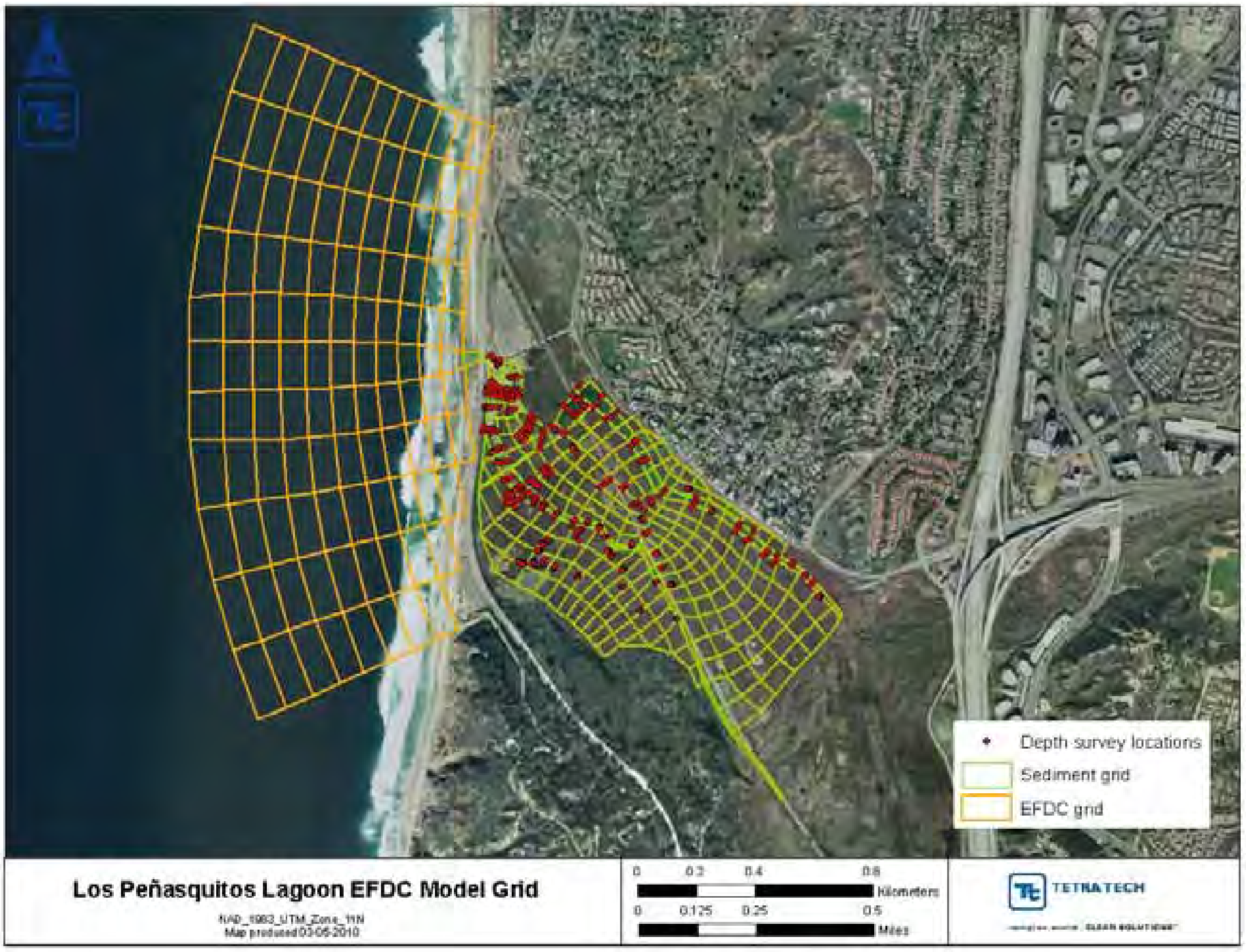


Figure 20. EFDC grid and bathymetry data for Los Peñasquitos Lagoon

As stated above, grid generation was based on available bathymetry data. A bathymetric survey of the Los Peñasquitos Lagoon was performed in March 2008 as part of the TMDL monitoring study (City of San Diego, 2009). The bathymetry for the two major channels were based on these data. These data include bottom elevations that were measured at several locations throughout the lagoon. Bottom elevation data were used to determine average grid bottom elevations. In addition, four lagoon mouth surveys were completed between October 2007 and April 2008 and were used to refine the ocean inlet. EFDC represents rectangular cross-sections; therefore, determination of grid bottom elevations cannot be assumed using average or lowest bottom elevations. Initial bottom elevations were estimated by reviewing these data and assigning the near deepest elevation values to each grid cell, where data are available. For grid cells where bottom elevations were not measured, initial bottom elevations were obtained through interpolation. Bottom elevations were refined during calibration for better hydrodynamic simulation.

For the salt marsh area, the more detailed USGS 1/9 arc second DEM data were downloaded. Average elevation within each EFDC cell was calculated using the DEM data. In addition to the DEM data, the 2006 Los Peñasquitos Lagoon Foundation monitoring report includes monitored elevation profiles in the lagoon (Hany et al, 2007). The elevations from the DEM were compared to the elevations in the report, and were adjusted slightly.

Boundary Conditions

As an open water system, conditions within the Los Peñasquitos Lagoon are continuously changing due to external forces. For example, flood tides allow for ocean water to flow into the lagoon, which increases salinity. Air temperature and solar radiation also have a strong influence on lagoon water temperature. These external forces are represented in the model using boundary conditions. In order to simulate water circulation and sediment transport using the EFDC model, boundary conditions must be specified. Boundary conditions include watershed freshwater inflows and associated sediment loading rates, the exchange of salt water and freshwater in the lagoon, and sediment carried by flood tide.

Watershed Inflow

Watershed inflows determine the amount of freshwater that is contributed to the lagoon and associated sediment loading rates. The lagoon primarily receives water from three main tributaries: Los Peñasquitos Creek, Carroll Canyon Creek, and Carmel Creek. Watershed hydrology and sediment loading were modeled using the LSPC model, as described earlier. Flow rates and sediment concentrations from catchments 1401, 1403, and 1404 were assigned as boundary conditions from the watershed to the EFDC model (Figure 21).

Modeled watershed flows were converted to EFDC format and assigned to the corresponding EFDC grid cells. Catchment 1401 is a small direct drainage to the lagoon and is input to grid cell (28,14). The reach in catchment 1403 is Carmel Creek and feeds into grid cell (26, 5), Los Peñasquitos Creek and Carroll Canyon Creek merge in catchment 1404 and feeds into grid cell (19, 3), and a small direct drainage area was specified at grid cell (19, 3). Water temperature for the watershed inflows were obtained from continuous temperature data provided by the City of San Diego (2009) and converted to EFDC format. Salinity from the direct drainage area was set to zero, and salinities from the three creeks were specified based on monitored salinity data. The LSPC model simulated three sediment particle sizes: sand, silt, and clay. LSPC modeled sand, silt, and clay concentrations were converted to EFDC format.

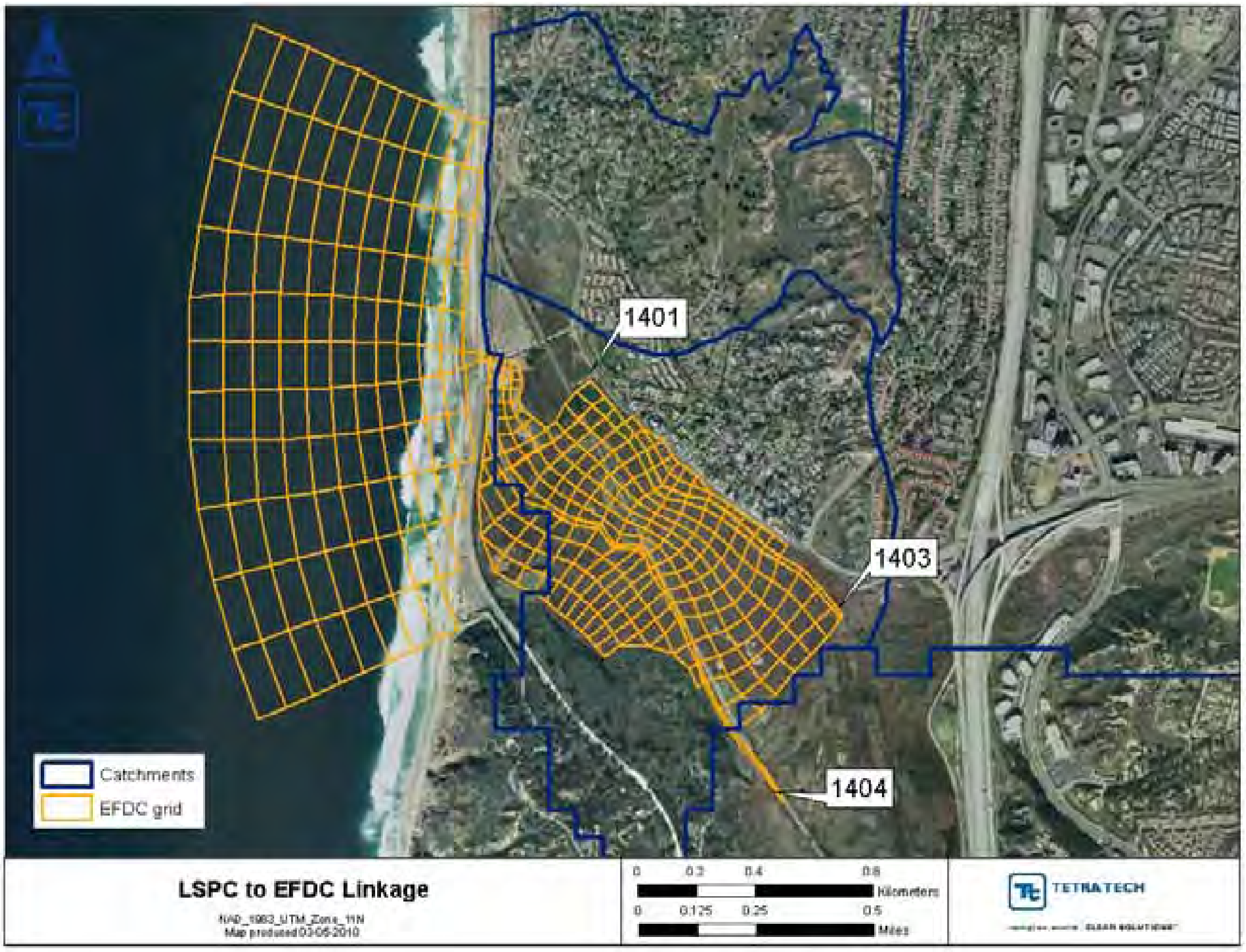


Figure 21. Assignment of watershed inputs to the EFDC grid

Representation of Ocean Boundary

In addition to the watershed, the ocean has both hydrodynamic and water quality influences on the lagoon. A narrow channel exists between the lagoon and the open ocean. The ocean is one of the major driving forces that influences lagoon circulation. Ocean water enters the lagoon during flood tides and leaves the lagoon during ebb tides. Changes in ocean water surface elevation determine the direction of flow and the transport of water quality constituents. Ocean water also increases or decreases the pollutant concentrations in the lagoon depending on water quality conditions along the ocean boundary. Required data for the ocean boundary include tidal elevation in the ocean, water temperature and salinity in the ocean water, and suspended sediment concentrations.

There are no monitoring stations located along the ocean boundary outside the lagoon mouth. Ocean inlet monitoring was conducted, however, this station is located at the lagoon/ocean interface. Conditions at this location are impacted by both the ocean and lagoon; therefore, data collected at the ocean inlet are not representative of ocean conditions. Tide data collected at the closest NOAA station in La Jolla were used to determine the open ocean water surface elevation boundaries for the lagoon model. The La Jolla station is located approximately 5 miles south of the Los Peñasquitos Lagoon. Tide data from La Jolla were used because it is similar to other available tide data in the vicinity and provides a more complete dataset in terms of the time period available. Mean sea level elevation data were downloaded from the NOAA site and were converted to EFDC format (Figure 22). Water temperature data were also obtained from the La Jolla NOAA station, although salinity data were not available at this station. The salinity boundary condition was set to 35 psu at the ocean open boundary location.

For sediment simulations, the modeled water surface elevation, salinity, and water temperature immediately outside the lagoon (predicted from the full grid simulation) were specified as boundary conditions. Ocean sediment concentration data were not available. It is assumed that sediment entering the lagoon during flood tides primarily originates from beach erosion. The concentrations of sand, silt, and clay fractions were set to constant values initially and then adjusted during calibration.

Meteorological Data

Meteorological data are an important component of the EFDC model. Surface boundary conditions are determined by the meteorological conditions. Data required for model setup include atmospheric pressure, air temperature, relative humidity, precipitation, cloud cover, solar radiation, wind speed, and wind direction.

Meteorological data from station KCASAND153 located east of Interstate 5 in Torrey Woods Estates/Carmel Valley was downloaded from the website: www.weatherunderground.com. This website allows download of daily (5-minuted resolution) rainfall, wind speed and direction, air temperature, and percent humidity measurements (Figure 22). Solar radiation was estimated based on the latitude of the station and then adjusted based on the sky cover condition for each time-step. Sky condition data (i.e. cloud cover data) were not available and the estimated clear sky solar radiation data were adjusted/interpreted based on when precipitation occurred. Solar radiation data were further refined during calibration. Data for each day were provided by the City of San Diego (2009) from October 2007 through April 2008. These data were converted to the appropriate units and formatted for input into the EFDC model.

Figure 22. Meteorological and Ocean Boundary stations

Initial Conditions

For a dynamic model such as EFDC, initial conditions of water surface elevation, water temperature, salinity, water column sediments, and bottom sediments must be specified. Because the lagoon is an open system that is flushed by ocean water and watershed inflows frequently, the initial conditions of water surface elevation, water temperature, salinity, and water column sediments can be quickly replaced by boundary conditions. Model initial conditions were found to not be very sensitive to the model predictions. Initially assigned water surface elevation, water temperature, salinity, and water column sediment concentrations changed quickly as the model responds more readily to the driving boundary conditions from the ocean and watershed. Initial conditions were set to reasonable values based on modeling judgment. Water surface elevations were set to 0.92 meters above mean sea level (MSL) to ensure that all the grid cells were wet during the start of the simulation. Initial water temperatures were set to 10 degrees Celsius; salinities were set to 10 psu, and sand, silt, and clay fractions in the water column were set to 10 mg/L.

Sediment bottom conditions in the lagoon are the result of the long-term balance between deposition and erosion. Initial lagoon sediment depth at the beginning of the model simulation period determines the amount of sediment that can be eroded. Bottom sediment conditions were measured at the beginning of the modeling period on 10/1/2007. The only available data were collected (post storm) during 2/11/2008 and 2/15/2008 at 26 locations in the lagoon for sediment size distributions as part of the TMDL monitoring study. Sand, silt, and clay percentages from the sediment size distributions were set as the initial mass fractions for the sediment bed in the lagoon with the assumption that the sediment components have reached an equilibrium status and did not change dramatically from the beginning of the modeling period to the survey dates. In addition to mass fractions, other sediment properties including porosity and density must be specified in the model. These data were not collected; therefore default values for porosity (0.4) and density (1.99 gm/cm3) were used (Tetra Tech, 2007).

Model Calibration and Validation

Modeling parameters for the watershed and lagoon models were adjusted based on available monitoring data, as detailed below. For both models, it was essential that the physics of the system (hydrology and hydrodynamics) be accurately characterized in order to provide a sound foundation for simulating water quality conditions within the lagoon. Simulations of sediment fate and transport processes are dependent on an accurate representation of runoff, water movement and circulation, and other dynamic components. The time-step for the LSPC model is hourly and the time-step for the EFDC model is 0.5 seconds.

Watershed Model Calibration and Validation

Long term hydrology (1993-2008) was calibrated and validated using streamflow data from USGS gage 11023340 at the bottom of catchment 1406 (Figure 6). The period of record was divided into separate calibration and validation periods. Additional flow data were collected during TMDL monitoring by the City of San Diego (2009) at the bottom of catchments 1403 (Carmel Creek), 1405 (Los Peñasquitos Creek), and 1411 (Carroll Canyon Creek) were used for validation of the model hydrology (see Figure 19).

Hydrology

Measured and modeled average daily flows compared well throughout the model calibration and validation periods. Overall summary statistics comparing observed and simulated hydrology were within the recommended criteria based on HSPEXP (Lumb et al., 1994) for all metrics except summer volume error. Summer volume was primarily a function of the irrigation factor which was developed to balance observed summer low flows throughout the entirety of the simulation period.

Figure 23 through 30 compare modeled and measured flows during the calibration (1993-2000) and validation (2000-2008) periods. Table 4 presents the statistical comparison of modeled and measured flows at the USGS gage on Los Peñasquitos Creek (11023340).

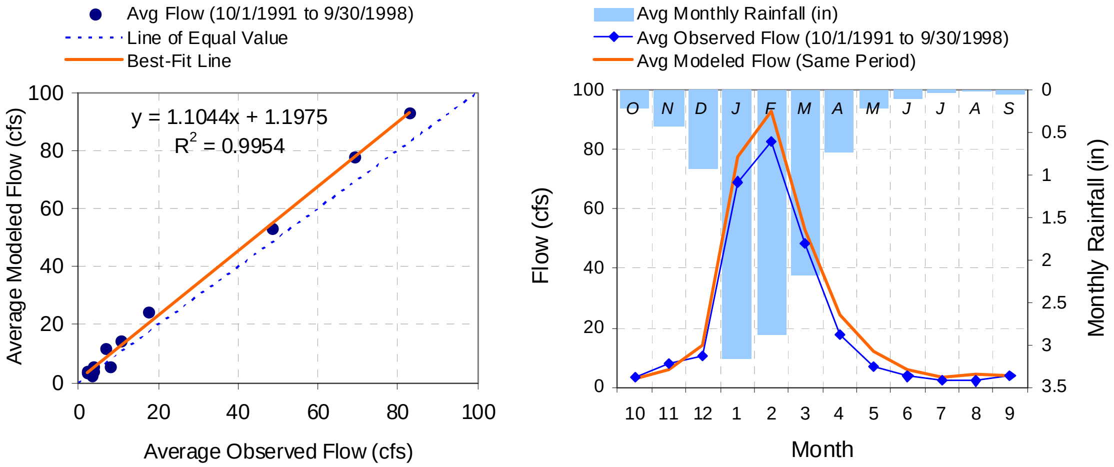


Figure 23. Mean monthly flow for calibration period (USGS 11023340)

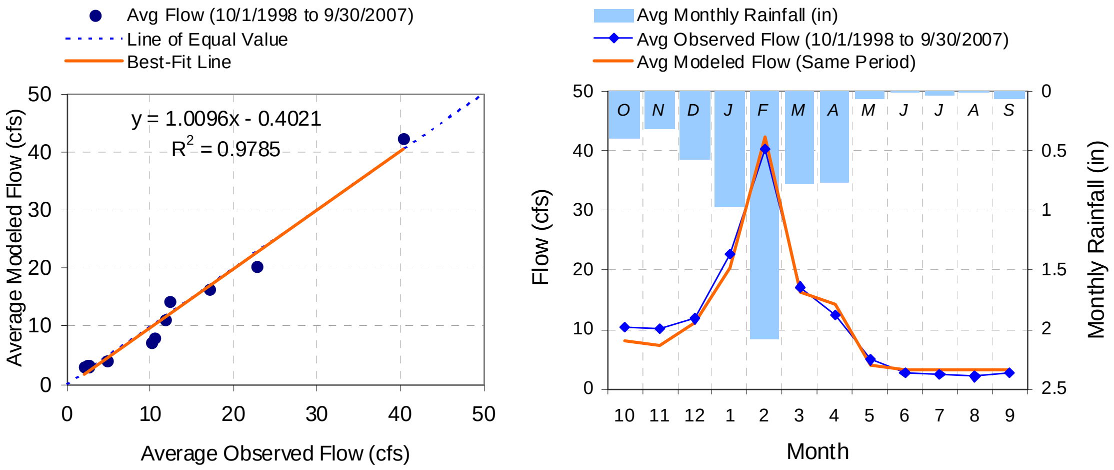


Figure 24. Mean monthly flow for validation period (USGS 11023340)

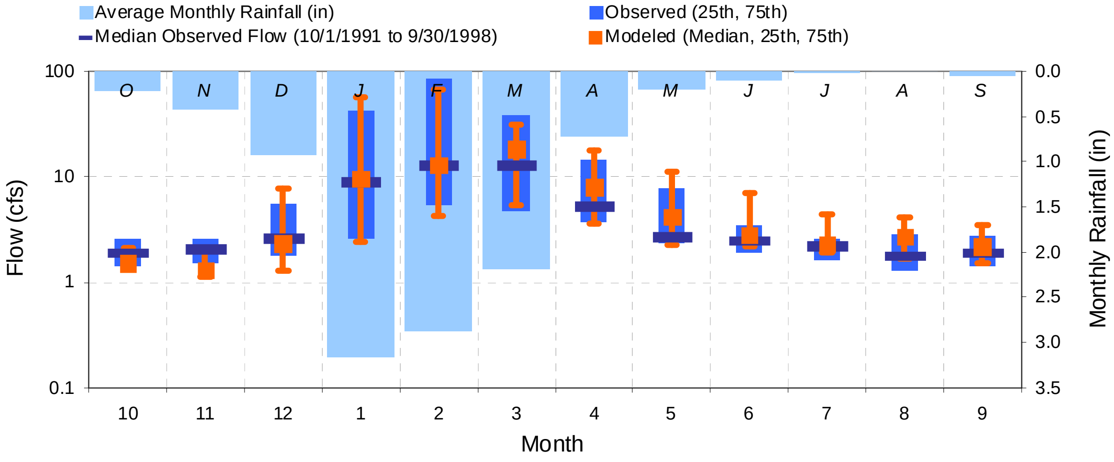


Figure 25. Monthly median and percentile flow comparison – calibration period

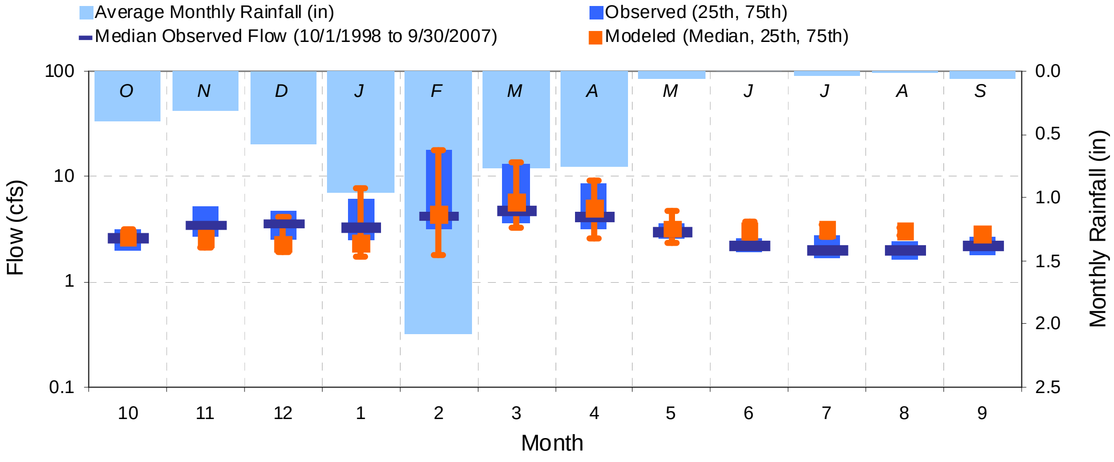


Figure 26. Monthly median and percentile flow comparison – validation period

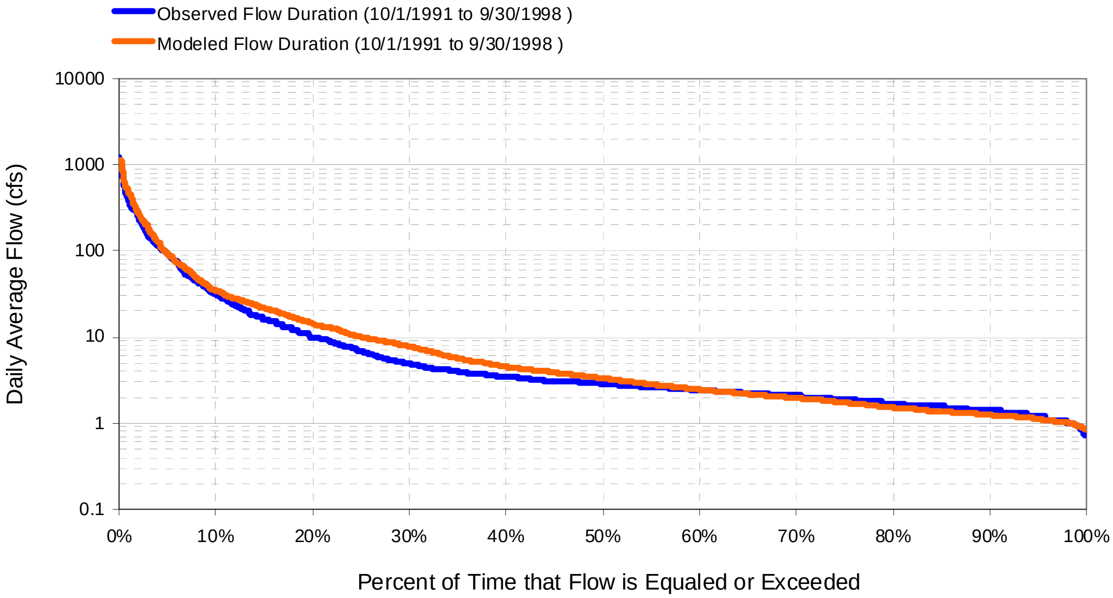


Figure 27. Flow exceedence output comparison – calibration period

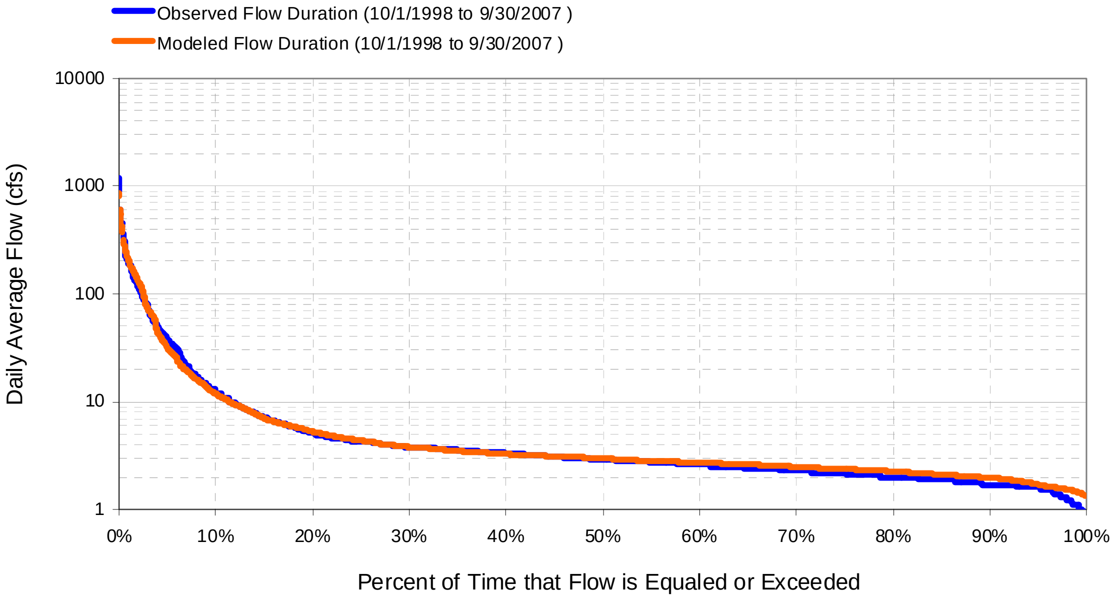


Figure 28. Flow exceedence output comparison – validation period

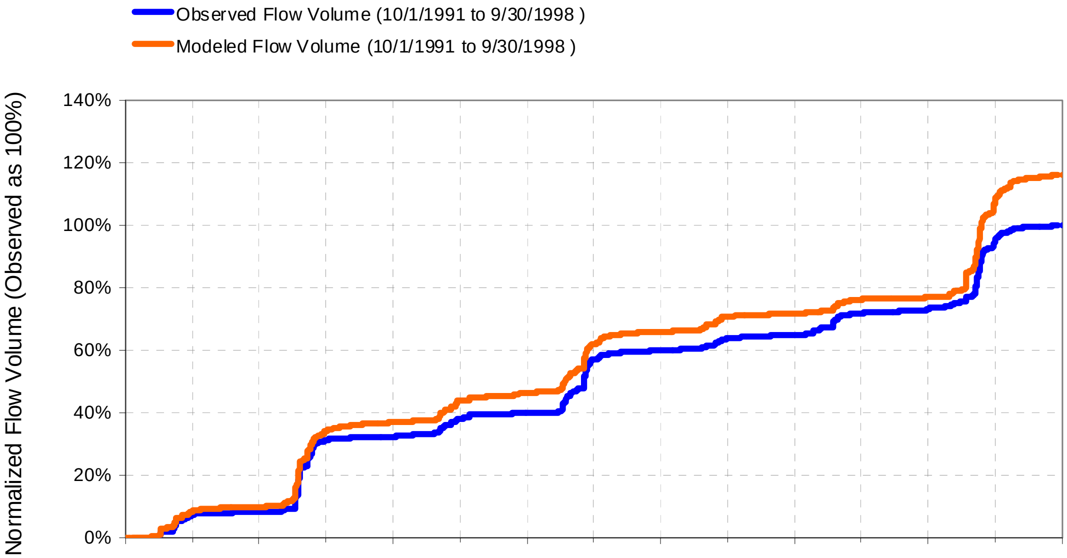


Figure 29. Cumulative volume comparison – calibration period

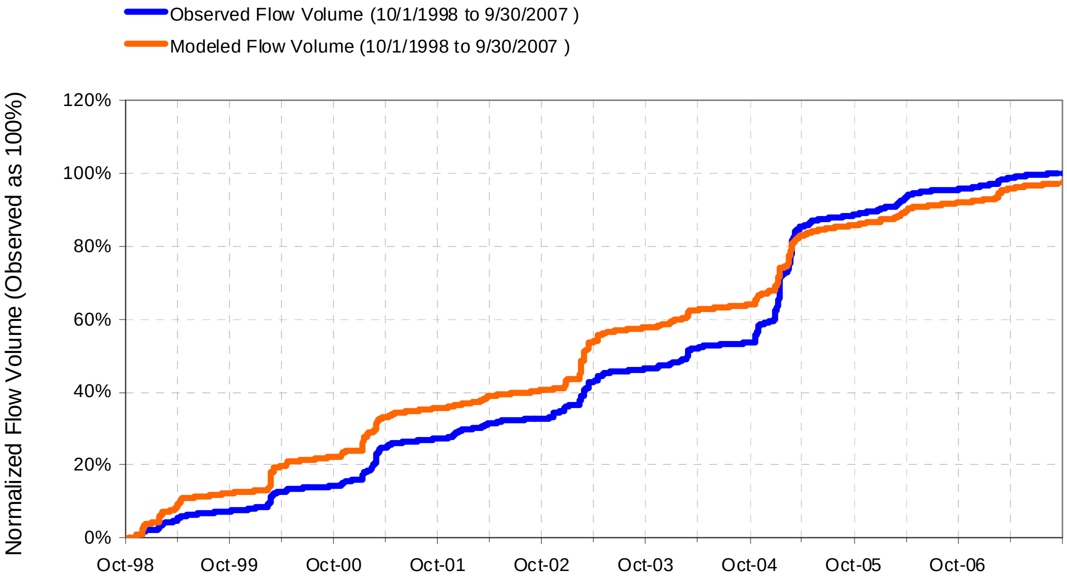


Figure 30. Cumulative volume comparison – validation period

Table 14. LSPC hydrologic model performance - entire simulation period

LSPC Simulated Flow **OUTFLOW FROM CATCHMENT 1406** 15.16-Year Analysis Period: 1/1/1993 - 2/29/2008 Flow volumes are normalized, with total observed as 100		**Observed Flow Gage** **USGS 11023340 USGS Home**	
Total Simulated In-stream Flow:	116.10	Total Observed In-stream Flow:	
Total of simulated highest 10% flows:	91.68	Total of Observed highest 10% flows:	
Total of Simulated lowest 50% flows:	4.36	Total of Observed Lowest 50% flows:	
Simulated Summer Flow Volume (months 7-9):	4.60	Observed Summer Flow Volume (7-9):	
Simulated Fall Flow Volume (months 10-12):	9.01	Observed Fall Flow Volume (10-12):	
Simulated Winter Flow Volume (months 1-3):	86.17	Observed Winter Flow Volume (1-3):	
Simulated Spring Flow Volume (months 4-6):	16.33	Observed Spring Flow Volume (4-6):	
Total Simulated Storm Volume:	54.53	Total Observed Storm Volume:	
Simulated Summer Storm Volume (7-9):	0.85	Observed Summer Storm Volume (7-9):	

Errors (Simulated-Observed)	Error Statistics	Recommended Criteria	1995-1999	2000-2004
Error in total volume:	16.10	10	-1.43	7.35
Error in 50% lowest flows:	-2.00	10	-1.60	-3.91
Error in 10% highest flows:	13.77	15	2.26	1.75
Seasonal volume error - Summer:	42.46	30	13.27	-2.52
Seasonal volume error - Fall:	5.02	30	4.49	12.42
Seasonal volume error - Winter:	11.62	30	-18.21	13.31
Seasonal volume error - Spring:	48.44	30	1.90	6.11
Error in storm volumes:	21.88	20	1.13	12.07
Error in summer storm volumes:	11.76	50	3.16	15.42

Nash-Sutcliffe Coefficient of Efficiency, E:	0.675	Model accuracy increases as E or E' approaches 1.0	0.688	0.814
Baseline adjusted coefficient (Garrick), E':	0.683		0.517	0.549

Additional validation flow data from the City of San Diego (2009) were available for comparison to model output. Los Peñasquitos Creek flows were monitored by the USGS (15 minute data at gage 11023340) and the City of San Diego (5 minute data at MLS) which represent drainages of 42 and 59 mi^2, respectively. Flows at the two monitoring stations reflected the amount of rainfall that was received within each drainage area. Peak stormflow (Figure 31) and storm volume (Figure 32) were greater at the upstream USGS gage (11023340) than measured at the MLS near the bottom of the watershed. Baseflow volume, defined as daily flows with more than 50% of flow from surface runoff using hydrograph separation techniques, was 9% greater at the downstream gage. For each of the three sampling events that were monitored, model output compared well to streamflow measurements at the USGS gaging station as opposed to the MLS (Figure 33 through 35). Timing differences may be due to several factors including possible data limitations, as described below.

Flows typically increase further downstream barring withdrawals and/or infiltration; however, storm volumes during the monitoring period at the downstream station were significantly lower than reported at the upstream USGS gaging station. This may indicate that the flow rating table for the downstream station may not characterize higher flows well, especially since the model calibrated well to the upstream USGS gaging station. As a result, significant adjustments were not made to the model in order to match the measured flows at the MLS.

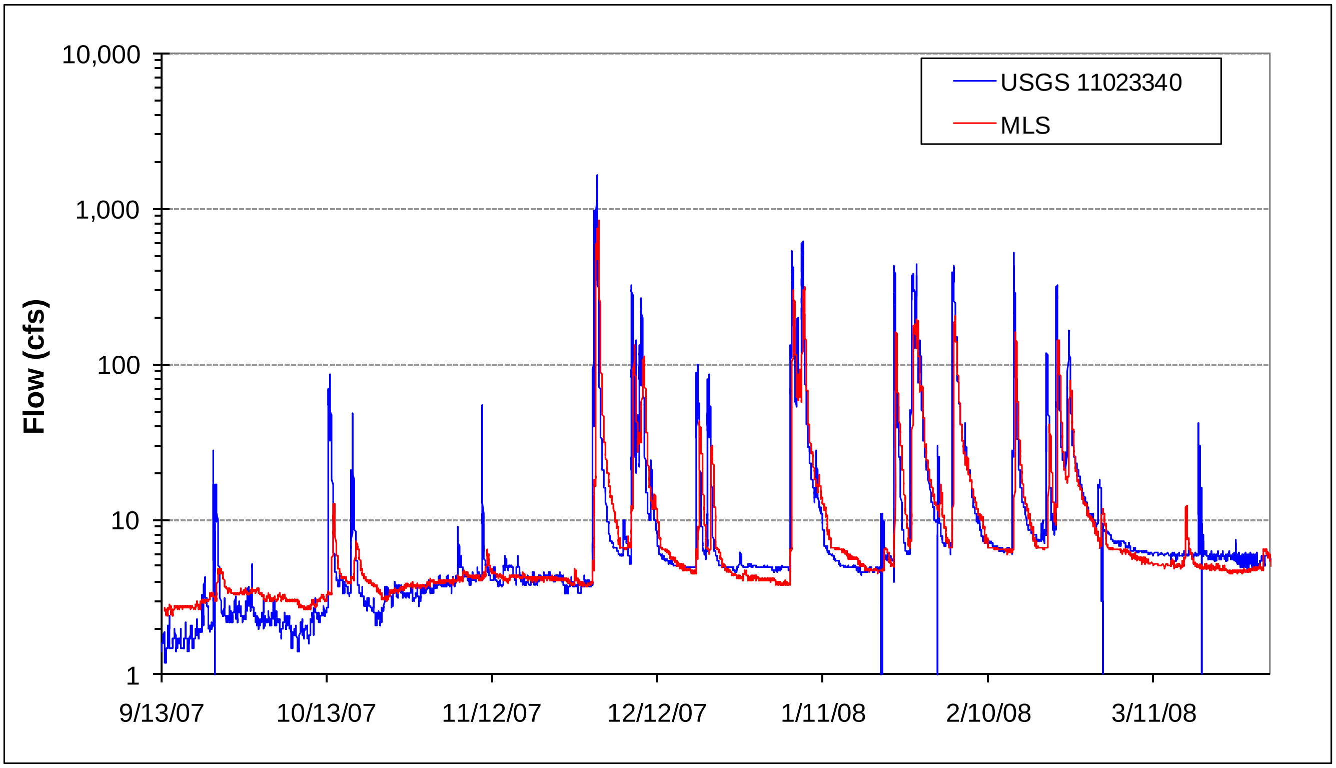


Figure 31. Time-series streamflow measured on Los Peñasquitos Creek

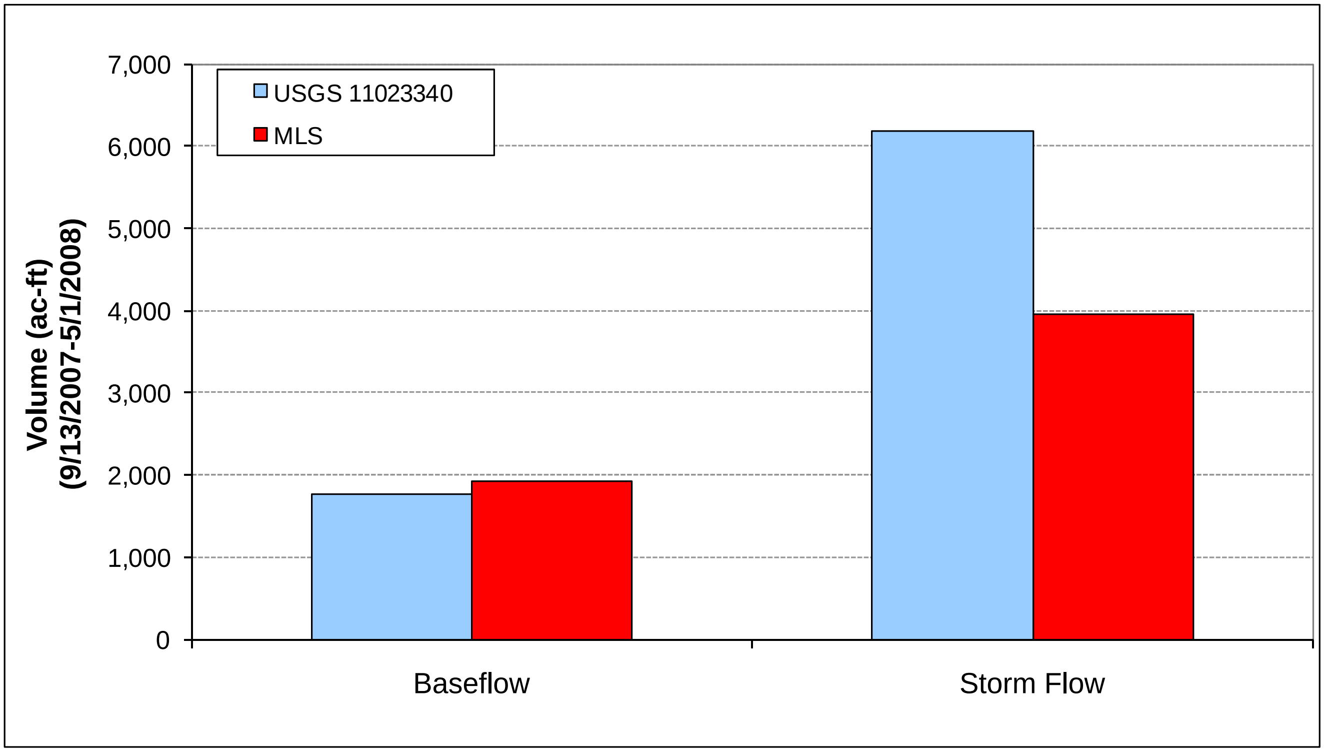


Figure 32. Baseflow and storm volumes measured on Los Peñasquitos Creek

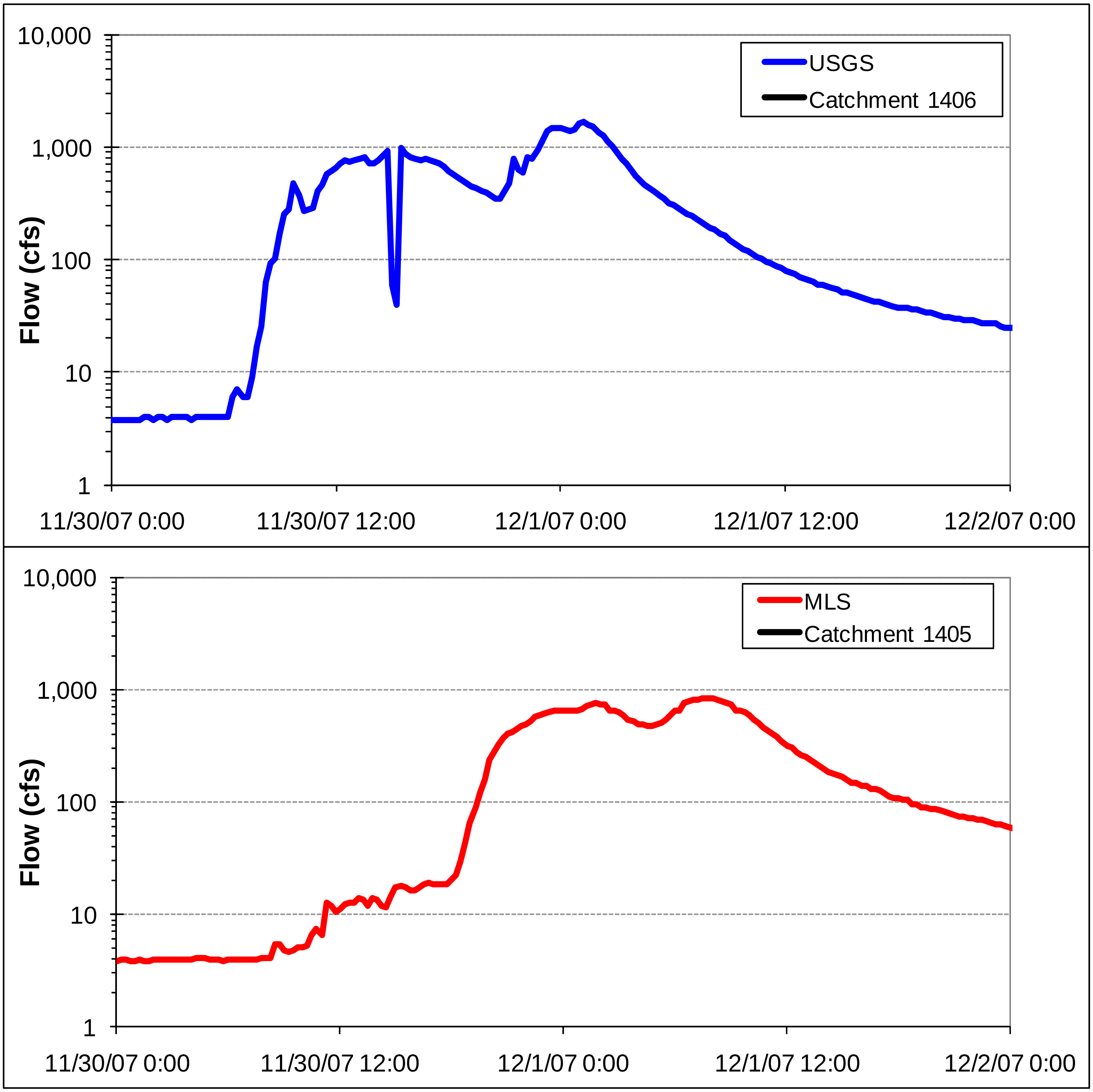


Figure 33. Comparison of modeled and observed flows at the USGS and MLS stations – 11/30/2007 storm

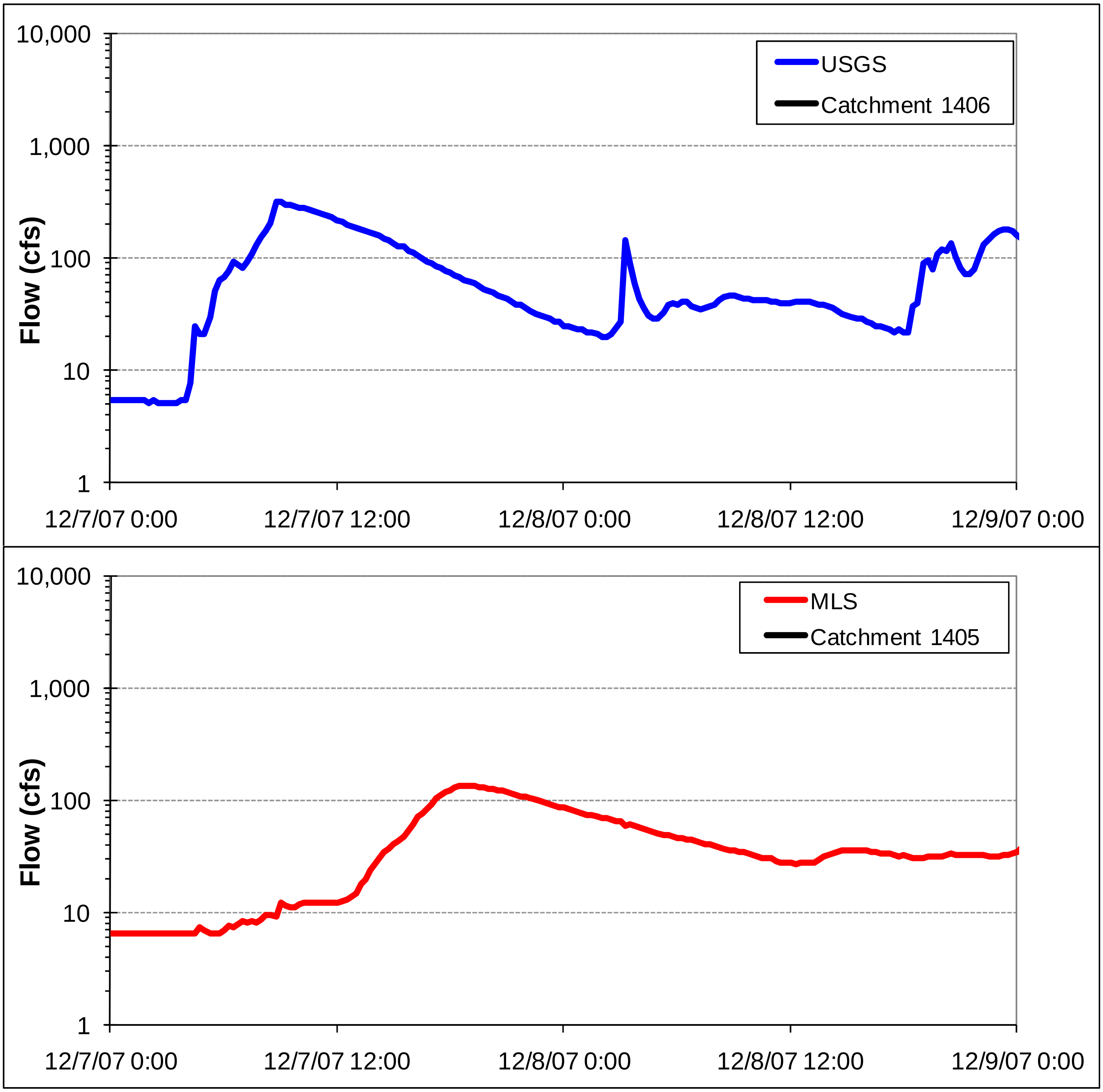


Figure 34. Comparison of modeled and observed flows at the USGS and MLS stations – 12/7/2007 storm

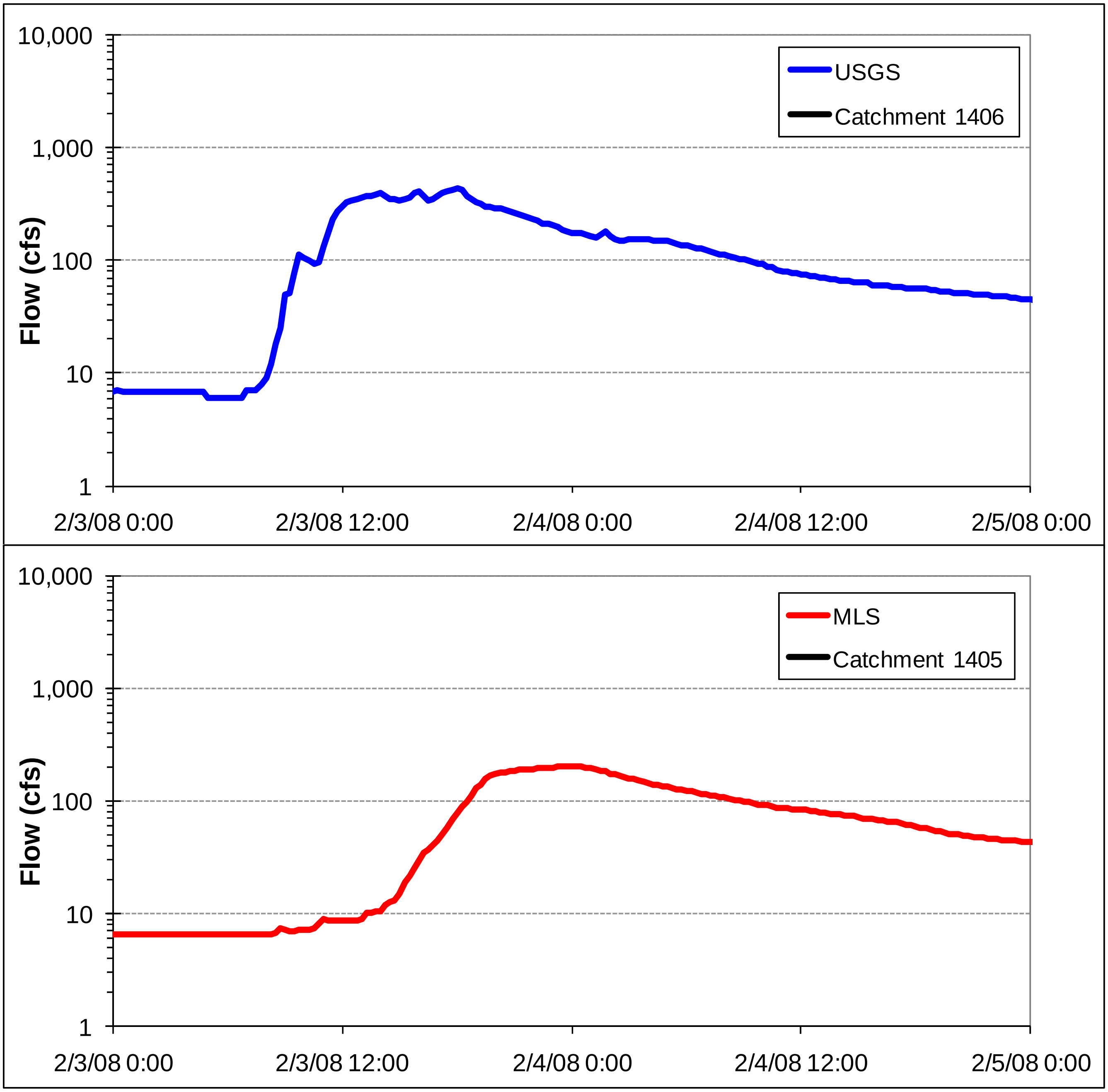


Figure 35. Comparison of modeled and observed flows at the USGS and MLS stations – 2/3/2008 storm

Suspended Sediment

Sediment deposition and scour can add or remove sediment from the modeled catchment reaches. Sand carrying capacity was assumed to be represented by a power function of velocity. The coefficient and exponent of the equation were modified to achieve a dynamic steady state where the sand in the bed remained relatively constant throughout a 16 year simulation period. The reach-specific shear stress required for deposition and resuspension of silt and clay were determined following the same methodology that was employed to define the sand dynamics.

At two of the monitoring locations, land use inputs were insufficient to replicate the observed suspended sediment concentrations. Both Carroll Canyon Creek and Carmel Creek required additional sediment inputs from the streambanks. The streambank erosion module in LSPC was used to account for the additional sediment load to the system (see Appendix B for those coefficients). The incorporation of streambank erosion provided a much improved calibration of the model at those two sites; however, care must be used in interpreting those results.

The stream cross sections in the model were based on an algorithm relating stream cross section to upstream drainage basin. Sensitivity analyses were performed on the bank erosion processes where the linear term of the bank erosion equation was modified by ±25 percent. Carmel Canyon Creek was relatively insensitive to the stream bank coefficients with a ±7 percent change in total sediment load from the catchment. Carroll Canyon Creek was more sensitive with load changes of ±21 percent when the stream bank coefficient was changed. To more accurately model the system, and the contribution from streambank erosion, accurate measurement of stream cross sections throughout the watershed would be required.

The primary dataset used in the calibration was pollutograph data for three storms that were sampled between November 2007 and February 2008 by the City of San Diego (2009) as part of the TMDL monitoring study. Both pollutograph samples and storm EMCs from the three events were used for comparison at the three monitoring sites (Figures 36 through 39). Note that flow calibration discrepancies shown in Figures 37 through 39 are likely due to possible problems with the flow rating tables and resulting streamflow estimates for these stations, as discussed in the previous section.

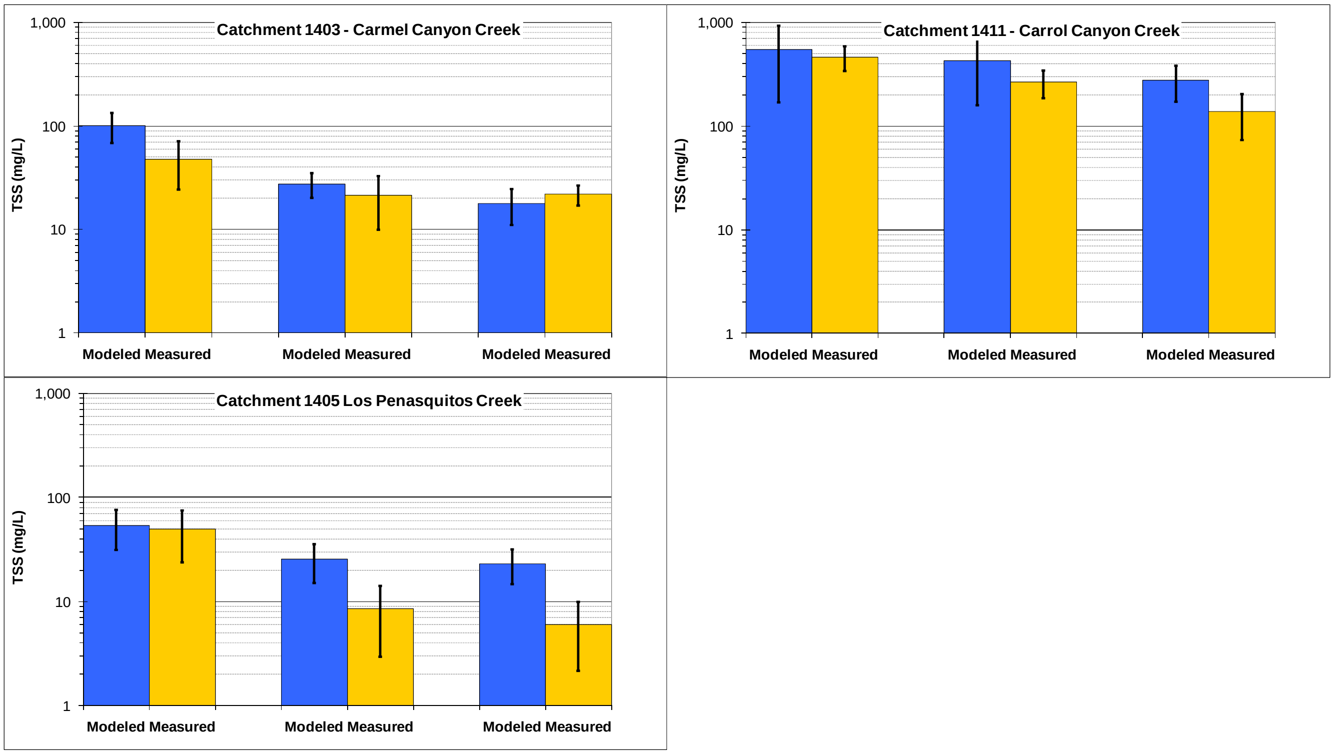


Figure 36. Comparison of EMC and 95th Percentile TSS data collected during each storm event

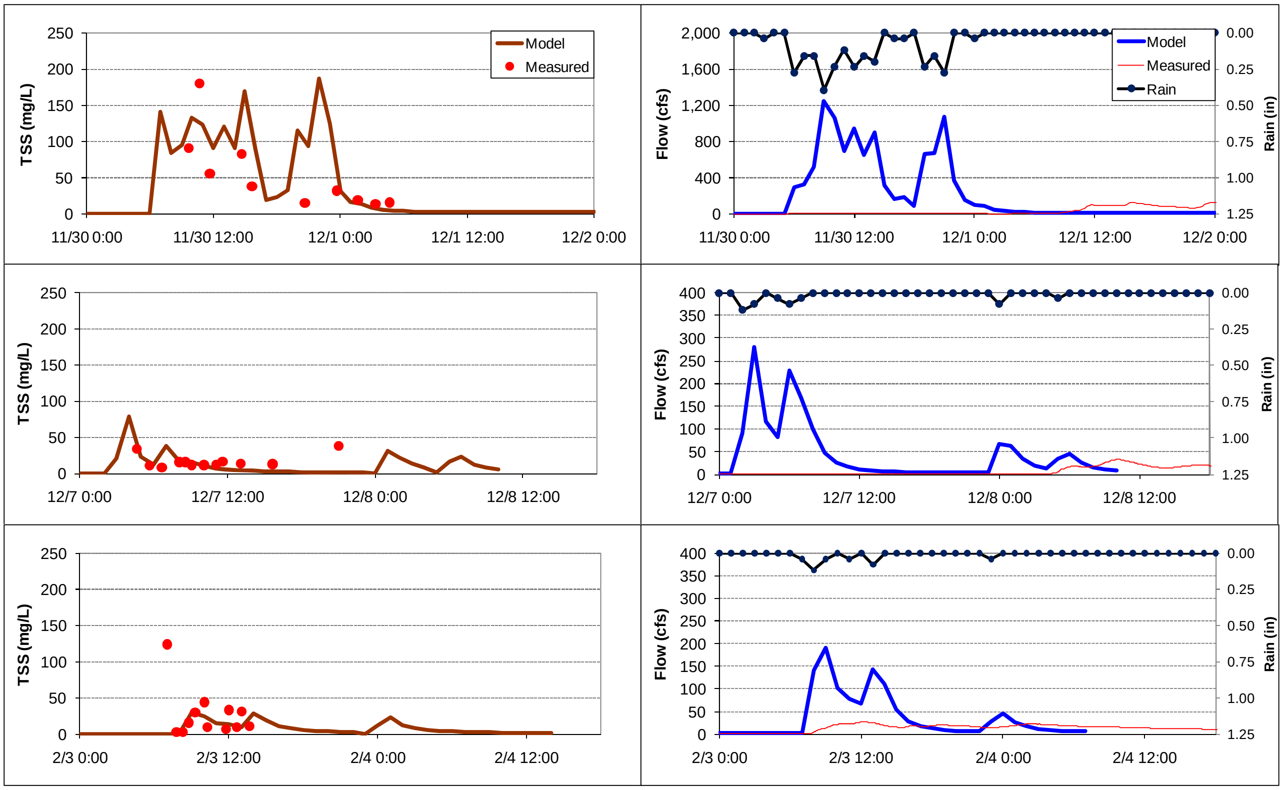


Figure 37. Pollutograph TSS calibration at Carmel Creek

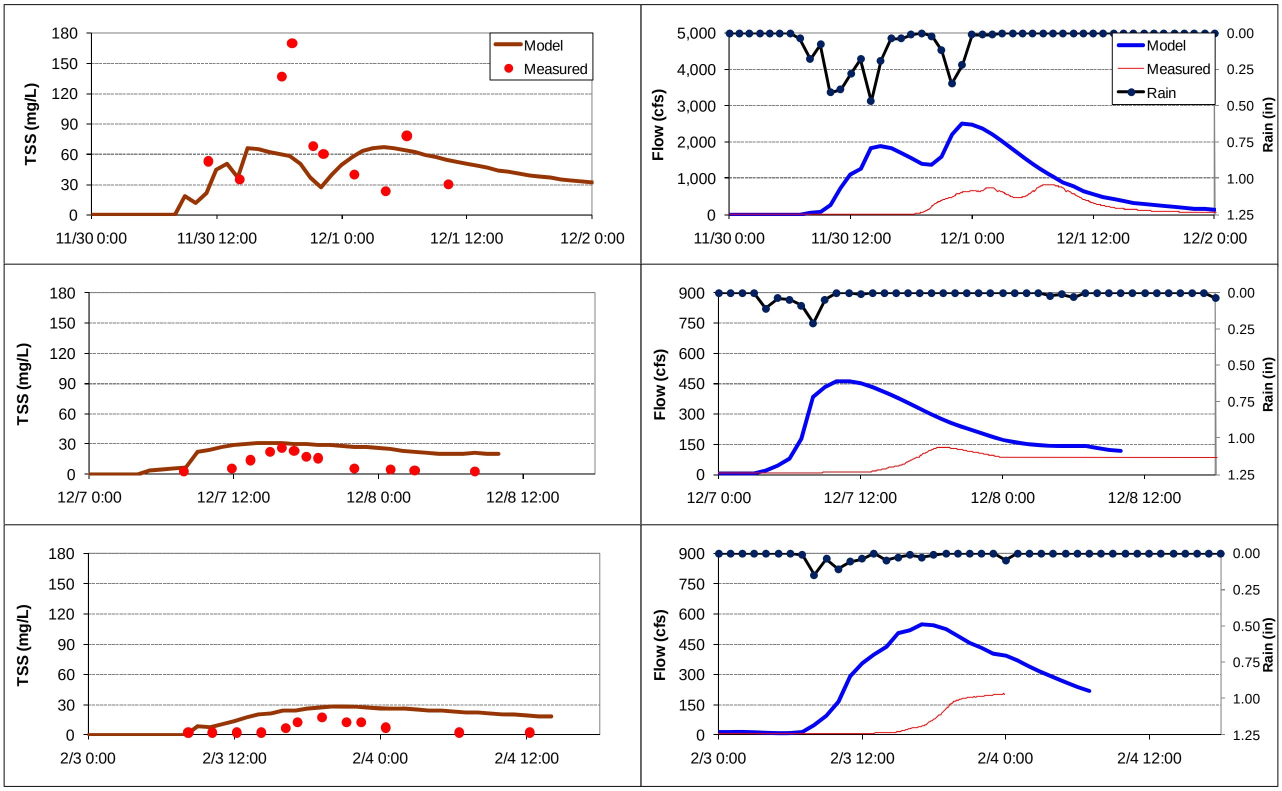


Figure 38. Pollutograph TSS calibration at Los Peñasquitos Creek

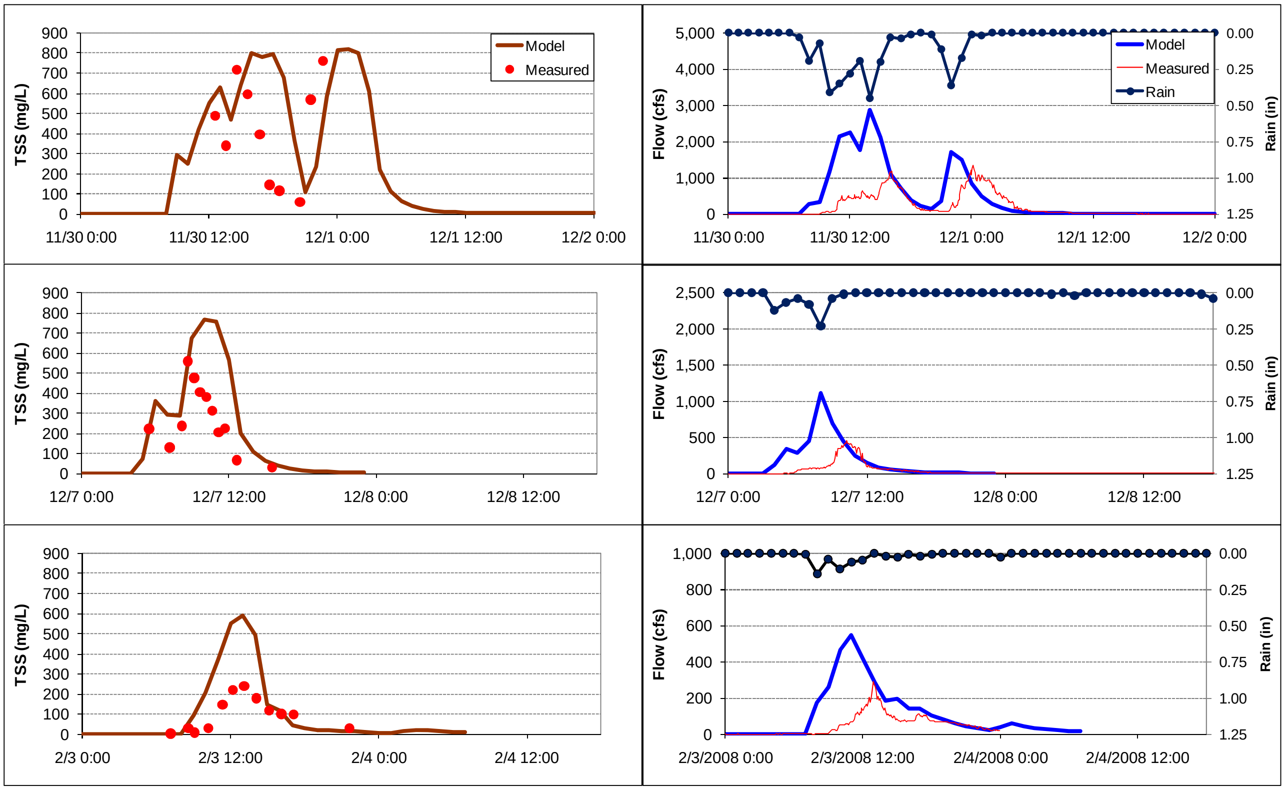


Figure 39. Pollutograph TSS calibration at Carroll Canyon Creek

Modeled particle size distributions were compared to the measured data presented in Figure 16 and 17. The measured particle size distributions were aggregated into sand (62.5-4000 µm), silt (3.1 – 53 µm) and clay (0.2 – 2 µm) fractions. Model output indicates a reasonable representation of the sand, silt and clay distributions observed in the 11/30/2007 and 12/7/2007 storms (Table 15).

Table 15. Comparison of modeled and measured sediment fractions for each storm event

	Sand	Silt	Clay

	Sand		Silt		Clay	
11/30/2007	**Measured**	**Modeled**	**Measured**	**Modeled**	**Measured**	**Modeled**
Carmel Creek	41 %	32 %	48 %	36 %	11 %	32 %
Los Peñasquitos Creek	12 %	21 %	74 %	44 %	14 %	35 %
Carroll Canyon Creek	8 %	33 %	72 %	34 %	19 %	33 %
12/07/2007						
Carmel Creek	42 %	41 %	44 %	30 %	14 %	29 %
Los Peñasquitos Creek	42 %	28 %	49 %	38 %	9 %	34 %
Carroll Canyon Creek	26 %	32 %	40 %	34 %	34 %	34 %
02/03/2008						
Carmel Creek	n/a	36 %	n/a	32 %	n/a	32 %
Los Peñasquitos Creek	n/a	29 %	n/a	38 %	n/a	33 %
Carroll Canyon Creek	n/a	32 %	n/a	34 %	n/a	34 %

The model performed reasonably well with respect to the observed concentrations at the three monitoring locations. The average difference between modeled and measured EMCs for Carmel Creek, Los Peñasquitos Creek, and Carroll Canyon Creek was 83%, 51%, and 65%, respectively. However these predictions are highly influenced by mis-timing or simply a poor comparison of measured and modeled hydrographs. The difficulties of establishing a good relationship between flow and depth is discussed in the previous section. While the measured and modeled EMCs were dissimilar, the predicted concentrations agreed well with observed data (see Figure through 39).

Additional sampling efforts within the Los Peñasquitos watershed included stormwater TSS measurements. The USGS had two separate sampling efforts in the watershed in the 1980’s (Table 5). NPDES monitoring on Los Peñasquitos Creek began in 2001 and is currently an ongoing effort. Two pollutograph sampling events (11/30/2007 and 12/7/2007) were also sampled during NPDES monitoring, providing both pollutograph and EMC data.

Output from a long term simulation (1/1/1998 – 2/28/2008) was used to validate the model. Storm TSS EMCs from the model output (Model) were compared against the USGS sampling results (USGS), NPDES monitoring (MLS), and paired NPDES (MLS-1 and -3)/pollutograph monitoring (Storms 1 and 3) (Figure 40). Model results were an order of magnitude lower than the USGS grab samples but were not significantly different at the 95th percentile level. Median model output was comparable to the long term NPDES EMC sampling. It is interesting to note that the EMCs from the two common storms for the pollutograph and NPDES sampling differed by more than double.

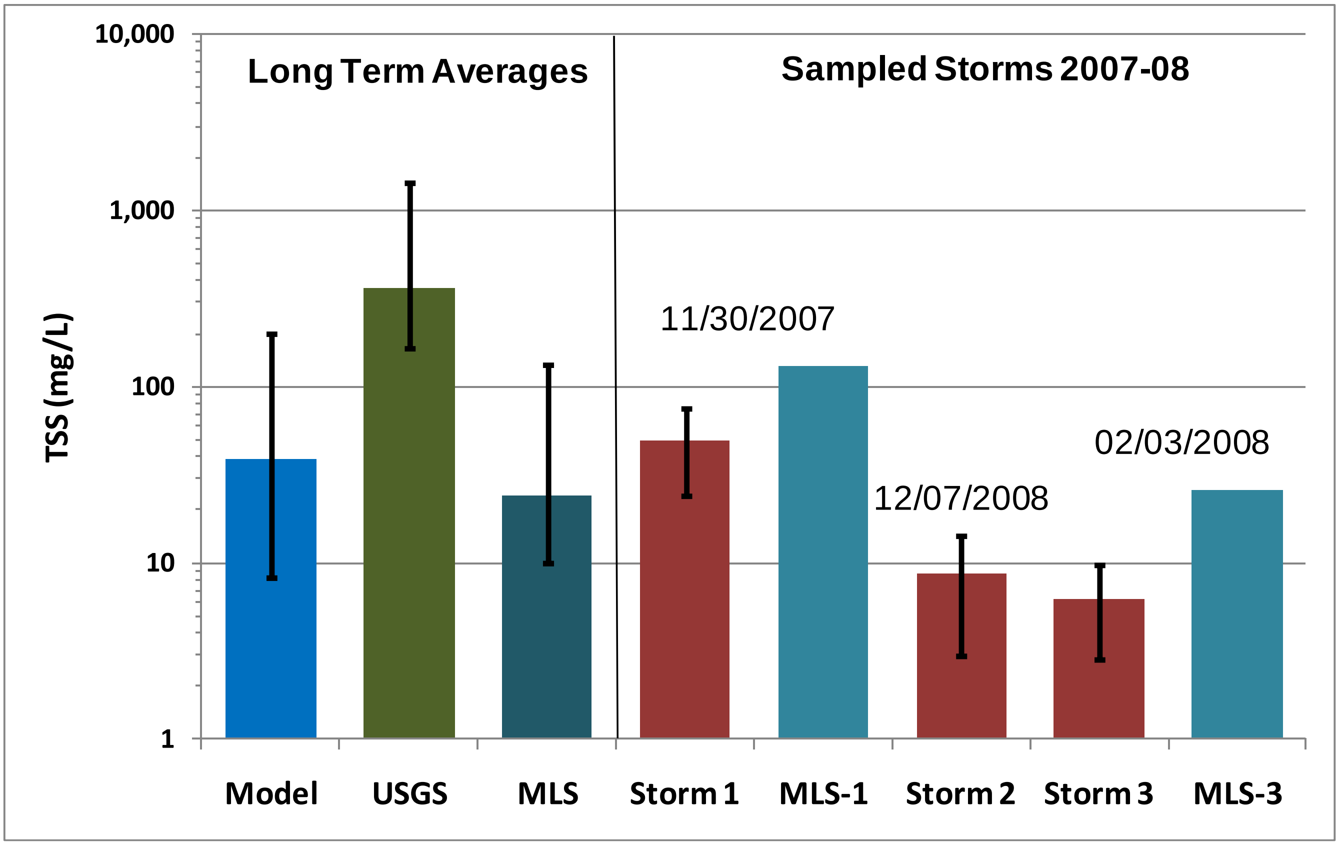


Figure 40. Comparison of modeled and measured TSS with 95th percentile confidence intervals

In 2005, the El Cuervo Norte wetlands were built upstream of the long-term MLS monitoring station. Flows from Los Peñasquitos Creek are diverted into the wetlands, creating the potential for solids to settle out and thus reduce the TSS measured at the MLS. Historic stormwater EMC monitoring data from the City of San Diego has not shown a significant reduction in TSS concentrations at the 95th percent confidence level (Figure 41).

Suspended sediment simulations reasonably predicted the observed stormwater TSS concentrations in the Los Peñasquitos watershed. Sediment transported via diffusive bed load processes also has the potential to be a significant source of sediment loadings; however, this source was neither characterized in the LSPC modeling or would be with traditional TSS sampling. Perennial flows into the lagoon were modeled with little to no sediment inputs throughout the majority of the simulation period. Because of the length of those periods without TSS at low levels, bed flow has the potential to be the dominate sediment transport pathway and could add significant sediment to the lagoon.

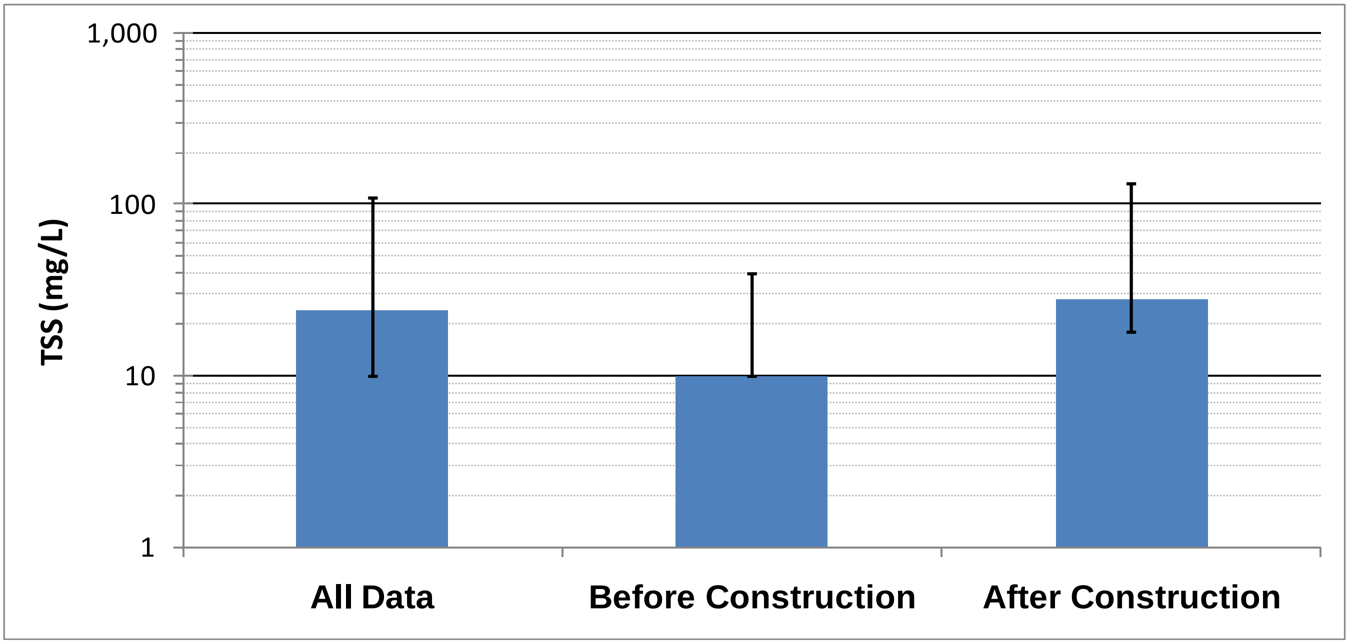


Figure 41. Measured TSS before/after construction of the El Cuervo Norte wetlands

Lagoon Model Calibration

Based on the TMDL monitoring study conducted by the City of San Diego (2009), two lagoon stations were available for model calibration. One station is located near the ocean inlet and one is located on the Carmel Branch lagoon segment. Figure 42 shows the locations where grab samples and continuous data were collected at these two locations within the lagoon. An inventory of all available monitoring data that were used during model calibration is provided in Table 16.

Table 16. Lagoon calibration data summary

Dates	Media	Sample type	Parameters	Location
11/30-12/1/07 12/07-12/8/07 2/02-2/04/08	Water	Pollutograph	TSS and Conductivity	Lagoon and ocean Inlet
11/30-12/1/07	Water	Storm composite	Percent composition of gravel, sand, silt, and clay	Lagoon segment and ocean inlet
10/07-4/08	Water	Continuous	Temperature, Conductivity, and Water Level (15 min data)	Lagoon segment and ocean inlet

In addition to these monitoring stations, the Los Peñasquitos Lagoon Foundation also routinely monitors salinity at station W2 (railroad trestle) (Figure 42). The EFDC model was calibrated based on monitoring data that were collected at these three locations. Note that monitoring data were not collected along the Los Peñasquitos/Canyon Creek lagoon segment (Los Peñasquitos Branch); therefore, comparisons could not be made to determine if the lagoon model results accurately predict conditions in this portion of the lagoon.

Model calibration involved adjusting parameters to achieve agreement between model results and observed data. The Los Peñasquitos lagoon model was calibrated in two steps. First, hydrodynamic parameters were calibrated, including examining the modeled water surface elevation, water temperature, and salinity at the two TMDL monitoring locations with the full grid. After hydrodynamics were calibrated, sediment processes were checked to ensure reasonable model representation of the lagoon using the reduced grid. The model was run from 10/1/2007 through 3/1/2008 in order to include the TMDL sampling events conducted by City of San Diego (2009).

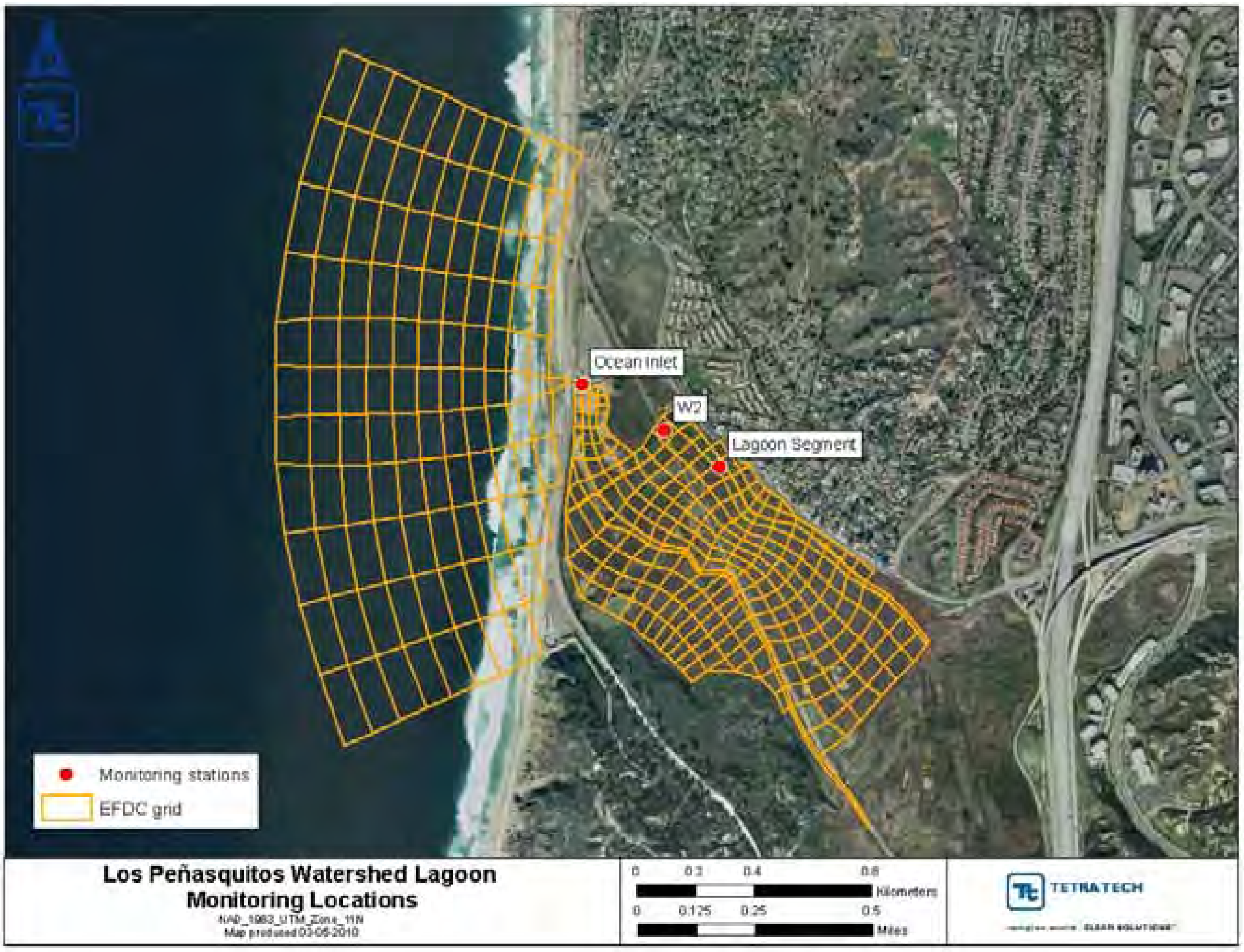


Figure 42. Calibration stations within Los Peñasquitos Lagoon

Hydrodynamics Calibration

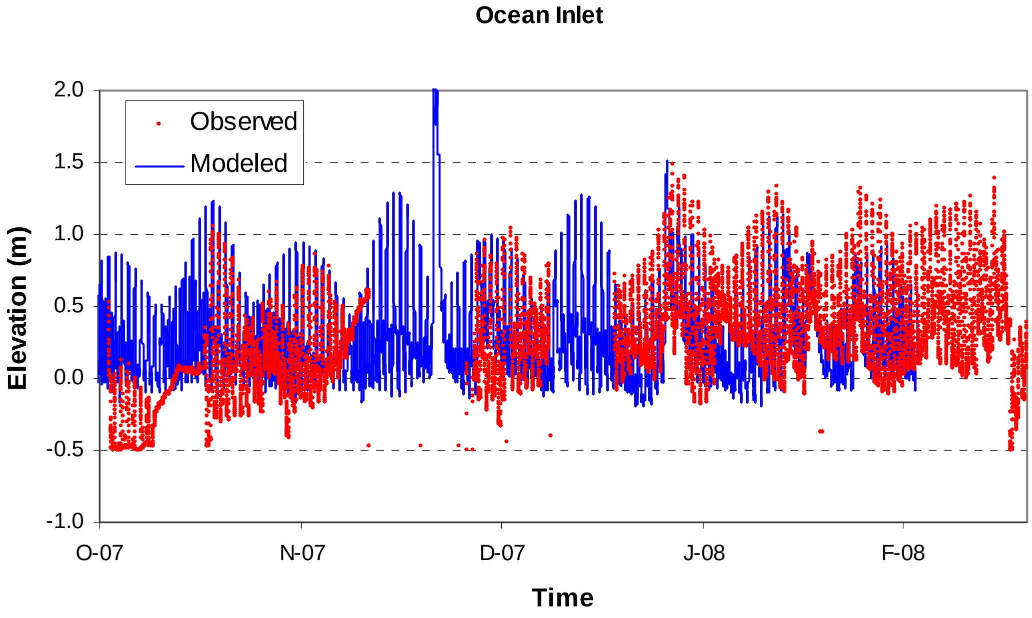
During hydrodynamic calibration, roughness height and lagoon bottom elevations for the model grid cells were adjusted slightly. The cross-section of EFDC cells is rectangular; therefore, measured cross-section data cannot be used directly. Original bottom elevations were estimated using the relatively deep measurements across the cross-section data. Final bottom elevations were determined during calibration.

Modeled water surface elevations, water temperature, and salinities were compared against observed data. Available observed data do not include water surface elevations and salinity measurements. Instead, TMDL monitoring data collected by City of San Diego (2009) included depth and specific conductance. Because model results are average depths and observed depths were determined at the sampling points, they cannot be compared directly. As a result, observed depths were converted to water surface elevations. The datum used for depth measurements was not recorded; therefore, conversion from depths to water surface elevations were estimated by assuming that average depths were near 0.5 meters above MSL.

Specific conductance data were measured continuously at the two sampling locations. EFDC can directly simulate the specific conductance as tracer. However, the impact of specific conductance on density cannot be considered as a tracer, therefore, salinity was modeled for the lagoon. Salinities were converted from specific conductance using the UNESCO algorithm (UNESCO, 1983). An Excel VBA function was developed to convert the specific conductance to salinity using the UNESCO algorithm.

Model calibration results for water surface elevation are shown in Figure 43. In general, modeled water surface elevations agree well with the elevations converted from observed depths at both of the locations. The model was able to capture the magnitude and timing of the fluctuations of water surface elevations driven by the tide and watershed inflows. The modeled elevations show some spikes with much higher elevations. These spikes are caused by modeled peak flows from the watershed, which can be different from the actual flows due to the uncertainties caused by rainfall and other parameters. In addition to uncertainty associated with the watershed inflows, the ocean inlet can change due to the sediment deposition and erosion by strong wave and/or flood tides during the simulation period. Changes in ocean inlet bathymetry can also affect the exchange of ocean water and the resulting water surface elevation. Note that for the entire calibration period (10/1/2007 – 2/28/2008), the ocean inlet was open with closures starting to occur sometime in March of 2008 as indicated in the Los Peñasquitos Lagoon TMDL monitoring report (City of San Diego, 2009)

Lagoon water temperature is mainly governed by the temperature associated with watershed inflows, ocean water temperature, and meteorological conditions. Modeled water temperature agrees well with observed water temperature at both of the monitoring locations. The model slightly over-predicted water temperature in the beginning of the simulation. This was mainly due to the open boundary water temperature data used in the model. Water temperature data were from the La Jolla station, which is approximately 5 miles south of the lagoon. 4 shows the temperature calibration at the two locations.



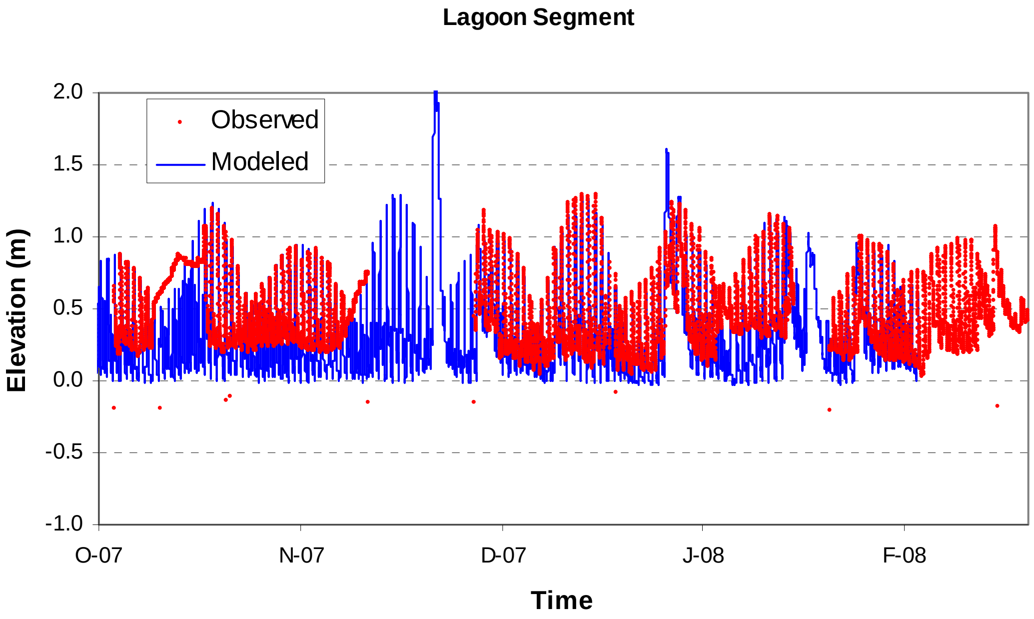
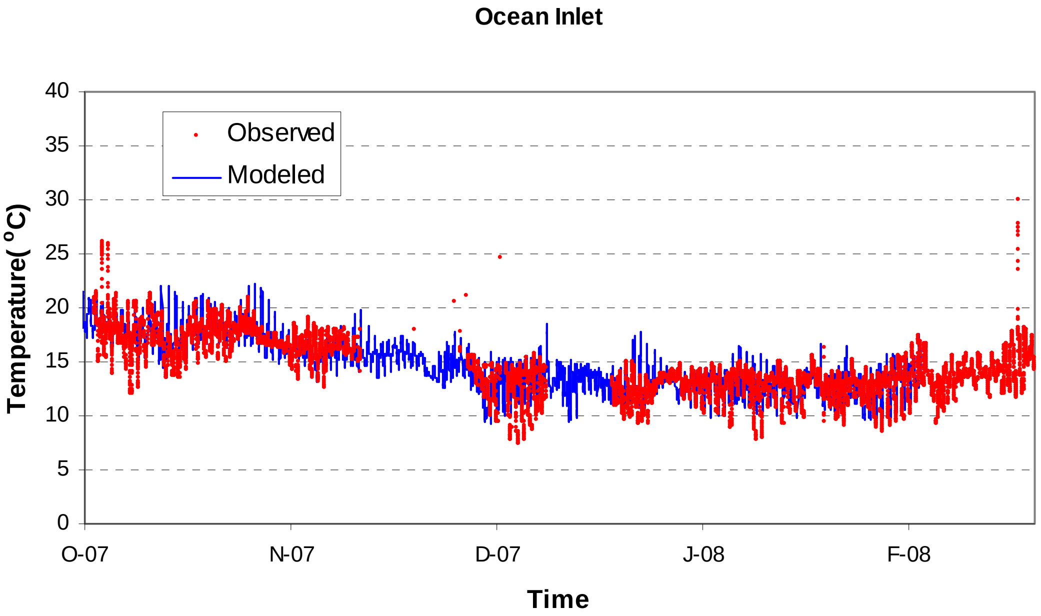


Figure 43. Water surface elevation calibration results



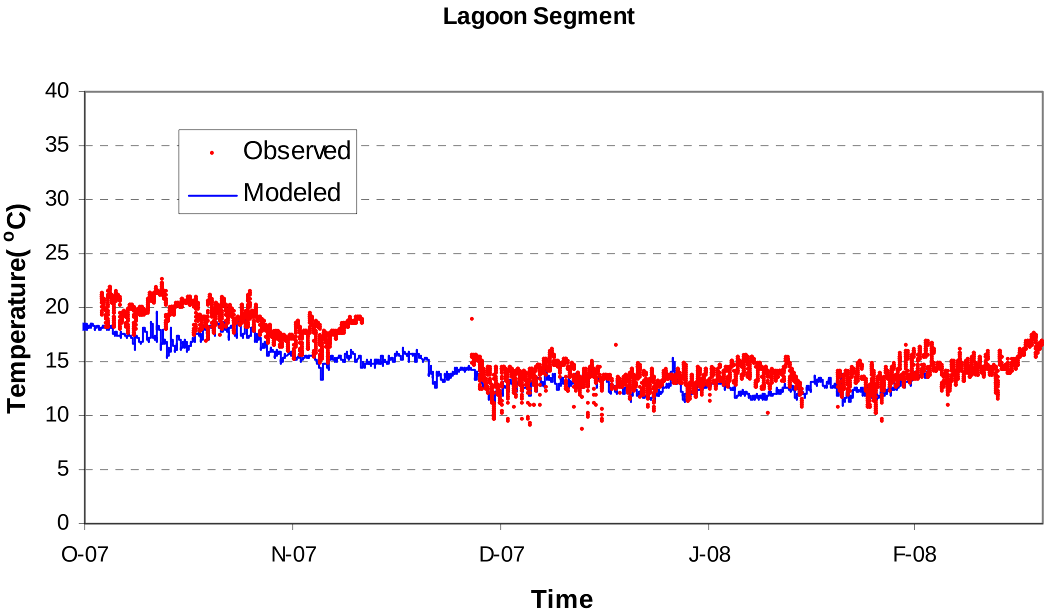
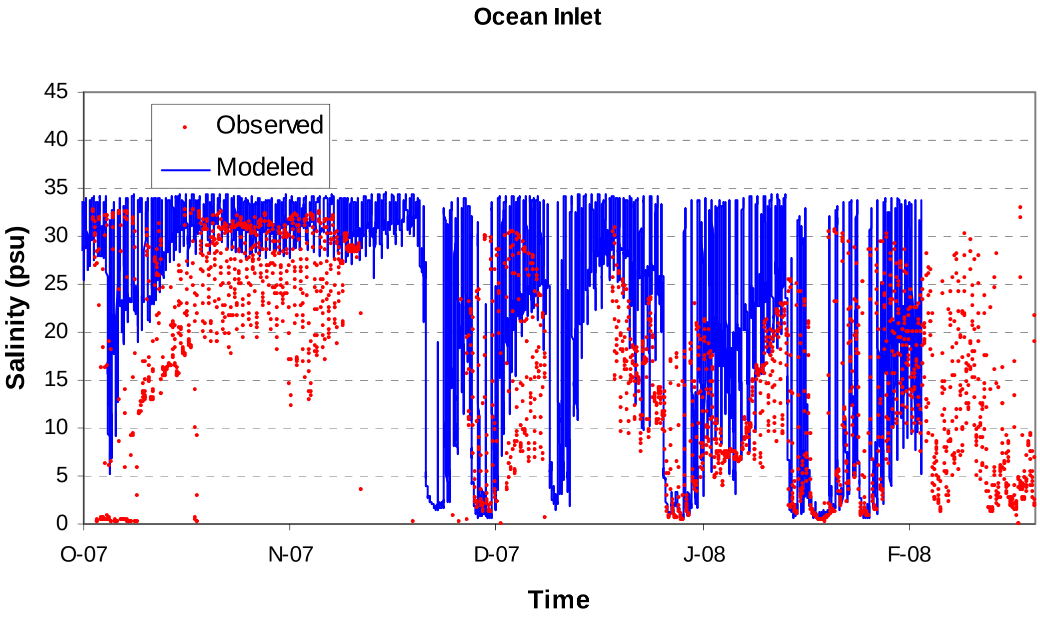
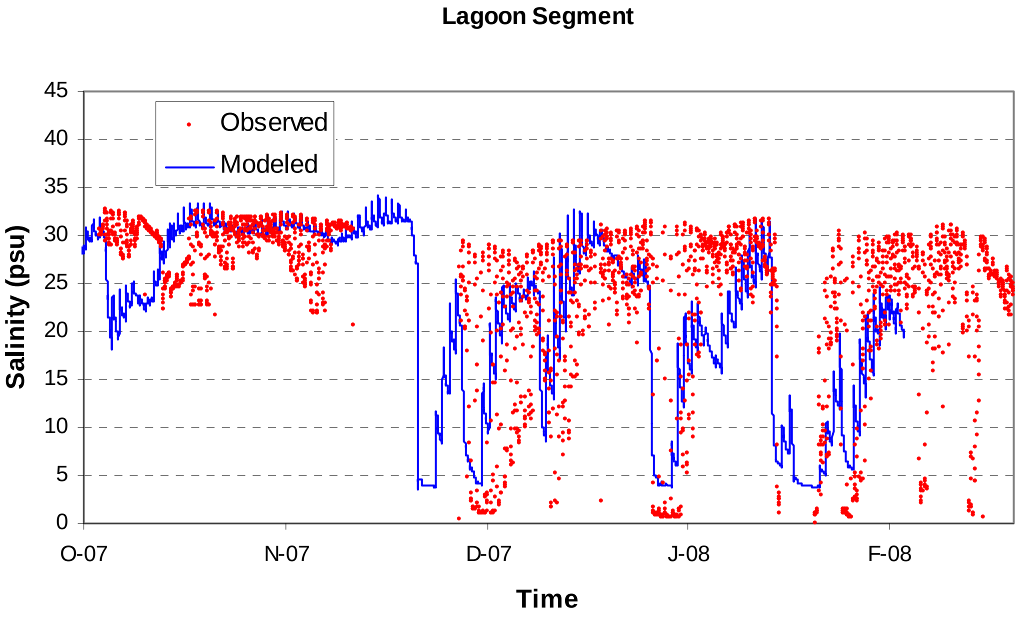


Figure 44. Temperature calibration results

Figure 45 presents the modeled and measured salinity results at the three lagoon monitoring stations. Overall, the model captured the fluctuation of salinity caused by the exchange of the ocean water and freshwater from watershed. Whenever there are storm events, the lagoon salinity decreases significantly. Salinity also changes along with the flood and ebb tides. Modeled salinity at the Ocean Inlet location agrees well with salinity data which were converted from specific conductance in terms of magnitude and fluctuation. The model under-predicted the fluctuation frequency of salinity at the Lagoon Segment location. Because the lagoon is very small compared to the watershed area, freshwater inflow has significant impact on salinity in the lagoon. The uncertainties associated with the estimation of the watershed inflows can be transported to the lagoon. In addition, the lagoon mouth is constantly changing, but the model can only represent a fixed configuration. This approximation also brings in uncertainties in the model to calculate the salt water entering the lagoon. There are also questions related to the accuracy of the monitoring data. For example, salinity levels at the Lagoon Segment location are frequently higher than salinity levels at the Ocean Inlet location. Salinity levels at the Lagoon Segment and Ocean Inlet show a strong fluctuation in a relatively short time period, while salinities observed by the Los Peñasquitos Lagoon Foundation at station W2 show consistent high salinity during dry weather conditions. Therefore, these data can only serve for qualitative evaluation of the model performance.





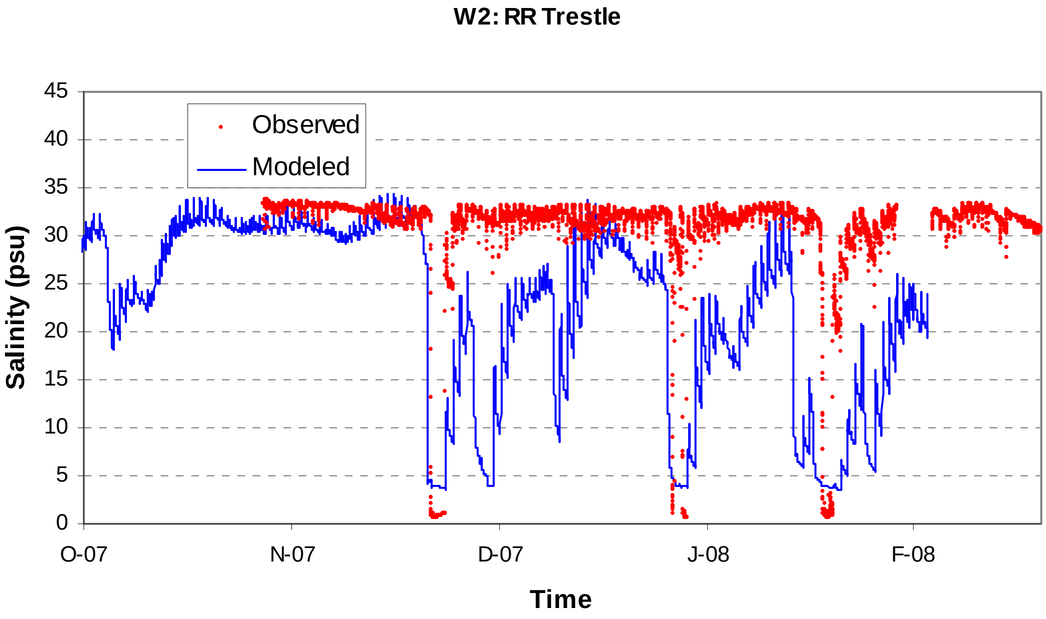


Figure 45. Salinity Calibration results for all stations (including Station W2)

Sediment Calibration

Sediment modeling in the lagoon mainly focused on the deposition and re-suspension of sand, slit, and clay fractions. The bed load transport of sand and silt was not modeled due to the lack of data needed for model representation. Sediment calibration mainly included adjustment of settling velocities for sediment deposition and critical shear stresses for sediment re-suspension. In addition, sand carried into the lagoon from the beach by flood tide represents a major source of sand based on the sediment bottom monitoring results. Monitoring was not conducted to measure the sand carried by the flood tide entering the lagoon; therefore, the concentrations of sediment at the open ocean boundary of the reduced grid were estimated during calibration. Modeled sediment components were compared against observed data during calibration.

TSS calibration plots for the Ocean Inlet and Lagoon Segment monitoring locations are shown in Figures 46 through 71. The entire calibration period is shown (Figures 46 and 59), as well as individual plots for each of the three storm events that occurred during the calibration period (Figures 47 through 49; Figures 60 through 62). In general, the model is able to capture the main pattern of sediment transport in the lagoon, which is related to storm events. The lagoon sediment in the water column increases during storm events due to the high watershed loading of sediment associated with storm events. Because the lagoon is sensitive to the watershed loadings, uncertainties associated with watershed modeling are transported to the lagoon modeling. The timing of modeled peak flow can be shifted several hours (earlier or later) and the peak concentrations of sediment may be different as compared to the observed data. For example, there appears to be a time lag in the TSS calibration results at the Lagoon Segment station (refer to Figure 60). Flow data collected at the MLS station on Los Peñasquitos Creek also indicate possible timing differences with the watershed model results, however, other information including the flow calibration results at the USGS gage upstream, TSS calibration results at each pollutograph station, and TSS calibration results at the Ocean Inlet station all indicate a good correlation with respect to time. Note that TSS grab samples were not collected at the Lagoon Segment station on 11/30/07 due to sampling problems; therefore, TSS samples were first collected on 12/1/07. Other data limitations are discussed below.

The calibration results for the Lagoon Segment station for the two later storm events (12/7/2007 and 2/3/2008) do not match because watershed flow into the lagoon during these storm events is relatively low in comparison to the first storm event (11/30/2007) (refer to Figures 59 through 62). Watershed contributions have a much greater influence on water quality conditions at this station, versus the Ocean Inlet station which showed better agreement in the calibration results. TSS calibration results for the watershed model showed good agreement for Carmel Creek; therefore, it is expected that TSS contributions from the watershed were correct. The lagoon model response for TSS was proportionate to the flow and sediment contributions from the watershed for all three storm events. It is also interesting to note that the TSS measurements from the Lagoon Segment station were similar in magnitude between the first and third storms, although watershed flows into the lagoon were much higher during the first storm. There may also be significant localized processes that affected TSS concentrations. For example, localized scour of bed or bank sediment may occur during storm events with high water velocity. The model represents the averaged condition of the channel and uses average width and depth for each grid cell. The modeled velocity for each grid cell represents average velocity and is, therefore, lower than the actual maximum velocity that can occur. Higher velocities can cause scouring and increase the sediment concentration locally, while the model will not mimic such local phenomenon. Other factors may also cause a discrepancy in the calibration results, including possible data quality issues, sample collection methods, and spatial differences in TSS concentration within lagoon channels (depth, distance from bank, etc.).

A detailed comparison of the three sediment size classes for both stations is also shown (Figures 50 through 58; Figures 63 through 71). Observed sand, silt, and clay fractions were estimated based on the TSS measurements and particle size distribution data that were derived from water column samples collected during the 11/30/07 monitoring event at these two locations. Among the three sediment classes modeled, sand is under-predicted. Sand from the ocean and watershed can settle out quickly due to its high settling velocity. Sand also moves throughout the lagoon primarily through bed load transport processes; therefore, sand concentrations near the bottom can be much higher than concentrations near the water surface. Modeled silt and clay fractions show better agreement with observed data at both stations. Note that the watershed model was calibrated using TSS rather than the individual sediment fractions. Also, particle size distributions for the observed data were based on sample results from one monitored storm event (11/30/2007). TSS data for all three storm events were separated into the three sediment classes based on the results from this single event. In addition, the particle size distribution for suspended sediment is highly time variable because of the different settling velocities for sand, silt, and clay fractions; therefore the size distribution from one storm sample cannot fully represent the size distribution of sediment throughout each storm event. Given the uncertainty of the sediment particle size distributions, model calibration focused on TSS and individual sediment class data only serve as supplemental evaluation of model performance.

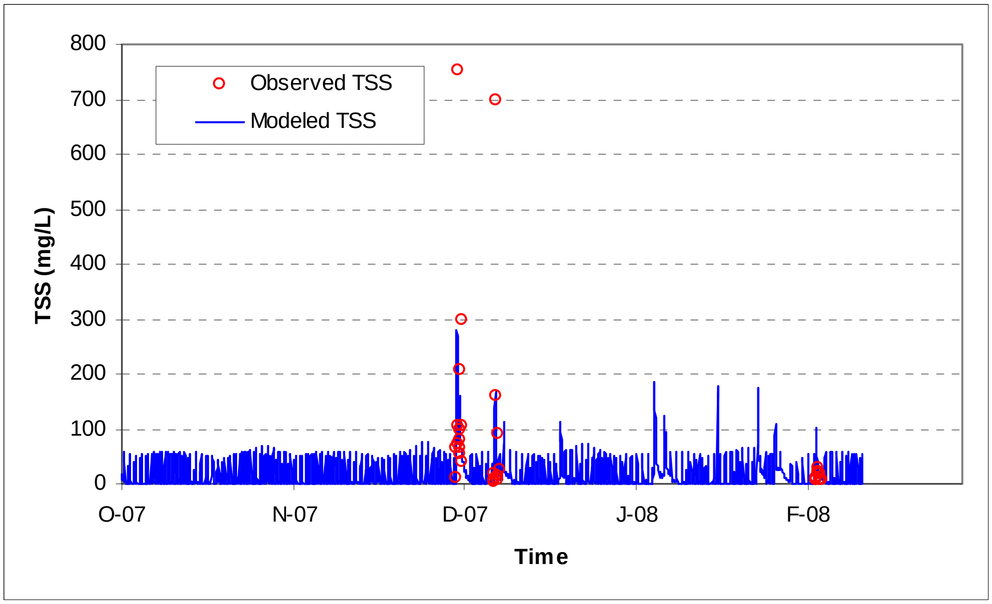


Figure 46. TSS calibration at Ocean Inlet – entire calibration period

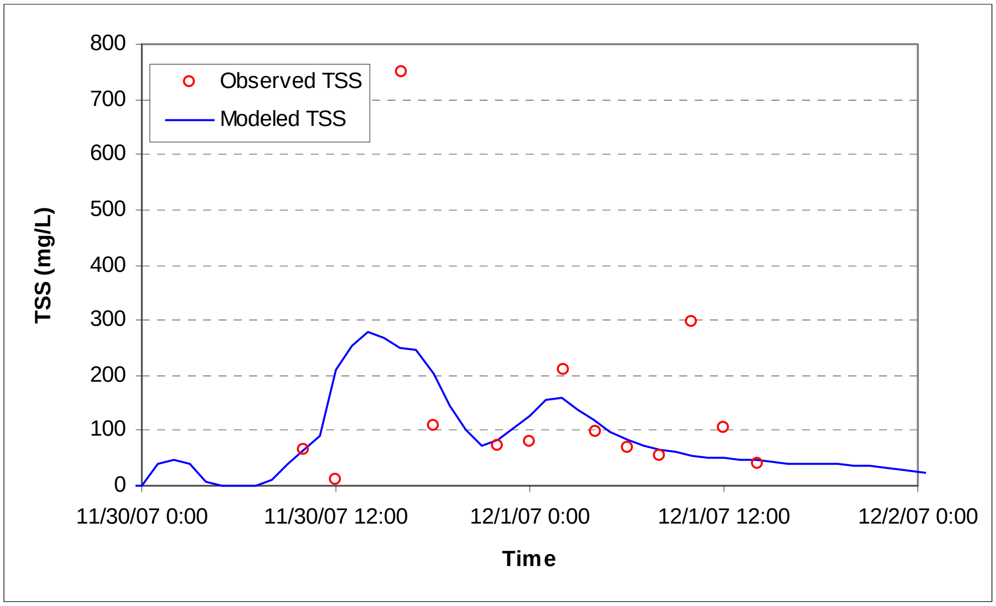


Figure 47. TSS calibration at Ocean Inlet – 11/30/2007 storm

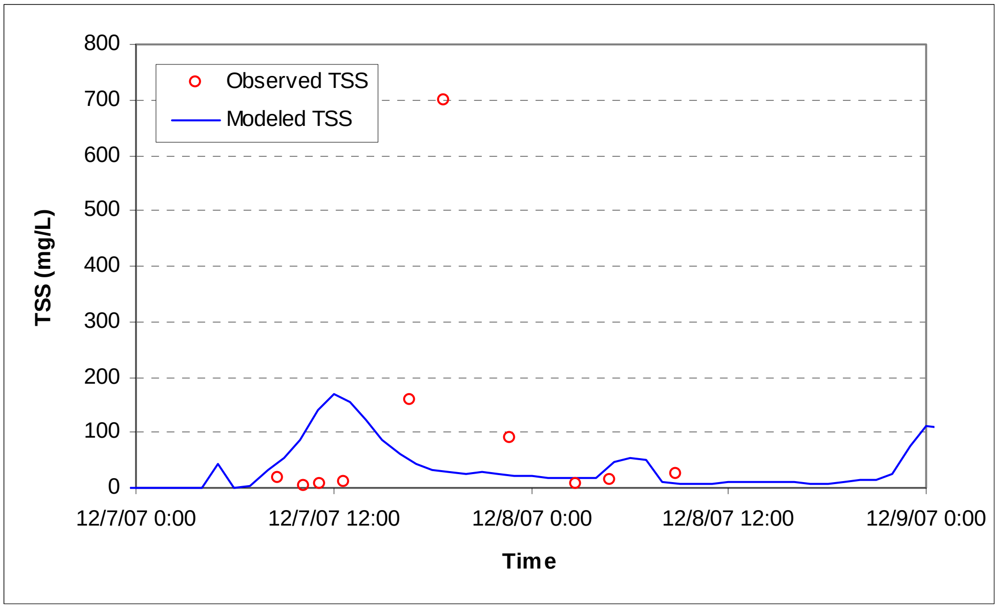


Figure 48. TSS calibration at Ocean Inlet – 12/7/2007 storm

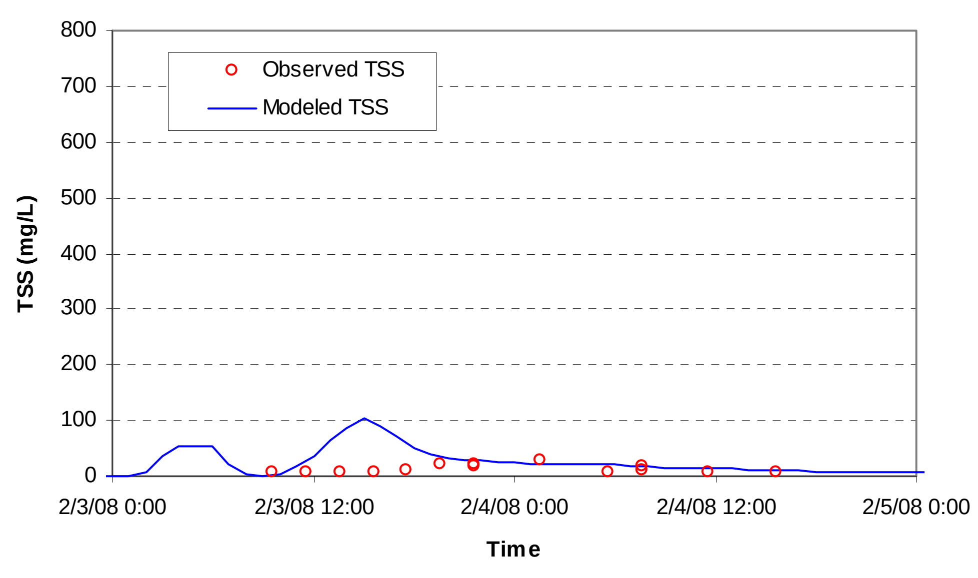


Figure 49. TSS calibration at Ocean Inlet – 2/3/2008 storm

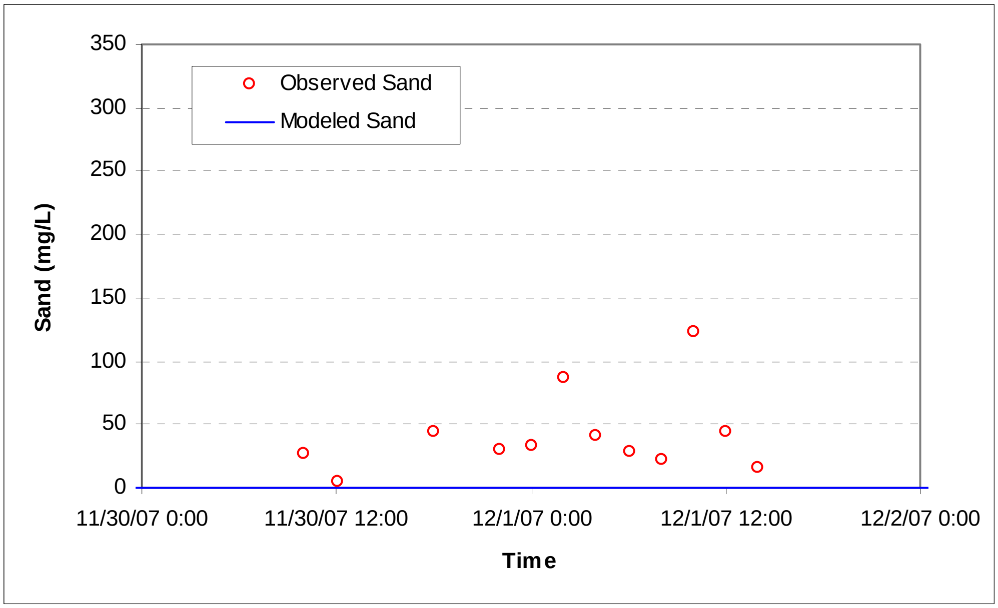


Figure 50. Modeled vs. observed sand fraction at Ocean Inlet – 11/30/2007 storm

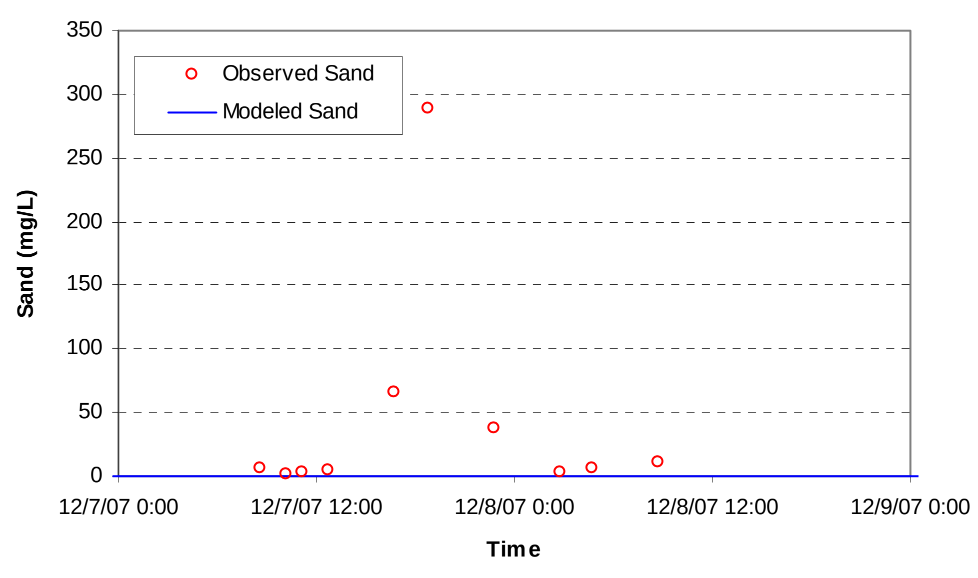


Figure 51. Modeled vs. observed sand fraction at Ocean Inlet – 12/7/2007 storm

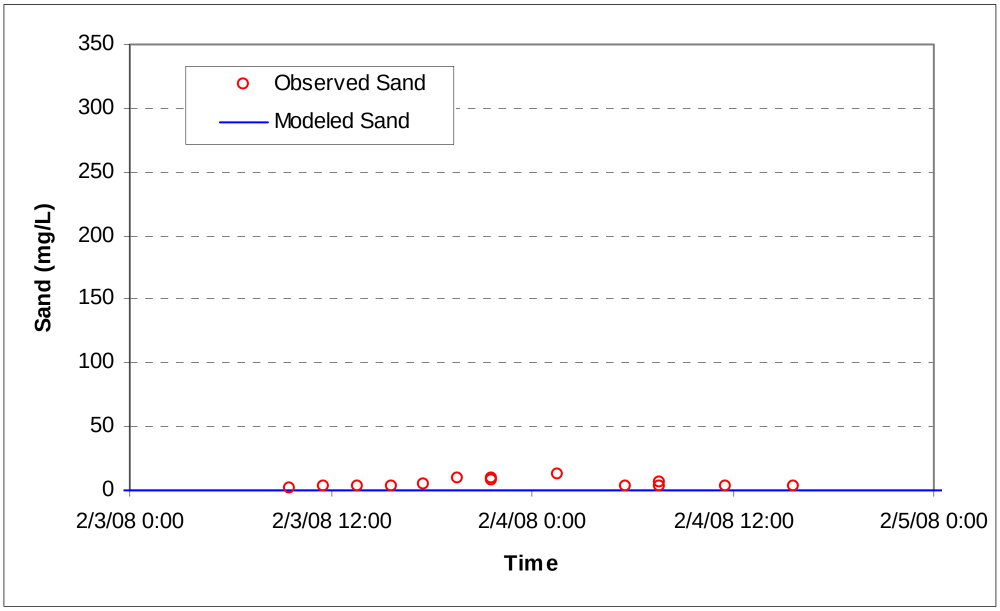


Figure 52. Modeled vs. observed sand fraction at Ocean Inlet – 2/3/2008 storm

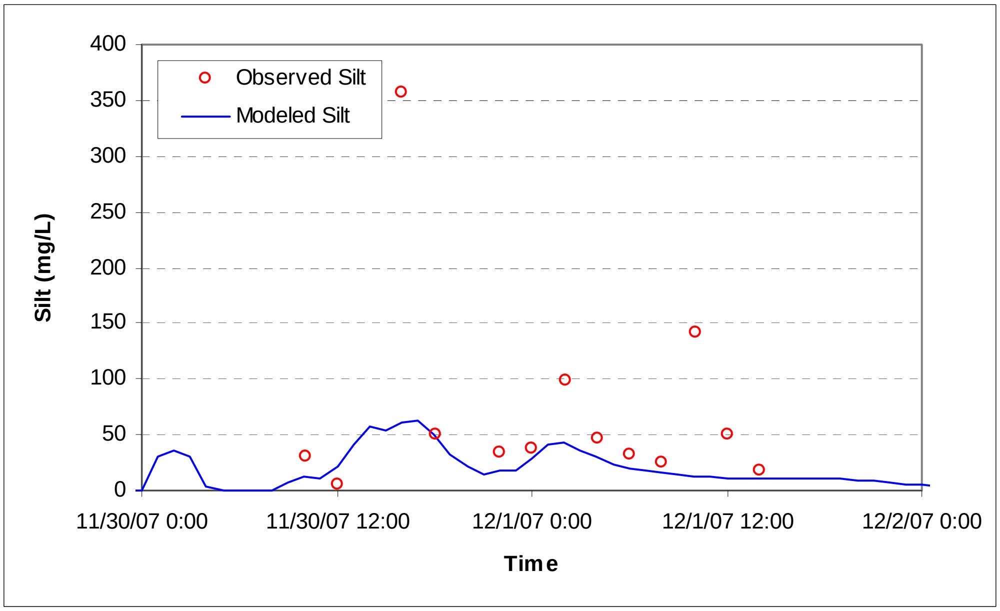


Figure 53. Modeled vs. observed silt fraction at Ocean Inlet – 11/30/2007 storm

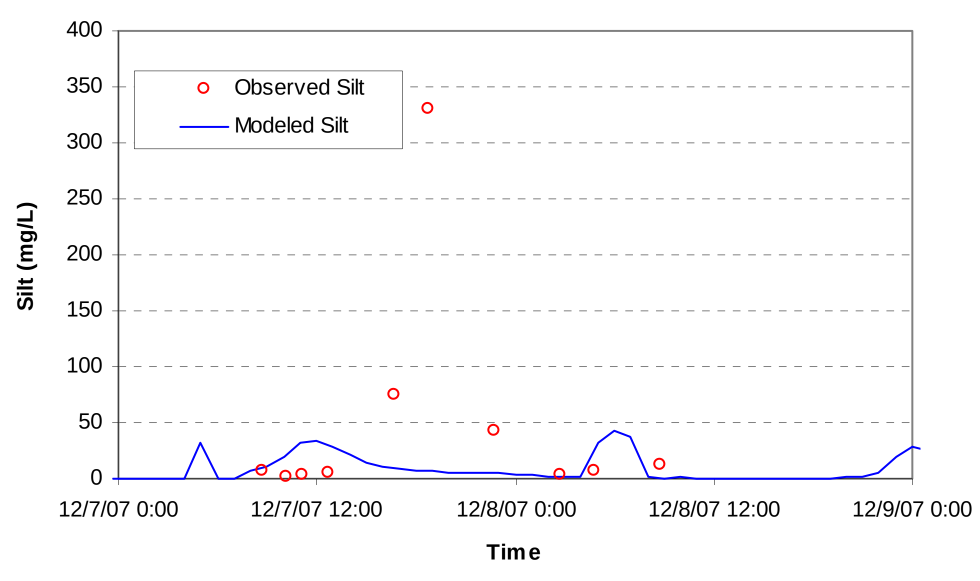


Figure 54. Modeled vs. observed silt fraction at Ocean Inlet – 12/7/2007 storm

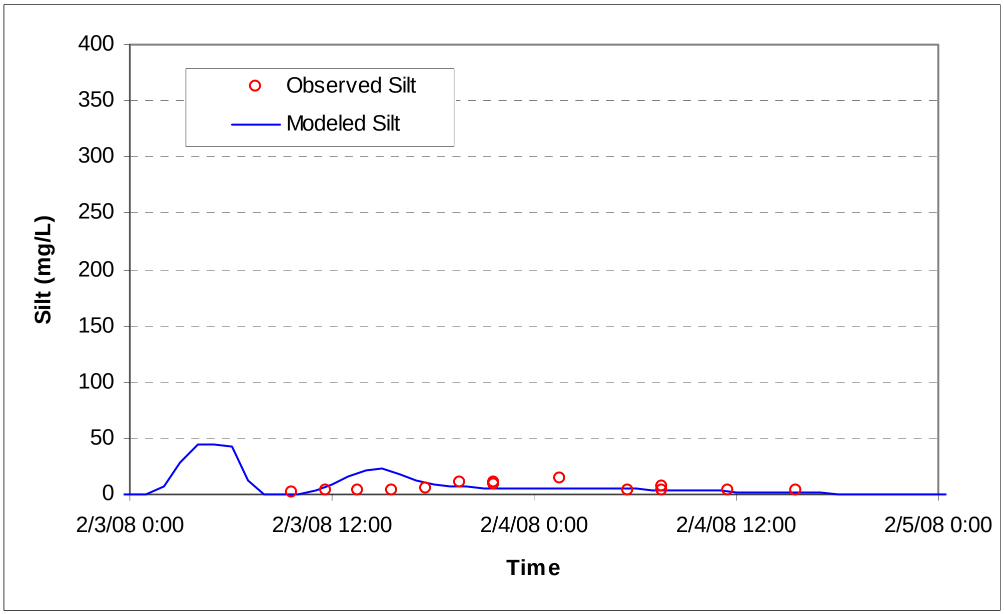


Figure 55. Modeled vs. observed silt fraction at Ocean Inlet – 2/3/2008 storm

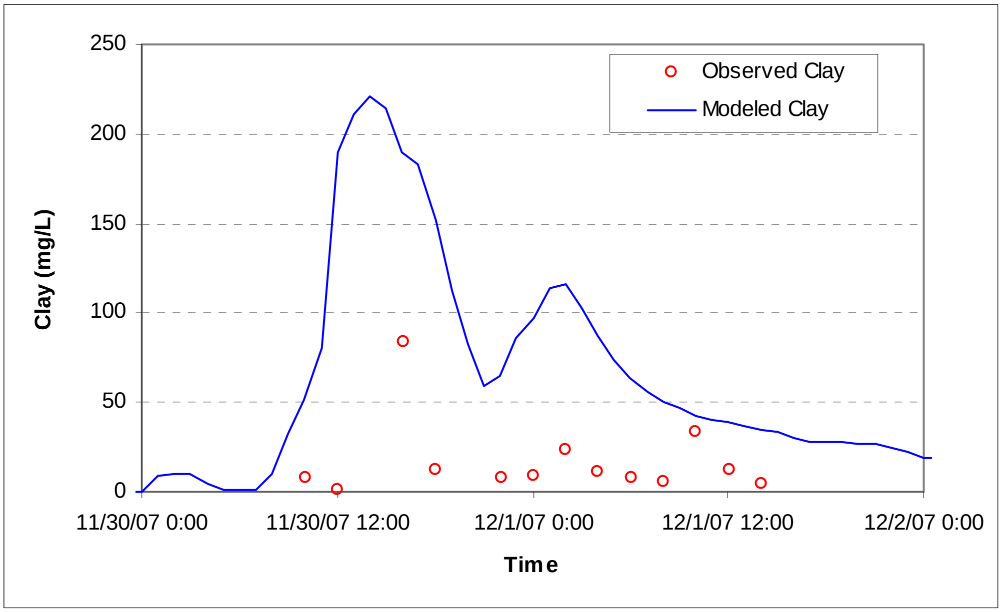


Figure 56. Modeled vs. observed clay fraction at Ocean Inlet – 11/30/2007 storm

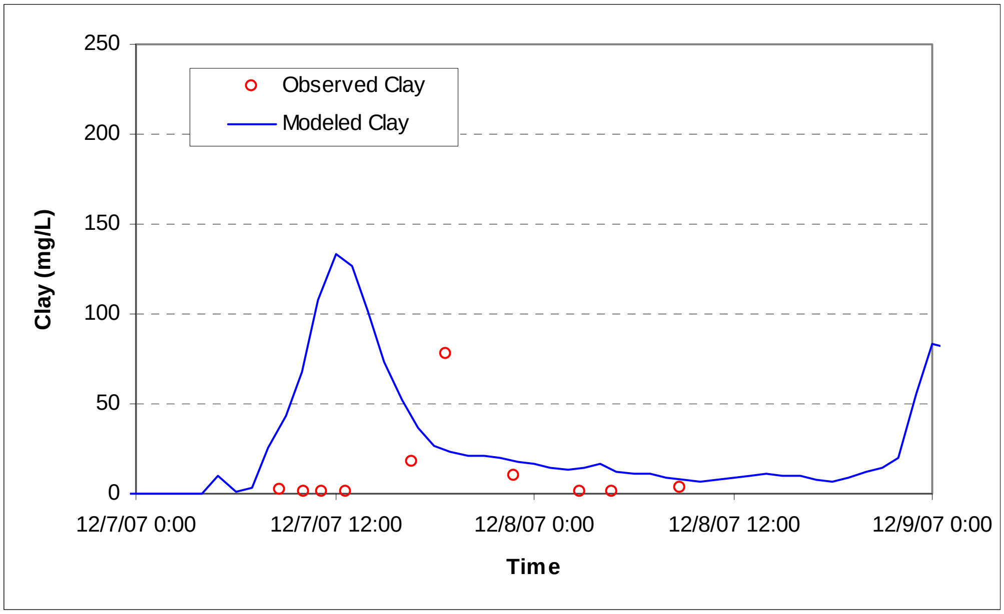


Figure 57. Modeled vs. observed clay fraction at Ocean Inlet – 12/7/2007 storm

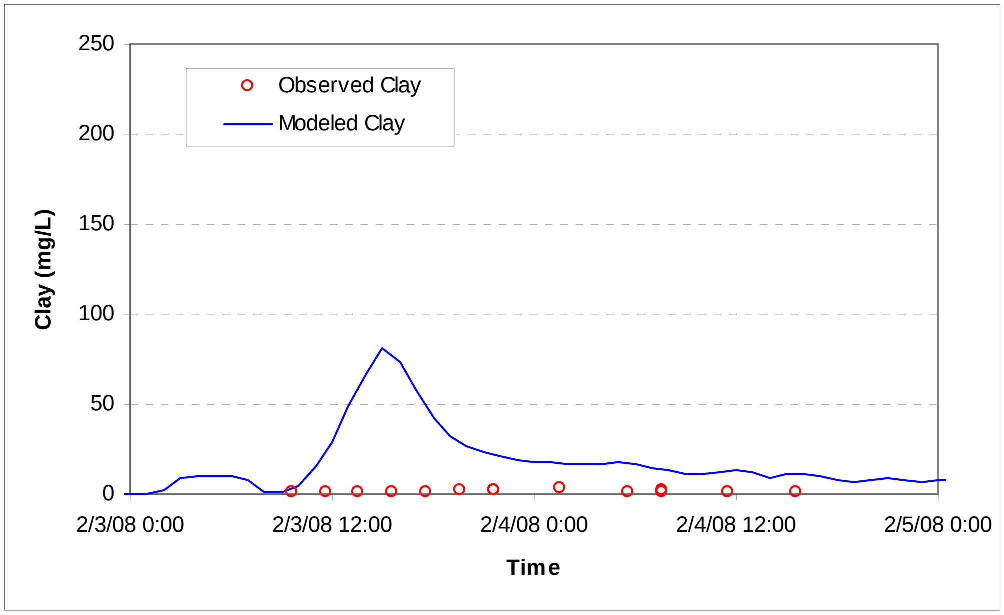


Figure 58. Modeled vs. observed clay fraction at Ocean Inlet – 2/3/2008 storm

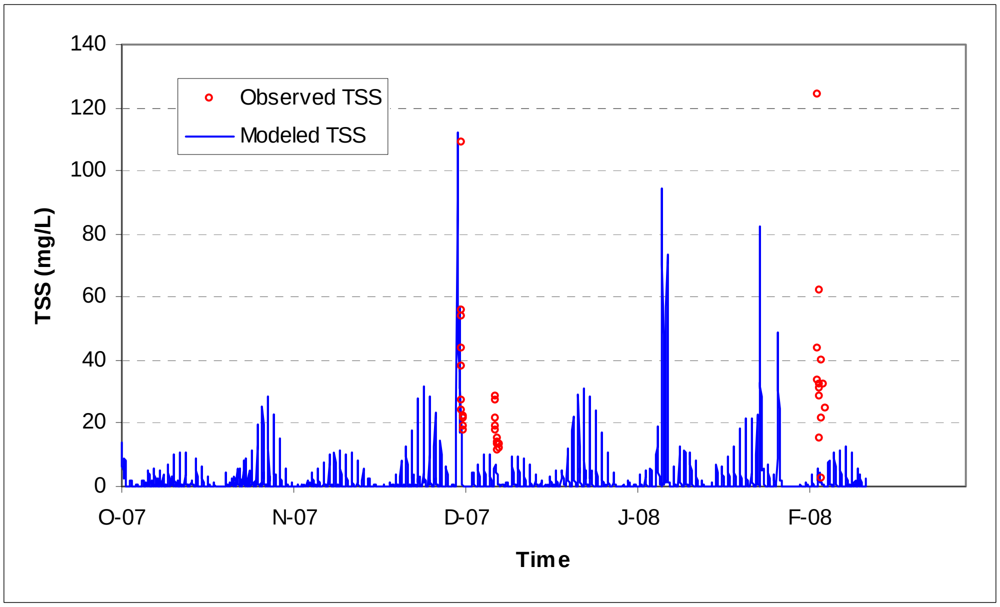


Figure 59. TSS calibration at Lagoon Segment – entire calibration period

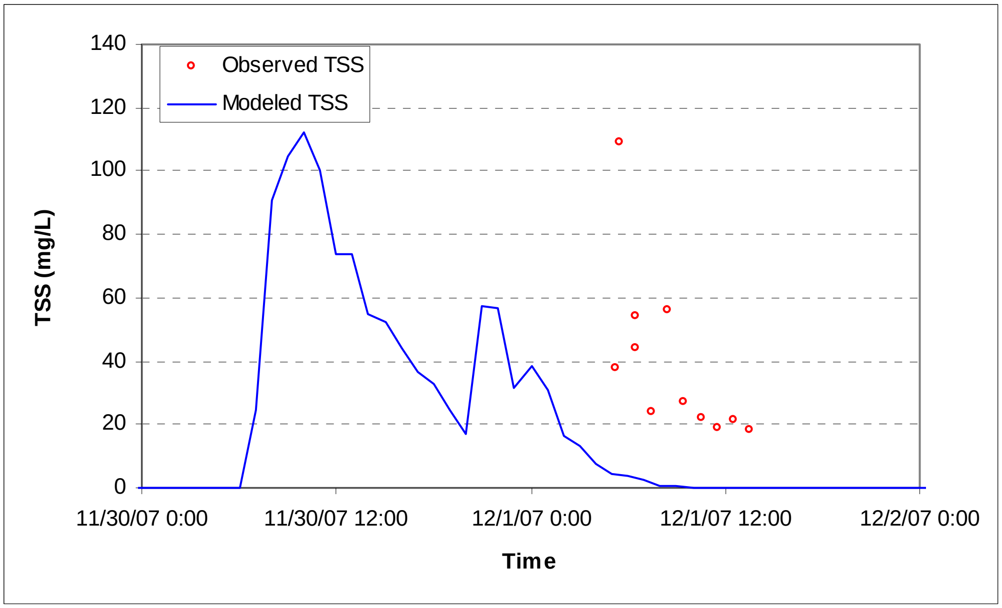


Figure 60. TSS calibration at Lagoon Segment – 11/30/2007 storm

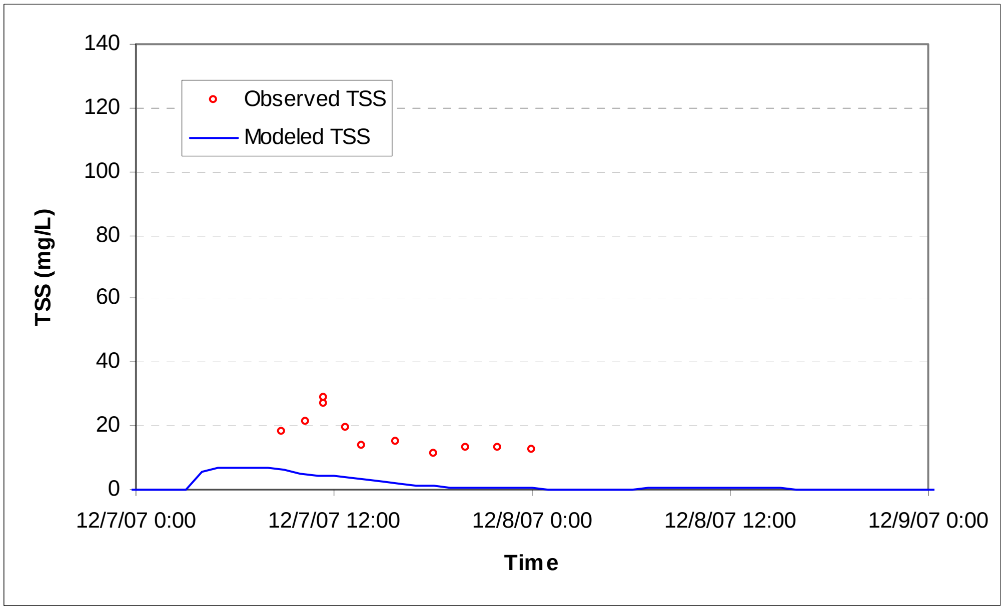


Figure 61. TSS calibration at Lagoon Segment – 12/7/2007 storm

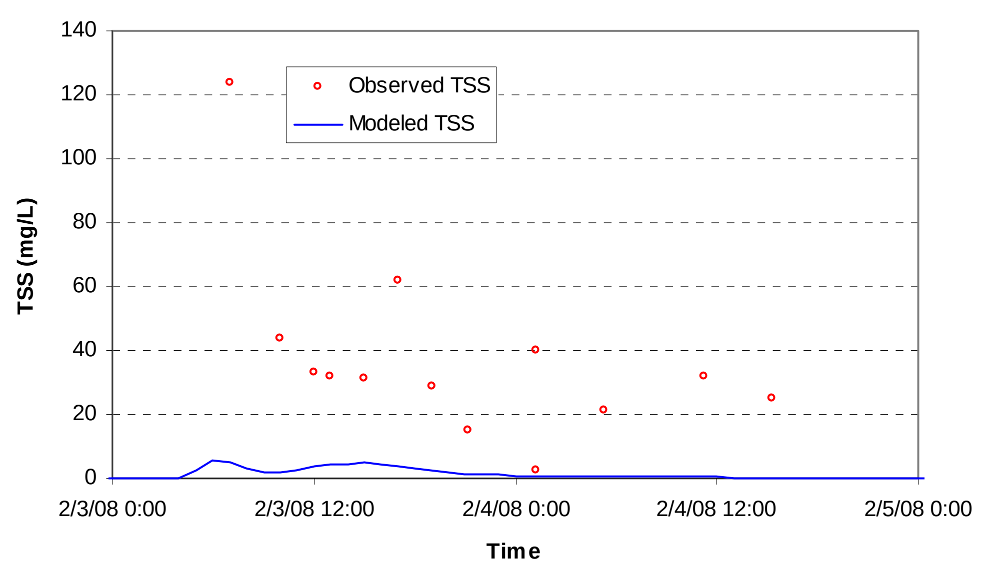


Figure 62. TSS calibration at Lagoon Segment – 2/3/2008 storm

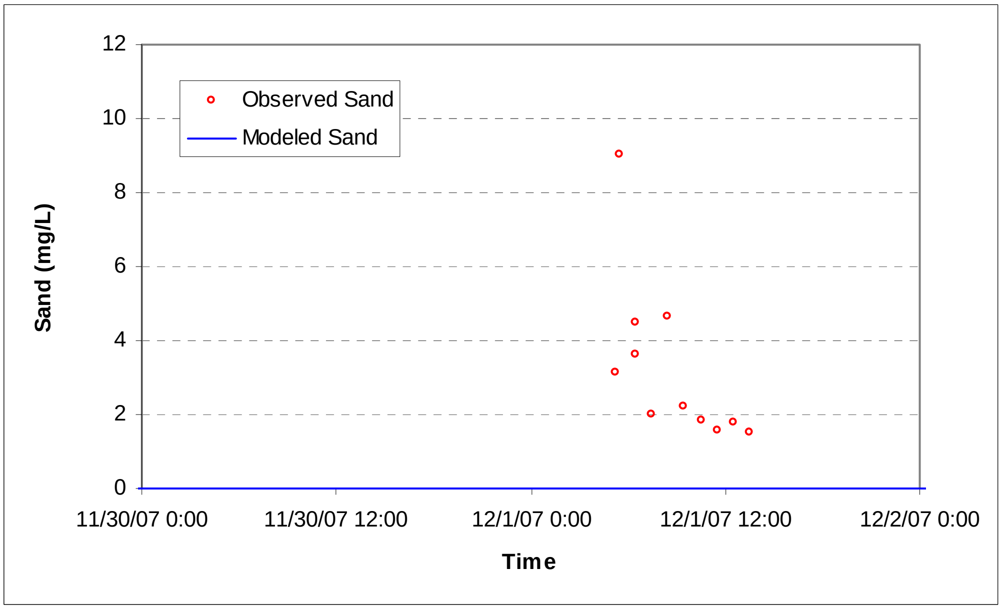


Figure 63. Modeled vs. observed sand fraction at Lagoon Segment – 11/30/2007 storm

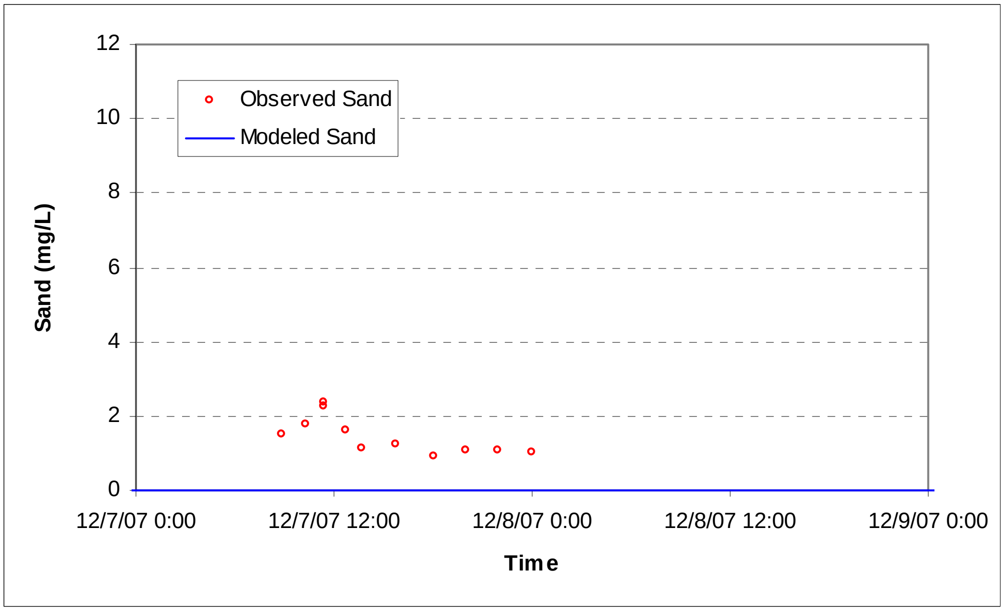


Figure 64. Modeled vs. observed sand fraction at Lagoon Segment – 12/7/2007 storm

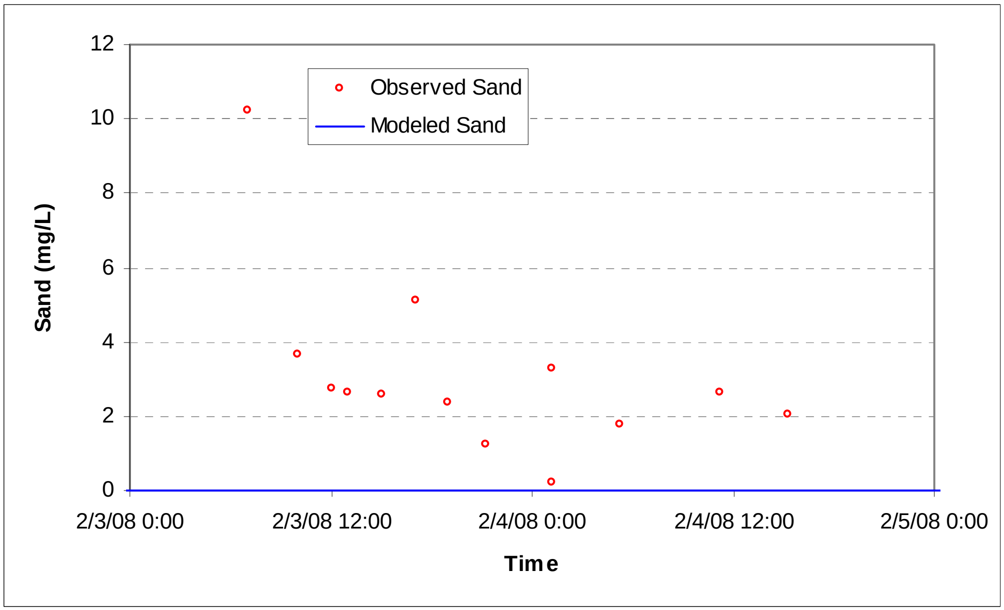


Figure 65. Modeled vs. observed sand fraction at Lagoon Segment – 2/3/2008 storm

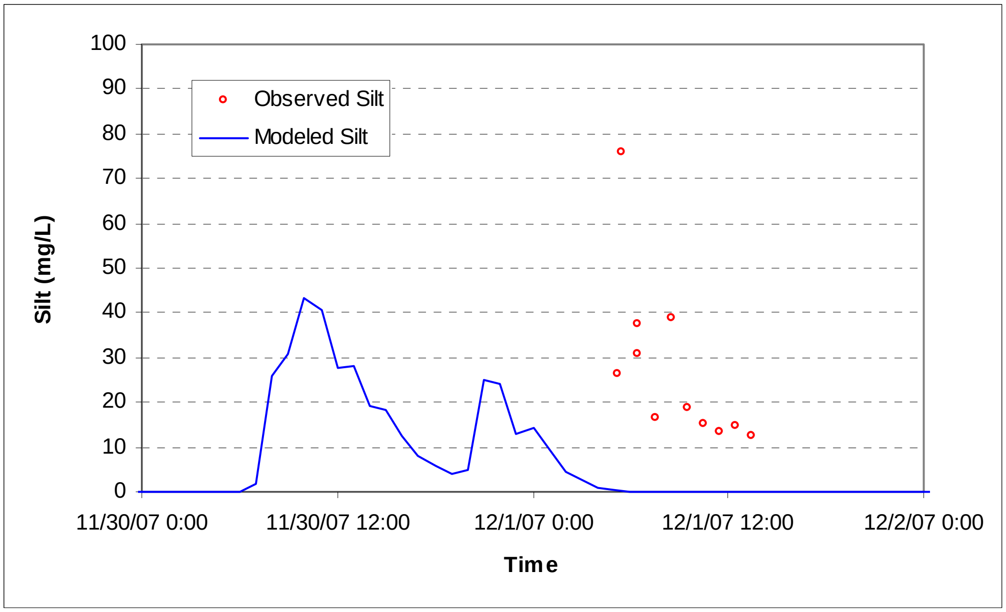


Figure 66. Modeled vs. observed silt fraction at Lagoon Segment – 11/30/2007 storm

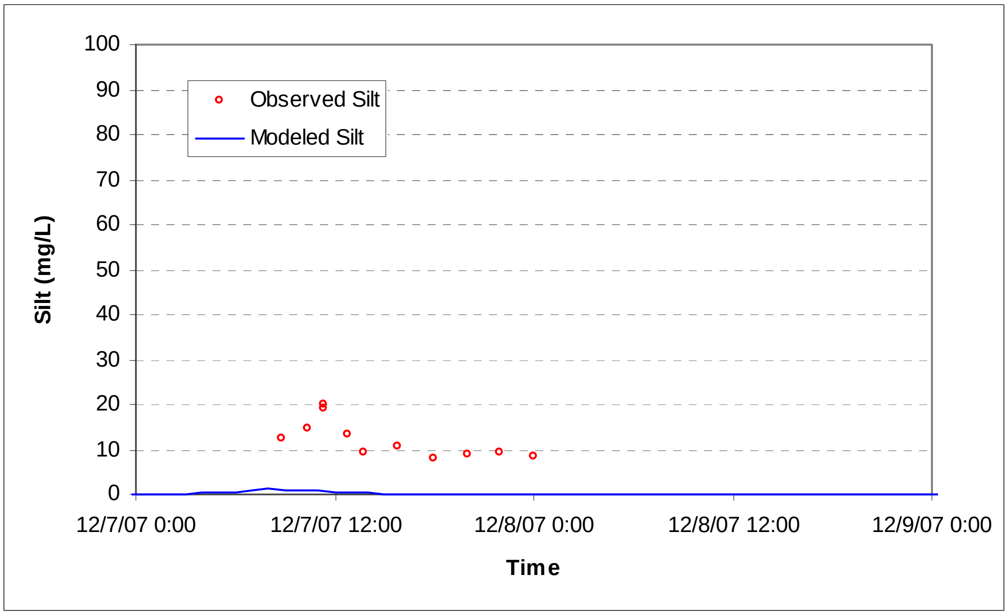


Figure 67. Modeled vs. observed silt fraction at Lagoon Segment – 12/7/2007 storm

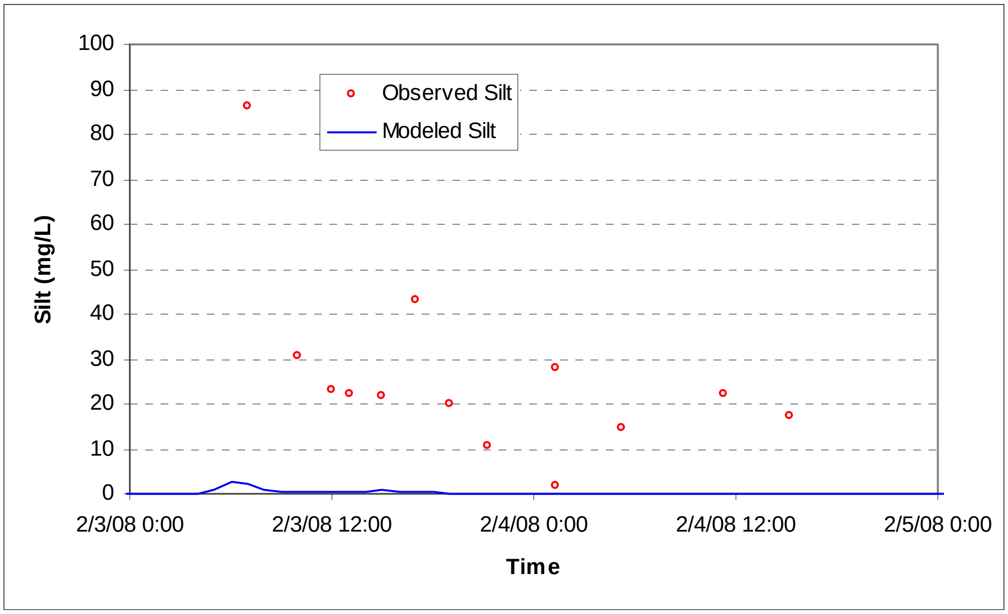


Figure 68. Modeled vs. observed silt fraction at Lagoon Segment – 2/3/2008 storm

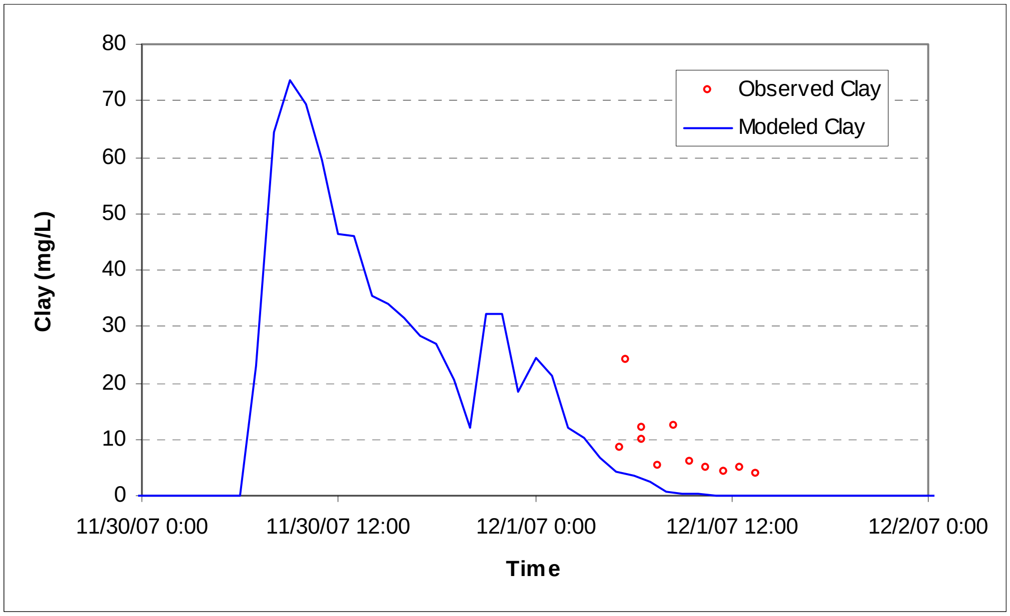


Figure 69. Modeled vs. observed clay fraction at Lagoon Segment – 11/30/2007 storm

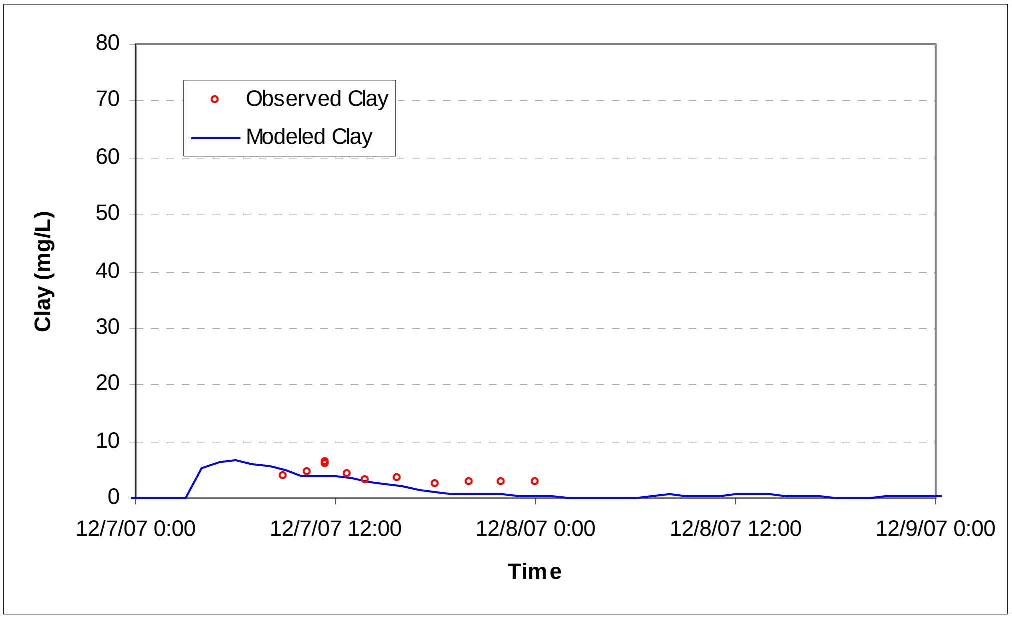


Figure 70. Modeled vs. observed clay fraction at Lagoon Segment – 12/7/2007 storm

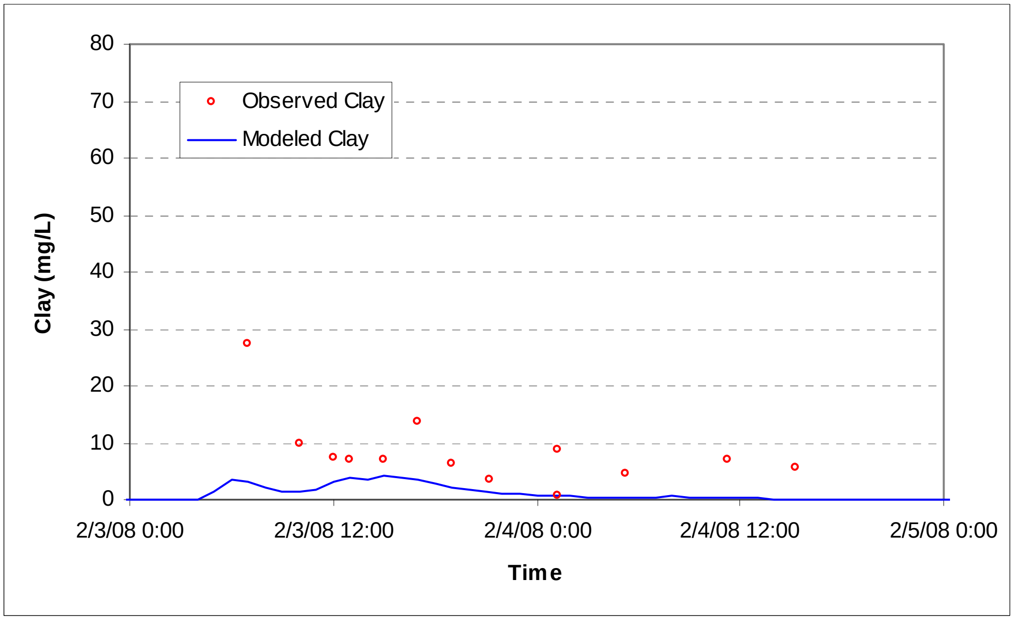


Figure 71. Modeled vs. observed clay fraction at Lagoon Segment – 2/3/2008 storm

Summary and Conclusions

A dynamic model was developed for the Los Peñasquitos Lagoon for simulating the transport of sediment through the lagoon using the EFDC framework. The model considered the ocean and watershed contributions of sediment. Model development involved two steps. In the first step, the model grid was extended into the ocean to use the tide elevation, salinity, and water temperature in the open ocean to drive the simulation of hydrodynamic conditions. After hydrodynamic calibration, the model was run using a reduced grid that incorporated the modeled water surface elevation, salinity, and water temperature at the immediate outside of the ocean inlet as the driving boundary conditions because the open ocean sediment conditions are significantly different from those at the ocean inlet. The sediment model was then calibrated using the reduced grid.

The Los Peñasquitos modeling framework can be used to simulate various management scenarios and for TMDL development purposes. In order to examine management scenarios related to controlling ocean and/or watershed inputs of sediment, model boundary conditions, the watershed model configuration, and the lagoon model grid can all be modified accordingly. For example, if the ocean inlet is widened, the model grid size can be increased at the ocean inlet. The application of BMPs within the watershed to control sediment input to the lagoon can also be examined through modifications to the sediment time series from the watershed, based on estimated BMP efficiencies, which can then be used to examine future changes in lagoon conditions. For management scenarios that involve dredging and other lagoon modifications, initial sediment bed conditions, such as the particle size distributions, can be updated accordingly.

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Appendix A: Model Hydrology Parameters

Table A-1. 110 pwat-parm2

defid	deluid	lzsn	infilt	kvary	agwrc
2	1	3.4	0.01	0.2	0.99
2	2	3.4	0.01	0.2	0.99
2	3	3.4	0.01	0.2	0.99
2	4	3.4	0.01	0.2	0.99
2	5	8	0.33	0.2	0.99
2	6	4	0.01	0.2	0.99
2	7	4.5	0.3	0.2	0.99
2	8	6.2	0.35	0.2	0.99
2	9	6.2	0.35	0.2	0.99
2	10	6.2	0.35	0.2	0.99
2	11	6.3	0.4	0.2	0.99
2	13	4.5	0.4	0.2	0.99
2	14	4	0.01	0.2	0.99
2	15	4	0.01	0.2	0.99
2	16	4	0.01	0.2	0.99
2	17	4	0.01	0.2	0.99
2	18	4	0.01	0.2	0.99
2	19	4	0.01	0.2	0.99
2	1	3.5	0.01	0.2	0.99
2	2	3.5	0.01	0.2	0.99
2	3	3.5	0.01	0.2	0.99
2	4	3.5	0.01	0.2	0.99
2	5	6.4	0.31	0.2	0.99
2	6	5	0.01	0.2	0.99
2	7	5.3	0.25	0.2	0.99
2	8	6.4	0.3	0.2	0.99
2	9	6.4	0.3	0.2	0.99
2	10	6.4	0.3	0.2	0.99
2	11	5	0.2	0.2	0.99
2	13	4.7	0.05	0.2	0.99
2	14	3.7	0.01	0.2	0.99
2	15	3.7	0.01	0.2	0.99
2	16	3.7	0.01	0.2	0.99
2	17	3.7	0.01	0.2	0.99
2	18	3.7	0.01	0.2	0.99
2	19	3.7	0.01	0.2	0.99
2	1	3.6	0.01	0.2	0.99
2	2	3.6	0.01	0.2	0.99
2	3	3.6	0.01	0.2	0.99
2	4	3.6	0.01	0.2	0.99
2	5	8	0.3	0.2	0.99
2	6	5.3	0.01	0.2	0.99
2	7	5.5	0.23	0.2	0.99
2	8	6.5	0.23	0.2	0.99
2	9	6.5	0.23	0.2	0.99
2	10	6.5	0.23	0.2	0.99
2	11	5	0.1	0.2	0.99
2	13	4.7	0.05	0.2	0.99
2	14	3.8	0.01	0.2	0.99
2	15	3.8	0.01	0.2	0.99
2	16	3.8	0.01	0.2	0.99
2	17	3.8	0.01	0.2	0.99
2	18	3.8	0.01	0.2	0.99
2	19	3.8	0.01	0.2	0.99
2	1	3.4	0.01	0.2	0.99
2	2	3.4	0.01	0.2	0.99
2	3	3.4	0.01	0.2	0.99
2	4	3.4	0.01	0.2	0.99
2	5	8	0.33	0.2	0.99
2	6	4	0.01	0.2	0.99
2	7	4.5	0.3	0.2	0.99
2	8	6.2	0.35	0.2	0.99
2	9	6.2	0.35	0.2	0.99
2	10	6.2	0.35	0.2	0.99
2	11	6.3	0.4	0.2	0.99
2	13	4.5	0.4	0.2	0.99
2	14	4	0.01	0.2	0.99
2	15	4	0.01	0.2	0.99
2	16	4	0.01	0.2	0.99
2	17	4	0.01	0.2	0.99
2	18	4	0.01	0.2	0.99
2	19	4	0.01	0.2	0.99

defid	parameter group id
deluid	land use id
lzsn	lower zone nominal soil moisture storage (inches)
infilt	index to the infiltration capacity of the soil (in/hr)
kvary	variable groundwater recession (1/inches)
agwrc	base groundwater recession (none)

Table A-2. 120 pwat-parm3

defid	deluid	petmax	petmin	infexp	infild	deepfr	basetp	agwetp
2	1	40	35	2	2	0.1	0	0.01
2	2	40	35	2	2	0.1	0	0.01
2	3	40	35	2	2	0.1	0	0.01
2	4	40	35	2	2	0.1	0	0.01
2	5	40	35	2	2	0.1	0.03	0.05
2	6	40	35	2	2	0.1	0	0.01
2	7	40	35	2	2	0.1	0	0.01
2	8	40	35	2	2	0.1	0	0.01
2	9	40	35	2	2	0.1	0	0.05
2	10	40	35	2	2	0.1	0	0.05
2	11	40	35	2	2	0.1	0.03	0.03
2	13	40	35	2	2	0.1	0	0.03
2	14	40	35	2	2	0.1	0	0
2	15	40	35	2	2	0.1	0	0
2	16	40	35	2	2	0.1	0	0
2	17	40	35	2	2	0.1	0	0
2	18	40	35	2	2	0.1	0	0
2	19	40	35	2	2	0.1	0	0
3	1	40	35	2	2	0.1	0	0.01
3	2	40	35	2	2	0.1	0	0.01
3	3	35	30	2	2	0.1	0	0.01
3	4	35	30	2	2	0.1	0	0.01
3	5	40	35	2	2	0.1	0.03	0.05
3	6	40	35	2	2	0.1	0	0.01
3	7	40	35	2	2	0.1	0	0.01
3	8	40	35	2	2	0.1	0	0.01
3	9	40	35	2	2	0.1	0	0.05
3	10	40	35	2	2	0.1	0	0.05
3	11	40	35	2	2	0.1	0.02	0.03
3	13	40	35	2	2	0.1	0	0.03
3	14	35	30	2	2	0.1	0	0
3	15	40	35	2	2	0.1	0	0
3	16	40	35	2	2	0.1	0	0
3	17	35	30	2	2	0.1	0	0
3	18	40	35	2	2	0.1	0	0
3	19	40	35	2	2	0.1	0	0
4	1	40	35	2	2	0.1	0	0.01
4	2	40	35	2	2	0.1	0	0.01
4	3	40	35	2	2	0.1	0	0.01
4	4	40	35	2	2	0.1	0	0.01
4	5	40	35	2	2	0.1	0.03	0.05
4	6	40	35	2	2	0.1	0	0.01
4	7	40	35	2	2	0.1	0	0.01
4	8	40	35	2	2	0.1	0	0.01
4	9	40	35	2	2	0.1	0	0.05
4	10	40	35	2	2	0.1	0	0.05
4	11	40	35	2	2	0.1	0.02	0.03
4	13	40	35	2	2	0.1	0	0.03

defid	deluid	petmax	petmin	infexp	infild	deepfr	basetp	agwetp
4	14	40	35	2	2	0.1	0	0
4	15	40	35	2	2	0.1	0	0
4	16	40	35	2	2	0.1	0	0
4	17	40	35	2	2	0.1	0	0
4	18	40	35	2	2	0.1	0	0
4	19	40	35	2	2	0.1	0	0

defid	parameter group id
deluid	land use id
petmax	air temperature below which e-t will is reduced (deg F)
petmin	air temperature below which e-t is set to zero (deg F)
infexp	exponent in the infiltration equation (none)
infild	ratio between the maximum and mean infiltration capacities over the PLS (none)
deepfr	fraction of groundwater inflow that will enter deep groundwater (none)
basetp	fraction of remaining potential e-t that can be satisfied from baseflow (none)
agwetp	fraction of remaining potential e-t that can be satisfied from active groundwater (none)

Table A-3. 130 pwat-parm4

defid	deluid	cepsc	uzsn	nsur	intfw	irc	lzetp
2	1	0.08	0.204	0.2	1	0.5	0.3
2	2	0.08	0.204	0.2	1	0.5	0.3
2	3	0.08	0.204	0.2	1	0.5	0.3
2	4	0.08	0.204	0.2	1	0.5	0.2
2	5	0.27	0.48	0.3	1	0.5	0.5
2	6	0.15	0.24	0.2	1	0.5	0.3
2	7	0.15	0.27	0.3	1	0.5	0.4
2	8	0.15	0.372	0.3	1	0.5	0.7
2	9	0.3	0.372	0.3	1	0.5	0.6
2	10	0.3	0.372	0.3	1	0.5	0.6
2	11	0.15	0.378	0.3	1	0.5	0.55
2	13	0.15	0.27	0.3	1	0.5	0.4
2	14	0.05	0.24	0.08	1	0.5	0.3
2	15	0.05	0.24	0.08	1	0.5	0.3
2	16	0.05	0.24	0.08	1	0.5	0.3
2	17	0.05	0.24	0.08	1	0.5	0.3
2	18	0.05	0.24	0.08	1	0.5	0.3
2	19	0.1	0.24	0.08	1	0.5	0.3
3	1	0.08	0.21	0.2	1	0.5	0.2
3	2	0.08	0.21	0.2	1	0.5	0.15
3	3	0.08	0.21	0.2	1	0.5	0.15
3	4	0.08	0.21	0.2	1	0.5	0.15
3	5	0.27	0.384	0.3	1	0.5	0.5
3	6	0.15	0.3	0.2	1	0.5	0.3
3	7	0.15	0.318	0.3	1	0.5	0.4
3	8	0.15	0.384	0.3	1	0.5	0.7
3	9	0.3	0.384	0.3	1	0.5	0.6
3	10	0.3	0.384	0.3	1	0.5	0.6
3	11	0.15	0.3	0.3	1	0.5	0.5
3	13	0.15	0.282	0.1	1	0.5	0.2
3	14	0.05	0.222	0.08	1	0.5	0.3
3	15	0.05	0.222	0.08	1	0.5	0.3
3	16	0.05	0.222	0.08	1	0.5	0.2
3	17	0.05	0.222	0.08	1	0.5	0.2
3	18	0.05	0.222	0.08	1	0.5	0.3
3	19	0.1	0.222	0.08	1	0.5	0.3
4	1	0.08	0.216	0.2	1	0.5	0.2
4	2	0.08	0.216	0.2	1	0.5	0.15
4	3	0.08	0.216	0.2	1	0.5	0.15
4	4	0.08	0.216	0.2	1	0.5	0.15
4	5	0.27	0.48	0.3	1	0.5	0.65
4	6	0.15	0.318	0.2	1	0.5	0.3
4	7	0.15	0.33	0.3	1	0.5	0.4
4	8	0.15	0.39	0.3	1	0.5	0.7
4	9	0.3	0.39	0.3	1	0.5	0.6
4	10	0.3	0.39	0.3	1	0.5	0.6
4	11	0.15	0.3	0.3	1	0.5	0.5
4	13	0.15	0.282	0.1	1	0.5	0.2

defid	deluid	cepsc	uzsn	nsur	intfw	irc	lzetp
4	14	0.05	0.228	0.08	1	0.5	0.3
4	15	0.05	0.228	0.08	1	0.5	0.3
4	16	0.05	0.228	0.08	1	0.5	0.2
4	17	0.05	0.228	0.08	1	0.5	0.2
4	18	0.05	0.228	0.08	1	0.5	0.3
4	19	0.1	0.228	0.08	1	0.5	0.3

defid	parameter group id
deluid	land use id
cepsc	interception storage capacity (inches)
uzsn	upper zone nominal storage (inches)
nsur	Manning's n for the assumed overland flow plane (none)
intfw	interflow inflow parameter (none)
irc	interflow recession parameter (none)
lzetp	lower zone evapotranspiration parameter (none)

Appendix B: Model Sediment Parameters

Based on the SCWRRP regional sediment approach, the following parameters for the sediment module were used as initial values. Some adjustment was necessary based on local conditions and observed data.

Pervious Lands (PERLNDs)

SMPF	1.0
KRER	The presented model varies this parameter by soil group and land use (area-weighted average) as follows:

SSUGRO soil data for San Diego County was utilized to calculate weighted KRER values for each land use and soil hydrologic group (HSG) within the Los Peñasquitos watershed. A weighted average of soil slope (*S*) and soil erodibility factors (*K*) were calculated for each soil map unit in ArcGIS using Soil Data Viewer. The land use classification layer (which contained HSG values for each parcel) was subsequently intersected with both the aggregated slope and K factor layers. In a spreadsheet program, slope and K factor values were subtotaled and area weighted for each land use classification and soil hydrologic group across the watershed. In order to calculate *KRER* values, length-slope (*LS*) factors were first calculated according to the Wischmeier and Smith (1978) equation:

$$LS = (0.045\ L)^{b} \cdot (65.41 \sin^{2} \theta_{k} + 4.56 \sin \theta_{k} + 0.065)$$

where $\theta_k = \tan^{-1}(S/100)$, S in the slope in percent, L is the slope length, and b equals the following values: 0.5 for $S \geq 5$, 0.4 for $3.5 \leq S \leq 5$, 0.3 for $1 \leq S \leq 3$, and 0.2 for $S < 1$. An L value of 15 meters was used for all LS calculations, and LS values were not allowed to exceed 5. Finally, KRER values were calculated using the following equations:

$$KRER = G \cdot K \cdot LS$$

where G accounts for unit conversion and was assigned a value of 4.102.

JRER	Set all to 1.81 (SCWRRP used 2.0)
AFFIX	All set at 0.005
COVER	All set at 0.10 by SCWRRP
NVSI	Set to 0
KSER	Set to 1.8
JSER	Set to 2.0
KGER	Set to 0
JGER	Set to 2.0 (inactive)
DETS	0.5 tons/ac

Impervious Lands (IMPLNDs)

KEIM and JEIM varies by land use. The following values for impervious surfaces for general land use categories were used.

Table B-1. Impervious surface coefficients (KEIM and JEIM) by landuse

	Industrial	**LDR**	**HDR**	**Commercial**	**Open/Park**
KEIM	soils B = 0.10 soils C/D = 0.07	0.03	0.015	0.10	0.20
JEIM	2.5	2.5	2.5	2.5	2.5

ACCSDP	0.1 tons/ac/d
REMDSP	Set at 0.20

Upland Sediment Fractions

SSURGO data was used to set the fraction of total sediment from land that is sediment class (Table). Adjustments to account for deposition en route were made based on the assumption that 50 percent of the sand and 30 percent of silt is deposited using watershed delivery ratios in Vanoni, 1975. Table provides the resulting land fractions for the model.

Table B-2. Sediment fractions by hydrologic soil group

HSG	**Sand**	**Silt**	**Clay**
B	65	23	12
C	68	19	14
D	54	21	24

Table B-3. Sediment fractions adjusted for watershed delivery

HSG	**Sand**	**Silt**	**Clay**
B	33	16	51
C	34	13	53
D	27	15	58

Reaches (RCHRES)

The primary calibration parameters for maintaining dynamic steady state in each reach was defining the stresses for deposition and scour. The stream cross sections were defined by internal LSPC algorithms based on upstream watershed area. Properties for fall velocity in still water (w) and density (Rho) were set uniformly for all reaches (Table).

Table B-4. Model reach parameters

	Sand	**Silt**	**Clay**
Fall velocity (in/s)	1.0	0.05	0.0002
Rho (g/cm^3)	2.5	2.2	2.0

Sand transport in the reaches was simulated using the power function of velocity subroutine. The KSAND parameter was set to 1.0 and EXPSND to 2.0 within each reach. Critical shear stress deposition and scour stress and erodibility coefficient were unique by reach and calibrated to maintain a dynamic steady state during the long term calibration simulations.

Table B-5. Model reach sand and silt stress and erodibility coefficients

Reach	Sediment Class	Critical shear stress		Erodibility coefficient (m) (lb/ft^2 ·d)
		Deposition (lb/ft^2)	Scour (lb/ft^2)	
1	Silt	0.7	1.3	0.001
1	Clay	0.6	1.1	0.001
2	Silt	0.4	0.9	0.001
2	Clay	0.35	0.7	0.001
3	Silt	0.08	0.8	0.001
3	Clay	0.07	0.7	0.001
4	Silt	0.35	1	0.001
4	Clay	0.3	0.95	0.001
5	Silt	0.35	0.75	0.001
5	Clay	0.3	0.6	0.001
6	Silt	0.35	0.8	0.001
6	Clay	0.3	0.6	0.001
7	Silt	0.5	1	0.001
7	Clay	0.4	0.9	0.001
8	Silt	1.5	2.2	0.001
8	Clay	1.2	1.8	0.001
9	Silt	1.2	2	0.001
9	Clay	1	1.5	0.001
10	Silt	0.48	1.2	0.001
10	Clay	0.4	1	0.001
11	Silt	0.35	0.75	0.001
11	Clay	0.3	0.6	0.001
12	Silt	0.6	1.2	0.001
12	Clay	0.5	1	0.001

kber	coefficient for scour of the bank matrix soil (calibration)
jber	exponent for scour of the bank matrix soil (calibration)
qber	bank erosion flow threshold causing channel bank soil erosion (cfs)

RCHID	KBER	JBER	QBER	Sand	Silt	Clay
1	0	0.001	8.972199	0.34	0.33	0.33
2	0	0.001	94.98709	0.34	0.33	0.33
3	1.0	0.001	238.4284	0.34	0.33	0.33
4	0	0.001	92.76765	0.34	0.33	0.33
5	0	0.001	81.77471	0.34	0.33	0.33
6	0	0.001	68.26335	0.34	0.33	0.33
7	0	0.001	62.12131	0.34	0.33	0.33
8	0	0.001	78.1442	0.34	0.33	0.33
9	0	0.001	101.9106	0.34	0.33	0.33
10	0	0.001	43.68436	0.34	0.33	0.33
11	0.5	0.1	154.2955	0.34	0.33	0.33
12	0.5	0.1	223.6453	0.34	0.33	0.33

Attachment 3

Regulatory Authority for San Diego Water Board Actions

Regulatory Authority for San Diego Water Board Actions

The authorities that are available to the San Diego Water Board to regulate dischargers are given under the Porter-Cologne Water Quality Control Act (Division 7 of the Water Code). The available regulatory authorities include incorporating discharge prohibitions in to the Basin Plan,[1] issuing individual or general Waste Discharge Requirements (WDRs),[2] or issuing individual or general conditional waivers of WDRs.[3] The San Diego Water Board has the authority to enforce Basin Plan prohibitions, WDRs, or conditional waivers of WDRs through the issuance of enforcements actions (e.g., time schedule orders, cleanup and abatement orders, cease and desist orders, administrative civil liabilities).[4] The San Diego Water Board also has the authority to require monitoring and/or technical reports from dischargers.[5]

1 Basin Plan Waste Discharge Prohibitions

The San Diego Water Board may specify certain conditions or areas where the discharge of waste, or certain types of waste is not permitted, known as “waste discharge prohibitions,” in the Basin Plan.[6] Waste discharge prohibitions can apply to any controllable sources, including point sources and nonpoint sources discharged to ground or surface waters. The waste discharge prohibitions for the San Diego Region are listed in Chapter 4 (Implementation) of the Basin Plan, under the heading “Waste Discharge Prohibitions.”

2 Waste Discharge Requirements

The primary regulatory authority used by the San Diego Water Board to protect water resources and water quality in the San Diego Region is the issuance of WDRs.[7] The San Diego Water Board can issue WDRs to any controllable point source or nonpoint source discharging waste to ground or surface waters of the state. The WDRs impose conditions which protect water quality, implement the provisions of the Basin Plan, and when the discharge is to waters of the United States, meet the requirements of the Clean Water Act.

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[1] Pursuant to Water Code section 13243

[2] Pursuant to Water Code section 13263 and 13264

[3] Pursuant to Water Code section 13269

[4] Pursuant to Water Code sections 13301-13304, 13308, 13350, 13385 and/or 13399

[5] Pursuant to Water Code sections 13225, 13267, and/or 13383

[6] Authorized pursuant to Water Code section 13243

[7] Authorized pursuant to Water Code sections 13263 and 13264

2.1 Point Sources

The USEPA has delegated responsibility to the State Water Board and San Diego Water Board for implementation of the federal National Pollutant Discharge Elimination System (NPDES) program, which specifically regulates discharges of "pollutants" from point sources to "waters of the United States." The San Diego Water Board regulates discharges from point sources to surface waters with WDRs that implement federal NPDES regulations (NPDES requirements).

The NPDES requirements may include numerical effluent limitations, when feasible, on the amounts of specified pollutants that may be discharged and / or specified best management practices (BMPs) designed to minimize water quality impacts.[8] These numerical effluent limitations and BMPs or other non-numerical effluent limitations must implement both technology-based and water quality-based requirements of the Clean Water Act. Technology-based effluent limitations (TBELs) represent the degree of control that can be achieved by point sources using various levels of pollution control technology.

If necessary to achieve compliance with applicable water quality standards, NPDES requirements must contain water quality-based effluent limitations (WQBELs), derived from the applicable receiving water quality standards, more stringent than the applicable technology-based standards. In the context of a TMDL, the WQBELs must be consistent with the assumptions and requirements of the WLAs of any applicable TMDL.[9]

Although NPDES requirements must contain WQBELs that are consistent with the assumptions and requirements of the TMDL WLAs, the federal regulations do not specifically require the WQBELs to be identical to the WLAs. The regulations leave open the possibility that the San Diego Water Board could determine that fact-specific circumstances render something other than literal incorporation of the WLA to be consistent with the TMDL assumptions and requirements. WQBELs may be expressed as numeric effluent limitations using a different metric and/or as BMP development, implementation, and revision requirements.

2.2 Nonpoint Sources

Unlike discharges from point sources to surface waters, discharges from nonpoint sources to surface waters are not subject to regulation under the federal Clean Water Act. Discharges from nonpoint sources, however, are subject to regulation under the California state Porter-Cologne Water Quality Control Act. The San Diego Water Board

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[8] Code of Federal Regulations Title 40 section 122.44(k)(2)&(3)

[9] Code of Federal Regulations Title 40 section 122.44(d)(1)(vii)(B)

can regulate discharges from controllable nonpoint sources to surface waters with individual or general WDRs.

The California's Nonpoint Source Implementation and Enforcement Policy requires that controllable nonpoint sources be regulated via individual or general WDRs, conditional waivers of WDRs, or Basin Plan waste discharge prohibitions. In general, discharges from controllable nonpoint sources in the San Diego Region are not regulated under WDRs. The San Diego Water Board prefers to utilize conditional waivers of WDRs for discharges from controllable nonpoint sources. If necessary, however, the San Diego Water Board can issue individual WDRs to a specific nonpoint source operation that is identified as a significant source causing or contributing to impairment. Likewise, the San Diego Water Board may issue general WDRs for a type or category of controllable nonpoint source discharges that is identified as a significant source causing or contributing to impairment.

3 Conditional Waivers of Waste Discharge Requirements

There are several types of point source, as well as nonpoint source discharges that may not have an adverse affect on the quality of the waters of the state, and/or are not readily amenable to regulation under WDRs. For these types of discharge, the San Diego Water Board has the authority to issue conditional waivers of WDRs.[10] The types of discharge which may be eligible for a waiver only include discharges to land and groundwater, and discharges to surface waters that are not otherwise subject to National Pollutant Discharge Elimination System (NPDES) regulations.[11] NPDES regulations are federal regulations. There are no federal or state regulations that allow NPDES regulations to be waived.

In general, the San Diego Water Board utilizes conditional waivers of WDRs to address the discharges from controllable nonpoint sources. Development and enforcement of waiver conditions that are protective of water quality will likely be sufficient to implement LAs. The controllable nonpoint sources eligible for conditional waivers must comply with the conditions of the waiver to be consistent with the TMDLs and LAs. Controllable nonpoint sources that do not comply with the waiver conditions are no longer eligible for the waiver and must either come into compliance with the waiver conditions, become regulated under WDRs, or cease any discharge of wastes to waters of the state.

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[10] Authorized pursuant to Water Code section 13269

[11] Defined in Code of Federal Regulations Title 40 section 122.3 [40 CFR 122.3]

Discharges from controllable nonpoint sources may be eligible for one of the general conditional waivers of WDRs, which are provided in the Basin Plan.[12] Conditional waivers of WDRs may not exceed 5 years in duration, but may be revised and renewed, or may be terminated at any time.[13]

Because the conditional waivers of WDRs that may be utilized to implement LAs are contained in the Basin Plan, any revision of the conditions will require a Basin Plan amendment. If needed, the San Diego Water Board may amend the Basin Plan to remove these conditional waivers of WDRs from the Basin Plan and re-issue the conditional waivers of WDRs as a general order to reduce the administrative requirements for revising waiver conditions.

As required, the effectiveness of the conditional waivers of WDRs must be evaluated at least once every 5 years. If the conditions in the waivers of WDRs are not sufficient to implement the TMDLs and LAs, the San Diego Water Board will amend the waiver conditions to include more stringent conditions, including, but not limited to, additional BMP implementation, monitoring, and/or reporting.

If a conditional waiver of WDRs no longer appears to be effective in protecting water quality from discharges from specific nonpoint source facilities or category of nonpoint source facilities, the waiver may be terminated. For nonpoint source facilities that are no longer eligible for a conditional waiver of WDRs, they will need to be regulated under WDRs, or cease any discharges of waste to waters of the state.

4 Enforcement Actions

The regulatory actions described above generally consist of requirements that a discharge from a controllable source must comply with in order for the discharge to legally occur. If a discharge does not comply with those requirements, a violation has occurred. Violations are subject to enforcement action by the San Diego Water Board.

An enforcement action is any formal or informal action taken to address an incidence of actual or threatened noncompliance with existing regulations or provisions designed to protect water quality. Potential enforcement actions including notices of violation (NOVs), notices to comply (NTCs), imposition of time schedule (TSO), issuance of cease and desist orders (CDOs) and cleanup and abatement orders (CAOs), administrative civil liability (ACL), and referral to the attorney general (AG) or district attorney (DA). The San Diego Water Board generally implements enforcement through an escalating series of actions to: (1) assist

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[12] The current general conditional waivers in the Basin Plan were adopted under San Diego Water Board Resolution No. R9-2007-0104. These waivers will expire December 31, 2012.

[13] Pursuant to Water Code section 13269(a)(2)

cooperative dischargers in achieving compliance; (2) compel compliance for repeat violations and recalcitrant violators; and (3) provide a disincentive for noncompliance.

The San Diego Water Board shall consider enforcement actions, as necessary, against any discharger failing to comply with applicable waiver conditions, WDRs, and/or Basin Plan waste discharge prohibitions.[14] Enforcement actions can also be taken, as necessary, to control the discharge of pollutants to the impaired waterbody to attain compliance with the assumptions and requirements of the TMDL and WLAs.

For implementation of the TMDLs to begin as soon as possible, the San Diego Water Board may issue enforcement actions in lieu of, or before, revising and re-issuing general WDRs and NPDES requirements. The enforcement actions may direct the discharges to implement additional measures to restore compliance with the pollutant's WQO.

5 Investigative Orders

The San Diego Water Board has the authority to require any state or local agency to investigate and report on any technical factors involved in water quality control or to obtain and submit analyses of water.[15] The San Diego Water Board has the authority to require technical or monitoring program reports from persons who have discharged or are discharging waste that could affect the quality of the waters in the San Diego Region.[16] The San Diego Water Board also has the authority to establish monitoring and recordkeeping requirements for discharges regulated under NPDES requirements.[17]

6 Basin Plan Amendments

As the implementation of a TMDL progresses, the San Diego Water Board recognizes that revisions to the TMDLs, WLAs, LAs, Implementation Plan, and potentially to beneficial uses and water quality objectives for specific waterbodies may be necessary in the future. Any future revisions to the Basin Plan necessary to implement a TMDL will require a Basin Plan amendment.

7 Other Actions

In addition to the regulatory authorities and actions that the San Diego Water Board can use to implement a TMDL, the San Diego Water Board may take other actions to help the regulated community implement measures to comply with the regulatory actions above.

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[14] Authorized pursuant to Water Code sections 13300-13304, 13308, 13350, 13385, and/or 13399
[15] Authorized pursuant to Water Code section 13225
[16] Authorized pursuant to Water Code section 13267
[17] Authorized pursuant to Water Code section 13383

The San Diego Water Board can recommend that the State Water Board assign a high priority to awarding grant funding[18] for projects to implement the TMDL. Special emphasis will be given to projects that can achieve quantifiable pollutant load reductions consistent with the specific pollutant TMDL, WLAs, and LAs.

Implementation of a TMDL by the San Diego Water Board may require special studies to be conducted by the dischargers or other entities. The San Diego Water Board, however, may encourage and support any special studies proposed and undertaken by the dischargers or other entities that will provide information to refine and improve the implementation of a TMDL. The San Diego Water Board may develop agreements (e.g., a Memorandum of Understanding) with one or more entities to support and use the findings from any special studies that may be conducted. Proposing a special study project and initiating an agreement with the San Diego Water Board to use the results of the study to modify a TMDL Implementation Plan is the responsibility of the project proponent(s).

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[18] The State Water Board administers the awarding of grants funded from Proposition 13, Proposition 50, Clean Water Act section 319(h) and other federal appropriations to projects that can result in measurable improvements in water quality, watershed condition, and/or capacity for effective watershed management. Many of these grant fund programs have specific set-asides for expenditures in the areas of watershed management and TMDL project implementation for non-point source pollution.