

**La Jolla Shores
Area of Special Biological Significance
Regional Compliance Monitoring
2010-2011**

Final Report

June 2011



City of San Diego



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2010–2011**

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LIST OF ACRONYMS

ASBS	area of special biological significance
BMP	best management practice
CDFG	California Department of Fish and Game
City	City of San Diego
COC	chain of custody
DDT	dichlorodiphenyltrichloroethane
DO	dissolved oxygen
DOC	dissolved organic carbon
DOM	dissolved organic matter
EC ₅₀	effect concentration 50
ELAP	Environmental Laboratory Accreditation Program
L	liter
LC ₅₀	lethal concentration 50
LOEC	lowest observed effect concentration
MARINe	Multi-Agency Rocky Intertidal Network
MDL	method detection limit
MPN	most probable number
MRL	method reporting limit
MS4	municipal separate storm sewer system
NA	not analyzed
N/A	not applicable
ND	not detected
NOEC	no-observed-effect concentration
OP	organophosphorus
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
QA	quality assurance
QC	quality control
SCCWRP	Southern California Coastal Water Research Project
SIO	Scripps Institute of Oceanography
SOP	standard operating procedures
State Board	State Water Resources Control Board
SWMM	Storm Water Management Model
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily load
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
WQC	water quality criteria
WQO	water quality objective

EXECUTIVE SUMMARY

The purpose of this report is to provide an assessment of compliance monitoring and special studies conducted in the La Jolla Shores Areas of Special Biological Significance (ASBS). In 2010-2011, Weston Solutions Inc. (Weston) was contracted by the City of San Diego (City) to conduct monitoring in the La Jolla State Marine Conservation Area (ASBS 29), which lies within the City's jurisdiction. The State Water Resources Control Board (State Board) has produced a draft guidance document for monitoring discharges to ASBS, entitled *Special Protections for Selected Storm Water and Nonpoint Source Discharges into Areas of Special Biological Significance* (Special Protections). This study was designed to provide monitoring data for ASBS 29 consistent with the requirements in the Special Protections, in anticipation of their approval in the near future. Additional monitoring and assessment activities specific to the needs of the City in accordance with the Strategic Plan for Watershed Activity Implementation were also conducted.

The objective of this project was to address the following study questions:

- 1. What are the conditions of storm water effluent in the storm drain prior to being discharged to the ocean receiving waters?**
- 2. Are short-duration exposures to contaminants during storm events toxic to species living within the rocky intertidal zone?**
- 3. Do sediment contaminant concentrations differ between ASBS sites adjacent to storm water discharges and reference sites?**
- 4. Do the rocky intertidal biological communities differ between sites that are influenced by storm water runoff and those that are not?**

By answering these study questions, impacts from storm water runoff to organisms living within the ASBS, particularly, organisms living in rocky intertidal areas near storm drain outfalls, can be better assessed.

Relevance to Current City Efforts:

This study compliments other City of San Diego plans, programs, and cost reduction efforts that include the following:

- La Jolla Shores Coastal Watershed Management Plan.
- Strategic Plan for Watershed Activity Implementation.
- Watershed and Jurisdictional Urban Runoff Management Program (WURMP/JURMP).
- Compliance with ASBS regulatory requirements.

Results and Key Findings

Study Question 1:

To answer this question, “end of pipe” storm drain effluent samples (prior to mixing with the ocean receiving waters) were collected during a storm event from each of the five major storm drain outfalls that drain to ASBS 29. Most metal concentrations were below California Ocean Plan water quality objectives (WQOs) (as required in the Special Protections), except for those of total zinc and copper. Organophosphate pesticides were not detected, but synthetic pyrethroid concentrations were high, exceeding LC50 values by two to three orders of magnitude in some cases. Thus, reductions in the concentrations of some metals and pyrethroids may be required in the future to meet the requirements of the Special Protections.

Study Question 2:

The results of the pollutograph monitoring indicate that concentrations of some metals exceeded Ocean Plan WQOs and synthetic pyrethroid concentrations exceeded values in the literature shown to be toxic to marine organisms, by as much as three orders of magnitude. Elevated concentrations of these constituents were measured in the storm water effluent taken directly from the storm drain as well as in the tide pools in the ocean receiving waters. Toxicity evaluations indicated that storm water effluent was toxic to native marine species at concentrations observed in the receiving waters. However, further assessment suggested that the freshwater associated with storm water runoff may be the predominant source of toxicity observed in this study. Further assessment is needed to understand the impacts of storm water runoff on the beneficial uses of the ASBS.

Study Question 3:

To answer this question, surficial sediment samples were collected from the upper and lower intertidal zone in front of each of the five major storm drain outfalls that discharge to ASBS 29 following a storm event. Samples were analyzed for grain size and a suite of constituents. Chemistry results indicated that sediments had low concentrations of the constituents analyzed. Concentrations of PCBs, OP pesticides, pyrethroids, and PAHs were all less than reporting limits and metal concentrations were one or more orders of magnitude below ER-L (effects range low) values. The grain sizes of all upper and lower intertidal sediment samples consisted of greater than 95% sand and gravel. The results suggest that contaminants associated with storm water runoff are not accumulating in the intertidal sediments of the ASBS. Additional data will be necessary to confirm if these results are consistent over varying spatial and temporal gradients.

Study Question 4:

To answer this question, surveys were conducted to characterize the biological communities in the rocky intertidal habitats at the storm drain-influenced site (SDL-186 within ASBS 29) and two sites that are not influenced by storm drains. Results revealed that each site was significantly different from each other using numerous parameters. Biodiversity of macrophytes (macroscopic algae) and macroinvertebrates was lowest at the ASBS site while patterns were mixed for meiofaunal (small, macroscopic invertebrates that live within the sediments) diversity, with diversity sometimes being higher at the ASBS site. Multi-variate statistical analyses revealed that the ASBS site was clearly differentiated from the other two sites, but the sites may differ due to several factors, not just the presence of storm drain runoff. Despite some differences, evidence of obvious and consistent storm water impacts at the SDL-186 site relative to the reference sites is relatively weak. However, differences among sites warrant possible future examinations in a more robust manner using multiple impacted and non-impact sites and concentrating some sampling on non-turf habitats, such as intertidal tidepools.

Key Recommendations

Based on the study results, key recommendations that may be considered are as follows:

- Tier I – Develop and implement a data management system to consolidate data, track activities, load reductions, and determine effectiveness of storm water program efforts.

- Tier I – Conduct education and outreach programs to keep the public informed about protection of the ASBS and what they can do to help reduce toxicity to aquatic marine life.
- Tier I – Continue to monitor the ASBS receiving waters during storm events to be in compliance with State Board regulations and to fill data gaps needed to implement BMPs that may be required for load reductions.
- Tier I – Assess the potential for impacts to the rocky intertidal biological community adjacent to the discharge from SDL-186, where elevated concentrations of some constituents have been detected.
- Tier II – Implement aggressive street sweeping in areas likely to have high contaminant loads as a means of reducing pollutant loads to the ASBS.
- Tier II – Continue development of a pollutant loading model and load reduction calculations for the La Jolla Shores Coastal Watershed.
- Tier III – Conduct effectiveness monitoring of existing BMPs to assess success in complying with ASBS discharge regulations.

Benefits to the City

This Phase I Source Study provides the following benefits to the City:

- Supports ASBS compliance monitoring requirements for the La Jolla ASBS.
- Supports regional and jurisdictional management plans.
- Identifies constituents during storm events that may be toxic to the resident biological community and may influence community level parameters, such as abundance and diversity.

1.0 INTRODUCTION

The La Jolla Shores Coastal Watershed is located in La Jolla, California, within San Diego city limits. The watershed covers 1,639 acres and is composed of primarily residential and institutional land uses (e.g., the University of California, San Diego campus). Within the watershed's boundaries are 32 distinct sub-drainage areas (Figure 1-1), which drain west into two areas of special biological significance (ASBS), including the San Diego–Scripps State Marine Conservation Area (ASBS 31) and the La Jolla State Marine Conservation Area (ASBS 29). The majority of the runoff within the watershed is conveyed through a network of storm drains before it is discharged at several locations along the beach. The central and largest portion of the watershed drains to a single storm drain outfall that discharges at Avenida de la Playa.

Since 1983, the Ocean Plan has prohibited the point source discharge of waste into ASBS along the California Coast, unless the State Water Resources Control Board (State Board) grants an exception to dischargers. As part of the exception process, the State Board has produced a draft guidance document for monitoring discharges to ASBS titled *Special Protections for Selected Storm Water and Nonpoint Source Discharges into Areas of Special Biological Significance* (Special Protections) (State Board, 2008). The draft Special Protections are currently being ratified by the State Board and a final version of the document has not yet been released. The Special Protections document is intended to define the terms and conditions that limit storm water discharge to the 34 ASBS along the California Coast. The City of San Diego (City) is listed as the responsible entity for discharges into ASBS 29, the La Jolla State Marine Conservation Area, and has applied to the State Board for an exception to the ASBS discharge requirements.

As part of the exception process, the City participated in the Bight 2008 ASBS Regional Planning Committee (the Committee) with the State Board, the Southern California Coastal Water Research Project (SCCWRP), and other ASBS dischargers in Southern California. The Committee developed a Regional ASBS Work Plan as part of the Southern California Bight 2008 Regional Monitoring Survey. The Regional ASBS Work Plan is based on the draft Special Protections and is intended to provide compliance guidance for the majority of ASBS dischargers in Southern California who wish to be part of a regional monitoring effort.

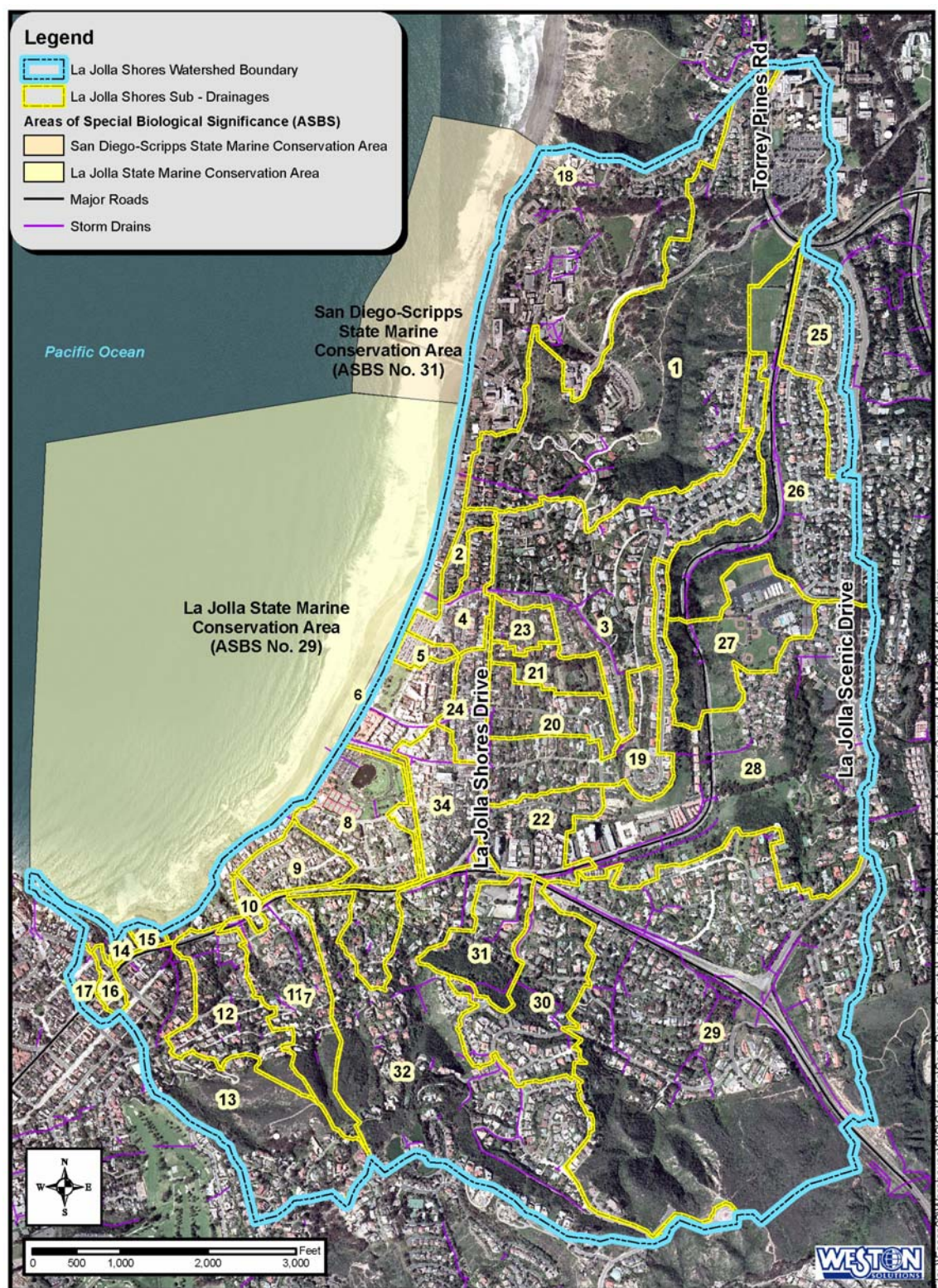


Figure 1-1. Sub-drainages within the La Jolla Shores Coastal Watershed and Adjacent ASBS

1.1 Program Overview

This study is designed to be in compliance with the Committee’s Regional ASBS Work Plan with additional monitoring and assessment activities specific to the needs of the City in accordance with the Strategic Plan for Watershed Activity Implementation (Weston, 2007). The study will provide data necessary to meet compliance requirements described by the Committee and the State Board and will build on previous studies conducted in the La Jolla Shores Coastal Watershed to advance the understanding of watershed influences on the ASBS. These studies include a sediment source investigation and ocean receiving water monitoring (Weston, 2009a), an aerial deposition study (Weston, 2009b), an initial water quality monitoring conducted in the watershed (Weston, 2008), and a compliance monitoring study that included seep monitoring and a biological community assessment of the rocky intertidal zone (Weston, 2010). In addition, a Storm Water Management Model (SWMM) was created for the La Jolla Shores Coastal Watershed. The purpose of the model is to integrate information generated in the studies listed above to assess potential impacts to the ASBS from storm water runoff generated from the watershed. The model serves as an initial, predictive tool that can be built on as additional data become available and can be used to test the effectiveness of best management practices (BMPs) that may be used to address impacts to the ASBS.

1.2 Study Objectives

The Special Protections document describes the following two types of monitoring requirements for ASBS dischargers:

1. **Core Discharge Monitoring** – Collecting and analyzing wet weather runoff directly from the storm water discharge during a storm event.
2. **Ocean Receiving Water Monitoring** – Collecting and analyzing samples from the ocean receiving waters before and after a storm event at all major discharge locations, including directly in front of the discharge and at a reference site removed from the discharge.

As highlighted in the Regional ASBS Work Plan, the goal of the ASBS program is to answer the following three primary questions:

1. What is the range of “natural conditions” at reference locations?
2. How does the range of natural conditions compare to conditions at ASBS sites?
3. What is the extent of impact in ASBS with and without discharges?

Within the context of the broader ASBS program, the objective of this project was to address the following study questions:

1. **What are the conditions of storm water effluent in the storm drain prior to being discharged to the ocean receiving waters?**
2. **Are short-duration exposures to contaminants during storm events toxic to species living within the rocky intertidal zone?**

- 3. Do sediment contaminant concentrations differ between ASBS sites adjacent to storm water discharges and reference sites?**
- 4. Do the rocky intertidal biological communities differ between sites that are influenced by storm water runoff and those that are not?**

To answer these questions, water quality was monitored in ocean receiving water and storm drain effluent associated with the largest storm drains that discharge to ASBS 29. In addition, marine sediment was collected within the ASBS from locations that are directly in line with the streams of storm drain effluent from each major outfall following a storm event. To understand if short-duration exposures to contaminants may be toxic to intertidal species, water samples collected over the course of a storm event were chemically analyzed and samples collected during the peak of the storm were used in the laboratory to mimic the exposure that various intertidal species (e.g. abalone, sea urchins, diatoms, bivalves, and mysid shrimp) would receive over a tidal cycle. Finally, rocky intertidal biological communities located in the ASBS near a storm drain discharge were compared to rocky intertidal communities that do not receive storm drain runoff, to determine potential impacts of storm water runoff on resident biota.

Understanding the source and nature of pollutants entering the ASBS from the watershed as well as their fate once they enter the marine environment will help the City establish a baseline to measure the effectiveness of management actions. In addition, this study will help the City prioritize and implement cost-effective best management practices (BMPs) to reduce pollutant loading and will help meet current and future ASBS regulatory compliance requirements by assessing pollutant loads that travel from the La Jolla Shores Coastal Watershed to the adjacent ASBS receiving waters.

This report presents and summarizes data collected from sampling events that occurred during the 2010–2011 Storm Water Monitoring Season.

1.3 Regulatory Framework (Area of Special Biological Significance Special Protections)

California established 34 ASBS along its coastline in the 1970s to protect biologically unique and fragile marine habitats for future generations. The designation of ASBS was established in 1970 and was adopted under the Ocean Plan by the State Board in 1974. The ASBS designation affords special protection to marine life residing within these areas through the maintenance of natural water quality and the prohibition of waste discharges (State Board, 1972). The La Jolla State Marine Conservation Area (ASBS 29) and the San Diego–Scripps State Marine Conservation Area (ASBS 31) are located within City jurisdiction. These two areas are part of a larger ecological reserve known as the San Diego–La Jolla Underwater Park.

Section III.E.1 of the Ocean Plan requires that “waste shall not be discharged to areas designated as being of special biological significance. Discharges shall be located a sufficient distance from such designated areas to assure maintenance of natural water quality conditions in these areas.” The Ocean Plan defines waste as the “total discharge, of whatever origin.” In 2004, the State Board informed the City that storm water (i.e., dry weather and wet weather runoff) that enters

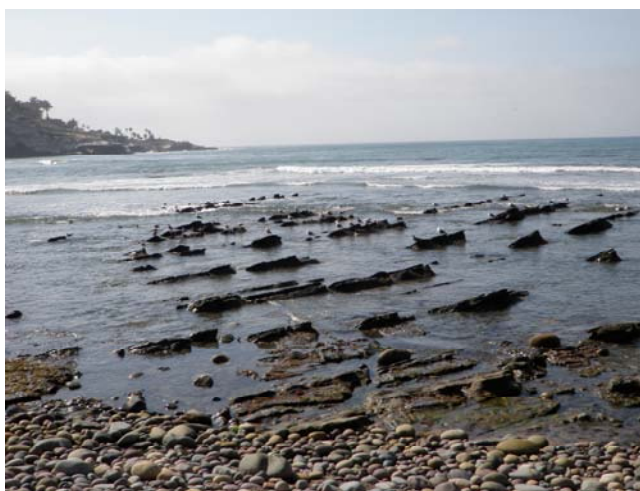
the San Diego–La Jolla Ecological Reserve is subject to the prohibition against waste discharges to an ASBS. Upon receiving the notice, the City requested an exception to the Ocean Plan discharge prohibition in 2004 and submitted a completed application package to the State Board in 2006. The City was informed that the exception would likely include provisions for minimizing or eliminating dry weather flows and reducing pollutants draining to the ASBS to maintain natural water quality in the receiving waters.

In 2007, as part of the exception process, the City participated in the Bight 2008 ASBS Planning Committee to develop a Regional ASBS Work Plan as part of the Southern California Bight 2008 Regional Monitoring Survey. Monitoring conducted under the Work Plan was to both define natural water quality and to assess the potential impacts to ASBS by monitoring ocean receiving waters before and after storm events. The final draft of the reports summarizing the results of the monitoring was completed in late 2010 (Schiff et al, 2010). Based partially on the results of the regional ASBS monitoring study, the State Board submitted an updated draft of the Special Protections as part of a Program Environmental Impact Report (PEIR) (State Board, 2011). The PEIR and attached Special Protections are expected to be approved by the State Board in late 2011.

Based on the anticipated adoption of the Special Protections, the Weston Solutions, Inc. (Weston) has assisted the City with designing and conducting this study to assess the potential impacts to ASBS 29. Immediately to the north of ASBS 29 is ASBS 31, which is managed by the University of California San Diego Scripps Institution of Oceanography (UCSD/SIO). Descriptions of these ASBS are provided below.

1.3.1 La Jolla State Marine Conservation Area (ASBS 29)

The La Jolla State Marine Conservation Area was established in 1971 by the City, in conjunction with the California Department of Fish and Game. The boundaries of the ASBS extend from Goldfish Point (adjacent to Ellen Browning Scripps Park) north to the southern end of the SIO. The ASBS extends west a maximum distance of 1.0 mile from shore, stretching along 1.5 miles of shoreline. A total of 518 acres in surface area are contained within the conservation area (SIO et al., 2008). The wide array of habitats that can be found within the ASBS include kelp forest, eel grass, submarine canyon, sandy shelf, submerged cobble and boulder, and rocky mudstone reef.



Water depths range from 0 ft along the shoreline to below 400 ft within the steep-walled submarine canyon that extends through the middle of the ASBS. The canyon is located within 1,000 ft of shore and acts as a spawning ground for the squid *Loligo opalescens*, a popular prey item for many fishes. A wide range of sandy substrate, rocky reef, and open water pelagic organisms can be found within the La Jolla State Marine Conservation Area, including California

sea lions, leopard sharks, kelp bass, garibaldi, gorgonian corals, gray whales, crabs, clams, harbor seals, green sea turtles, and a host of other species.

1.3.2 San Diego–Scripps State Marine Conservation Area (ASBS 31)

The San Diego–Scripps State Marine Conservation Area was established in 1929 by the California Fish and Game Commission to allow scientists working at the University of California to take marine invertebrates, marine plants, and algae without requiring a collector's permit from the California Department of Fish and Game (State Board, 1980). The ASBS extends west (seaward) 1,000 ft from the mean high tide line and encompasses a total of 92 acres, including 0.6 mile of shoreline.



Water depth within the conservation area ranges from approximately 0–40 ft and includes three distinct habitats (i.e., a gradual sloping sandy habitat, rocky intertidal mudstone reef complex, and vertical habitat of concrete pier pilings that support the Scripps Institute of Oceanography [SIO] pier). A submarine canyon occurs immediately north of the ASBS. A wide range of sandy substrate and rocky reef organisms can be found within the San Diego–Scripps State Marine Conservation Area in addition to a limited variety of hard substrate biota attached to pier pilings.

1.4 La Jolla Shores Coastal Watershed Management Plan

Although the Special Protections document is the primary regulatory driver for assessing compliance with State Board water quality regulations, monitoring and BMP implementation to meet these requirements are being conducted with the broader context of regional and jurisdictional management plans. The La Jolla Shores Coastal Watershed Management Plan (Plan) was published in January 2008 by the La Jolla Shores Management Group, a consortium comprising the City, UCSD, SIO, and San Diego Coastkeeper (SIO et al., 2008). The Plan was intended to be a blueprint for future management actions pertaining to the protection and improvement of water quality in the San Diego–La Jolla Ecological Reserve and the San Diego–Scripps State Marine Conservation Area. The following goals were identified for use in the Plan:

- Identify water quality pollutants of concern, their potential sources specific to the coastal watershed, and how they may impact the ASBS.
- Identify, evaluate, and prioritize urban runoff management activities, both structural and nonstructural in nature, to address pollutants of concern.
- Develop a model for science-oriented, ecosystem-based ASBS assessment and protection that is transferable to other ASBS statewide.
- Create a data management system at the core of the watershed plan that is transferable statewide and serves data providers, analysts, partner agencies, and the community.
- Encourage stewardship of the ASBS through a pioneering public involvement and outreach strategy that uses university tools and science.

The integrated approach used to characterize inputs to the ASBS for the Plan’s development involved the collection and analysis of multiple types of water quality data, including the following:

- Mussel and sand crab bioaccumulation studies were performed within the ASBS to provide a measure of pollutants that were biologically available to suspension feeders.
- A circulation study was conducted to determine circulation patterns and transport rates within La Jolla Bay.
- A dilution and dispersion study was performed on effluent from five permitted outfalls at SIO using a hydrodynamic modeling program (SEDXPORT) to determine dilution and dispersion rates during calm weather periods and during storm conditions.
- Water quality monitoring and toxicity testing were performed on samples collected within the watershed during wet weather conditions to characterize pollutant loads entering the ASBS via urban runoff.
- Ocean mixing zone and offshore water samples collected during wet weather conditions were chemically analyzed to establish baseline conditions within the ASBS during a storm event.

In developing the Plan, the La Jolla Shores Watershed Management Group divided technical analyses and implementation programs into the following four key areas:

- Urban runoff characterization.
- ASBS ecosystem assessment.
- Information management.
- Public participation/outreach.

These areas were selected as the primary components necessary to “characterize ASBS inputs, identify potential biological or ecosystem impacts to the ASBS, establish an information management system to house, integrate, and disseminate data collected for the Plan, and to begin an ocean stewardship program within the watershed” (SIO et al., 2008). A flow chart of the iterative process linking assessment, planning, implementation, and effectiveness monitoring with information management and public participation is depicted on Figure 1-2.

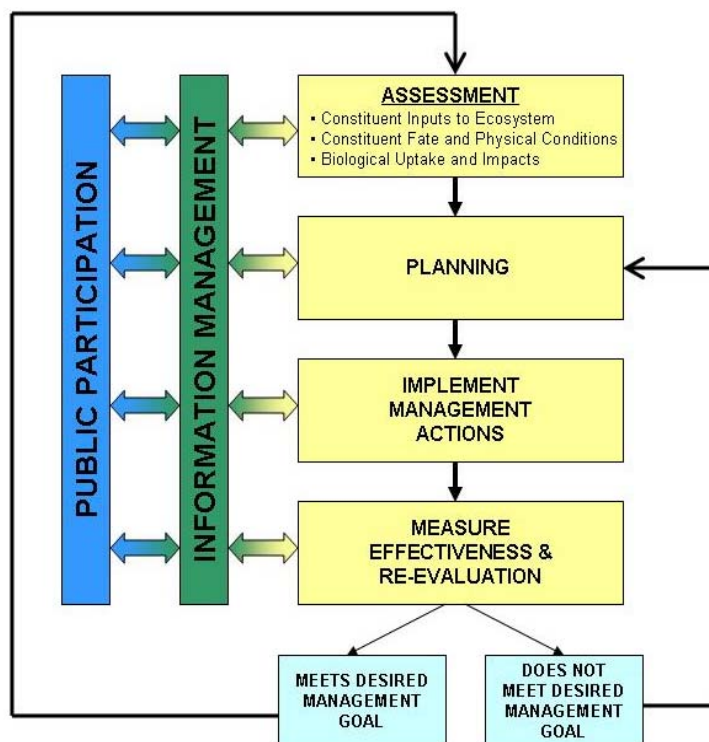


Figure 1-2. Adaptive Management Strategy for Pollutant Reduction Process

To accomplish the overall objective of protecting the ASBS and the beneficial uses in the La Jolla Shores marine areas, an ASBS protection model was developed. The ASBS protection model was developed as an adaptive strategy consisting of four elements (i.e., assessment, planning, implementation, and effectiveness assessment). A triad approach, consisting of physical, chemical, and biological data measures, is to be used to assess biological and beneficial use impacts to the ASBS, whereas a tiered approach is to be used to identify management strategies. The tiered approach will consist of short-term (i.e., Phase I) and long-term (i.e., Phase II and Phase III) measures that address current and potential constituents of concern. Effectiveness assessments will evaluate whether implemented BMP measures have lessened impacts to the ASBS and will determine whether adjustments are necessary to bring about desired outcomes. The following Phase I management measures (i.e., BMP projects) were recommended in the Plan to address the reduction/prevention of priority pollutants (i.e., copper, nickel, chromium, arsenic, indicator bacteria, and turbidity):

- Tier I (source control and prevention):
 - Source control measures and pollution prevention BMPs.
 - ASBS ecosystem assessment studies.
 - Effectiveness monitoring of implemented BMPs.
 - Creation of ocean stewardship through community involvement.
 - Integration of data using information management.
- Tier II (source reduction using structural BMPs):
 - Soil and hydrologic studies, source studies, and determination of design storm.
 - Aggressive pollutant source control in targeted areas.
 - Dry weather flow diversions.

- Effectiveness monitoring of implemented BMPs.
- Implementation of Low Impact Development techniques for urban runoff reduction.
- Tier III (treatment controls):
 - Property acquisition and easements (where necessary).
 - Install treatment controls in areas where Tier I and Tier II BMP measures have not met pollution reduction goals.
 - Effectiveness monitoring of implemented BMPs.

1.5 Strategic Plan

The La Jolla Shores Coastal Watershed Management Plan was designed to work in concert with the City's overall watershed management goals, which are detailed in the City's Strategic Plan for Watershed Activity Implementation (Weston, 2007). The Strategic Plan represents the City's Storm Water Pollution Prevention Program's implementation strategy for watershed activities within the City's jurisdictional boundaries from 2007 through 2012. Among the prioritized watershed activities identified in The Strategic Plan, eight projects pertained directly to the protection and enhancement of beneficial uses for ASBS 29 and ASBS 31. These projects included dry weather flow diversion, runoff reduction, ecosystem assessment, and street sweeping. The City recently received a Proposition 84 Grant to partially fund these projects.

The regulatory drivers that shaped the Strategic Plan included the Municipal Storm Water Permit, current and near-term (i.e., within 5 years) total maximum daily loads (TMDLs), and the Ocean Plan ASBS exception process for La Jolla Shores. Each of these regulatory drivers requires or was anticipated to require watershed activities aimed at reducing pollutant loads and concentrations. The Municipal Storm Water Permit requires each Copermittee to implement a least two Watershed Water Quality Activities and two Watershed Education Activities each year that result in pollutant reduction, source abatement, or other quantifiable benefits to water quality pertaining to the watershed's high-priority water quality issues. Several TMDLs are in effect for watersheds in San Diego, and other TMDLs are anticipated to be adopted in the near future. The ASBS Exception Process for La Jolla Shores requires the minimization or elimination of dry weather flows and the reduction of pollutants draining to the ASBS to maintain natural water quality in the receiving waters. Watershed activities are needed to define the source of pollutants of concern and to define their impact upon the marine ecosystem of the ASBS.

2.0 MATERIALS AND METHODS

Water sampling for both the Core Discharge Monitoring Program and the Ocean Receiving Water Monitoring Program required in the Special Protections was performed during the 2010–2011 Wet Weather Monitoring Season for the La Jolla Shores ASBS. The Regional ASBS Work Plan provided the framework for both of these components of the Ocean Receiving Water Monitoring Program. Additionally, chemical analyses were performed on samples collected over the course of a storm event from SDL-186 (i.e., pollutograph), its receiving water, and Cabrillo National Monument receiving water (reference site). Toxicity testing was performed using five species of marine invertebrates in exposures to various concentrations of storm water mixed with seawater to assess potential impacts of point sources of storm water runoff on the intertidal marine community. Lastly, sediment samples were collected from the upper and lower intertidal zone in line with the five major storm drain outfalls in ASBS 29 and at the Cabrillo National Monument reference site following a storm event and chemically analyzed to assess potential residual toxicity in the sediment resulting from storm water runoff. Details of each of these monitoring components specific to the City are provided below.

2.1 Sampling Locations

2.1.1 Core Discharge Monitoring

The Special Protections require Core Discharge Monitoring during storm events for storm drains that discharge to the ASBS with a diameter 18 inches or greater. There are five storm drains with these characteristics that discharge to ASBS 29, as shown on Figure 2-1.

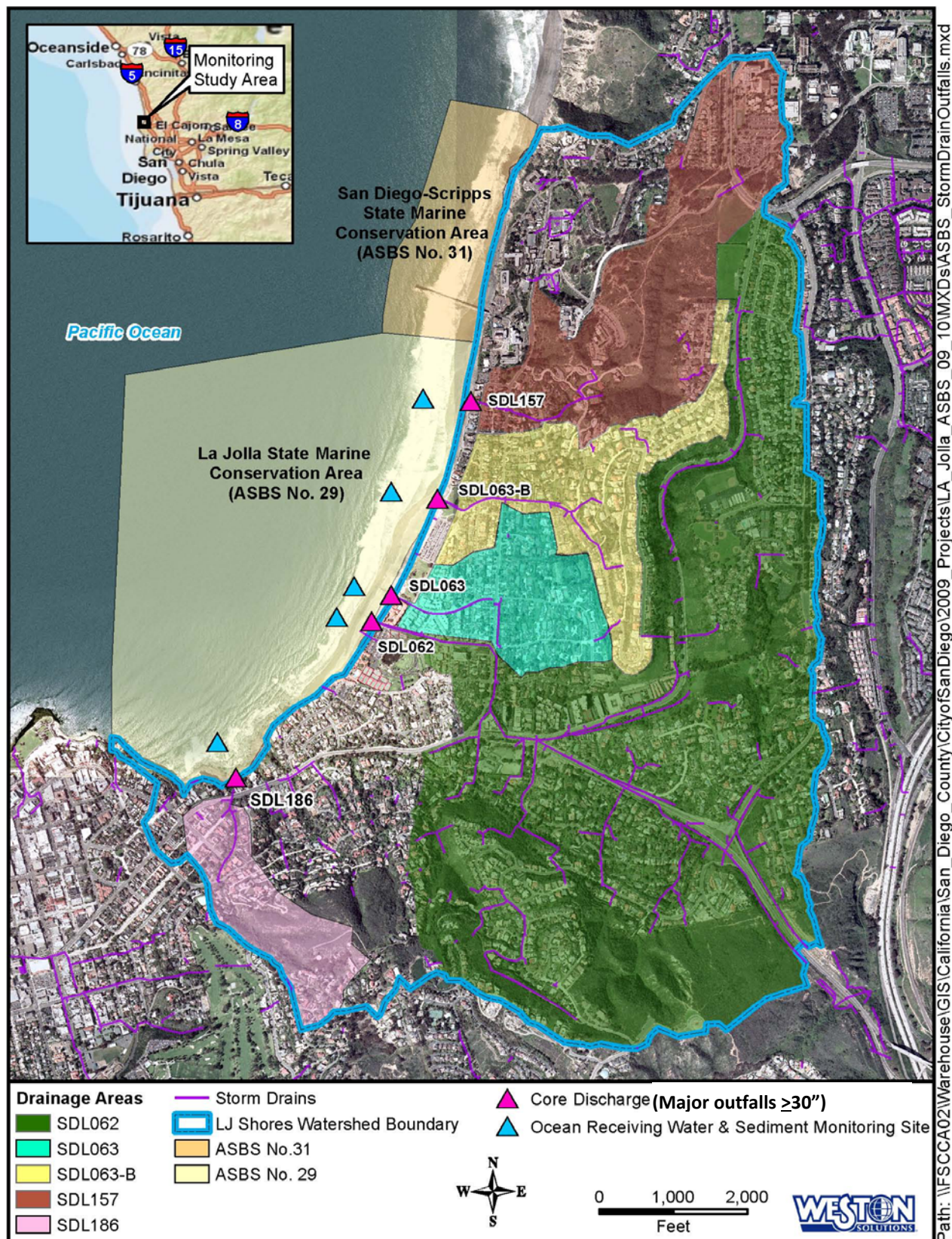


Figure 2-1. La Jolla Shores Coastal Watershed Core Discharge, Ocean Receiving Water, and Sediment Monitoring Locations within ASBS 29

Characteristics of the five storm drains are given below:

- **Storm Drain SDL-186** – This 36-inch storm drain outlets directly to the rock intertidal area of the ASBS and drains approximately 4% of the La Jolla Shores Coastal Watershed (Figure 2-2). The storm drain is accessed during monitoring via a manhole located on Torrey Pines Road between Prospect Place and Amalfi Street.
- **Storm Drain SDL-062** – This large storm drain (greater than 36 inches in diameter) drains approximately 49% of the La Jolla Shores Coastal Watershed. SDL-062 outlets at the end of Avenida de la Playa onto La Jolla Shores Beach (Figure 2-2).
- **Storm Drain SDL-063** – This 36-inch storm drain outlets directly onto the sand at La Jolla Shores Beach. SDL-063 drains approximately 5% of the La Jolla Shores Watershed and is located at the end of Vallecitos Street (Figure 2-2).

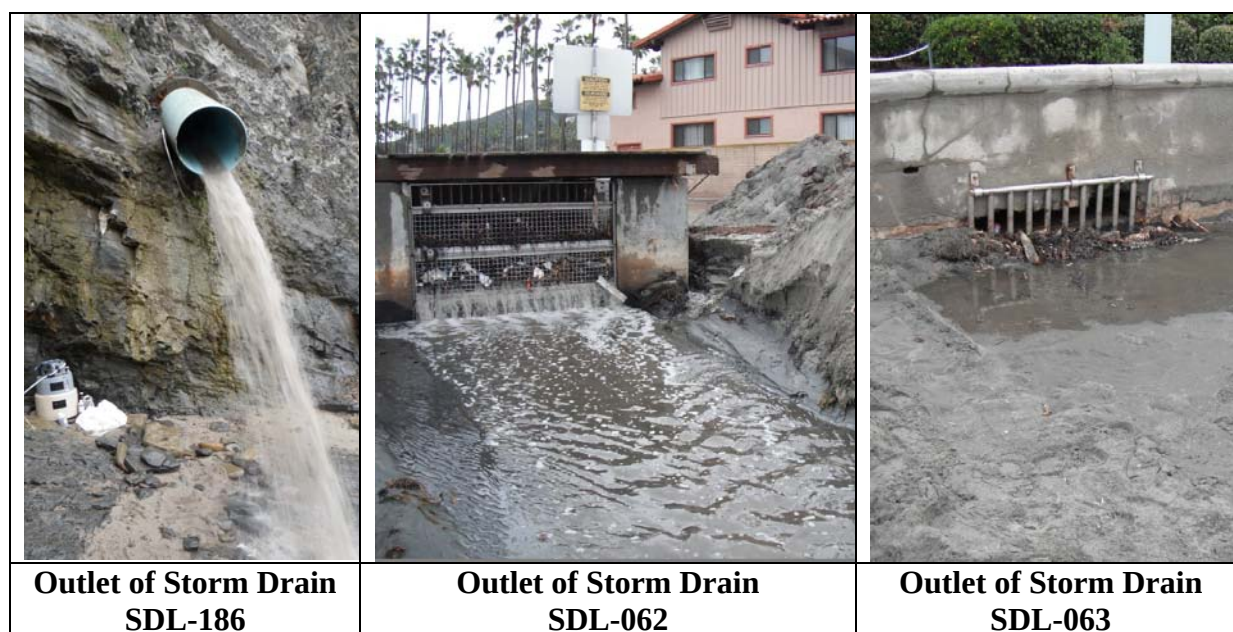


Figure 2-2. Storm Drain Outlets SDL 186, SDL-063, and SDL-063

- **Storm Drain SDL-063B** – SDL-063B consists of two 18-inch storm drain outlets that discharge directly to the sand at La Jolla Shores Beach. SDL-063B drains approximately 8% of the La Jolla Shores Watershed and outlets at La Jolla Shores Beach approximately 300 ft north of the northern end of the Kellogg Park parking lot (Figure 2-3).
- **Storm Drain SDL-157** – This 36-inch storm drain outlets directly onto the sand at La Jolla Shores Beach. SDL-057 drains approximately 12% of the La Jolla Shores Watershed and outlets at the beach beneath a house, approximately 400 ft north of Camino del Collado and 1,100 ft south of Scripps Pier (Figure 2-3).

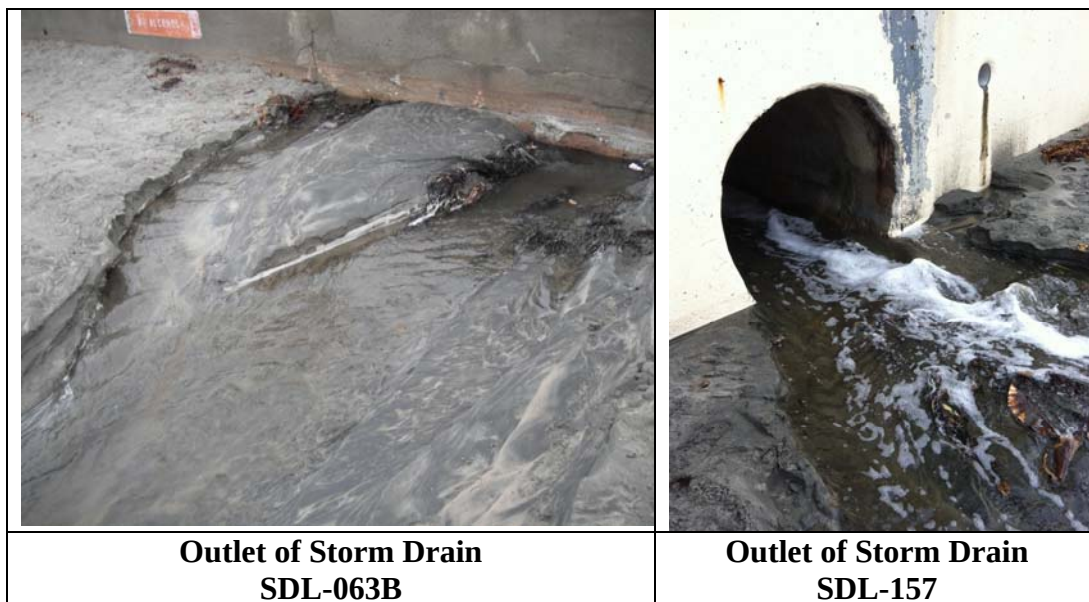


Figure 2-3. Storm Drain Outlets SDL-063B and SDL-157

2.1.2 Ocean Receiving Water Monitoring

Ocean receiving water was collected from the Pacific Ocean in front of each of the five major storm drain outlets that discharge to ASBS 29 (Figure 2-1) and from the ocean receiving water at Cabrillo National Monument, a reference site that receives no direct input of storm water runoff via storm drains (Figure 2-4). Samples were collected in knee-depth water (approximately 0.5 m in depth) within the surf zone at all sites. An example of the collection point for SDL-062 is shown in Figure 2-5.

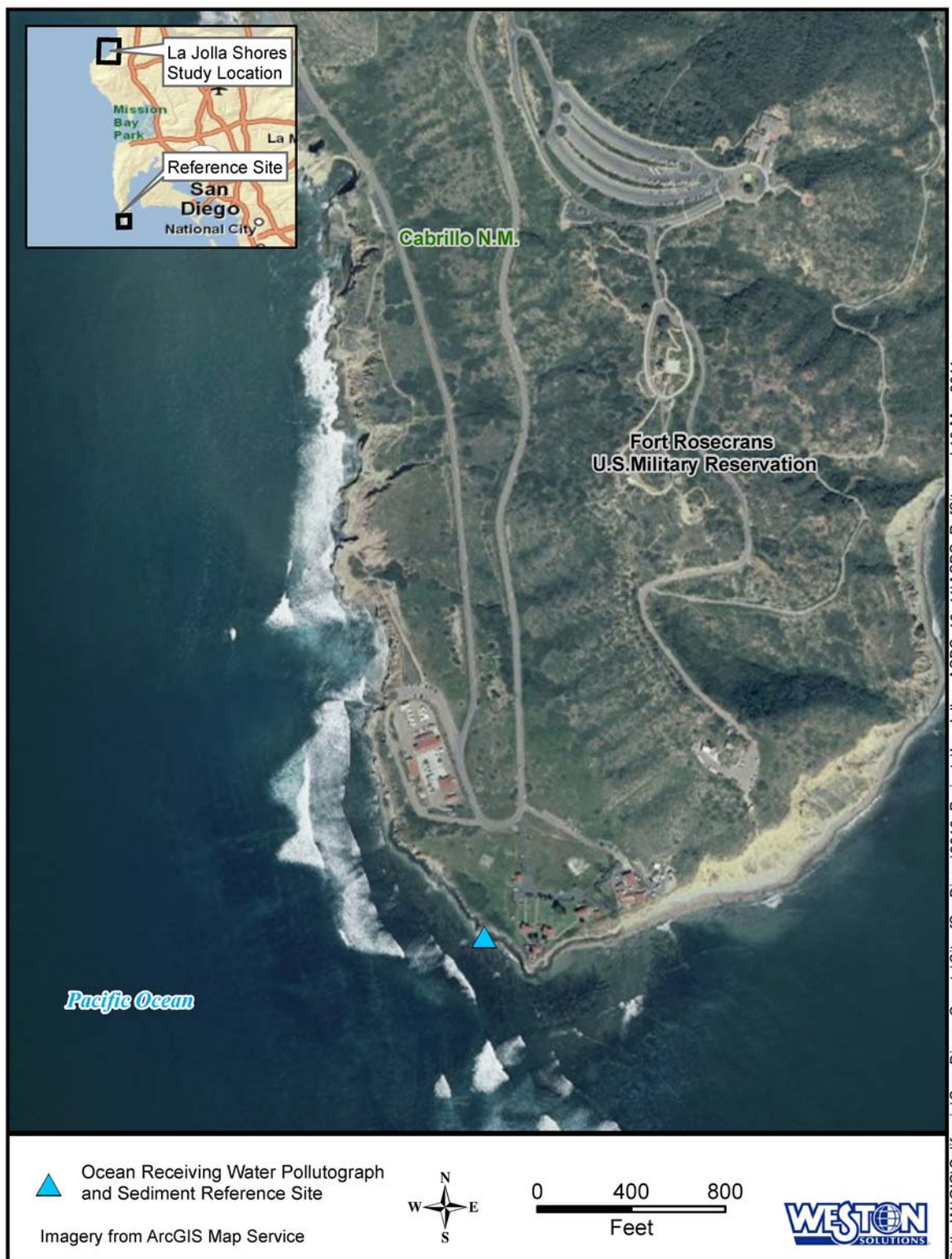


Figure 2-4. Cabrillo National Monument Reference Site Ocean Receiving Water and Sediment Sampling Location



**Figure 2-5. Receiving Water Collection Point in Front of Storm Drain SDL-062 at
Avenida de la Playa**

2.1.3 Pollutograph Monitoring

Samples for pollutograph monitoring were collected from storm drain SDL-186 over the course of a storm and from the rocky intertidal habitat directly in front of the discharge from SDL-186 (Figure 2-1 and Figure 2-6). Samples were also collected over the course of a storm within the intertidal zone of Cabrillo National Monument on Point Loma near the mouth of San Diego Bay (Figure 2-4 and Figure 2-7). Intertidal water samples were collected as grab samples from shallow tide pools throughout the entire storm event at both sites, as described below.

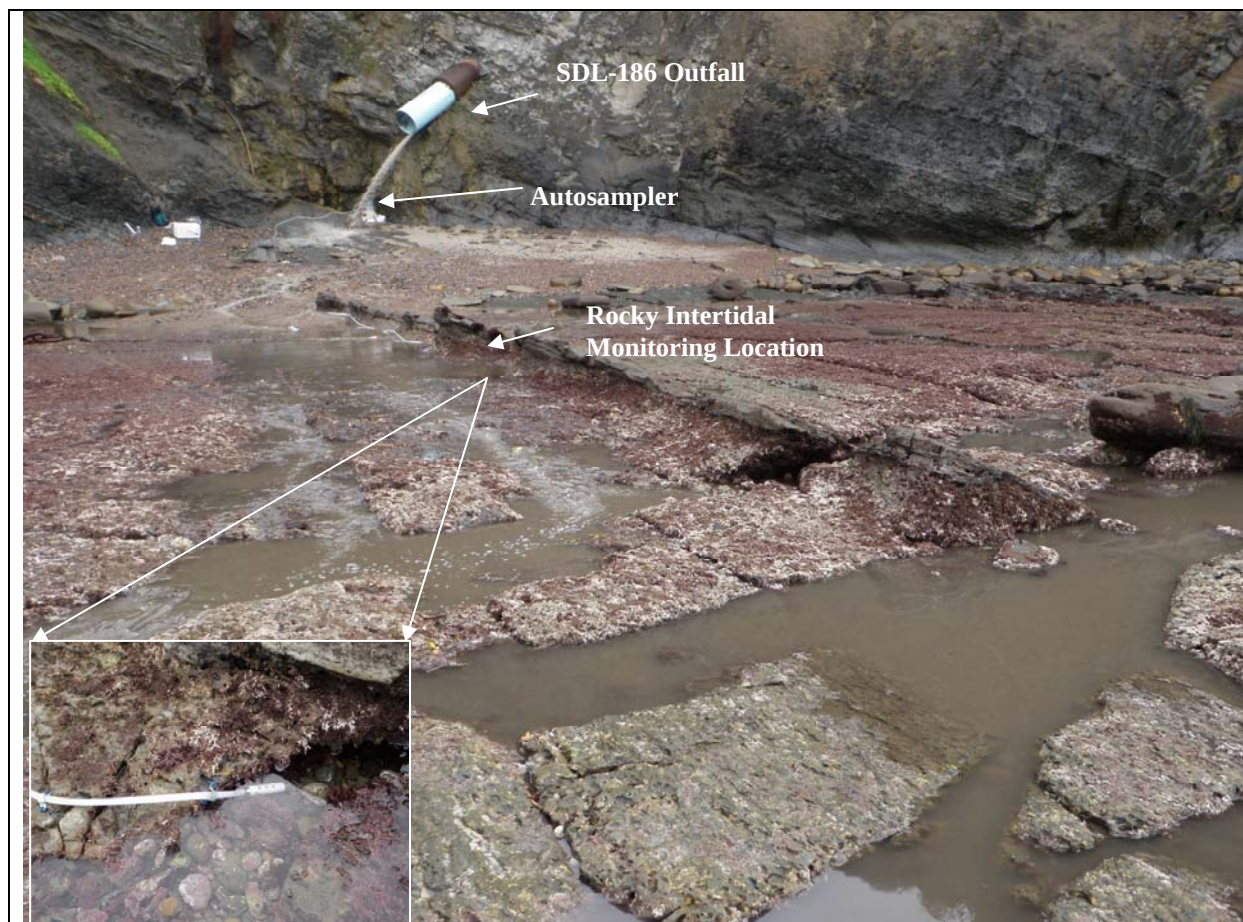


Figure 2-6. Rocky Intertidal Monitoring Location Below SDL-186 Outfall Pipe Showing Autosampler and Close-up of Tubing and Strainer (Inset)



Figure 2-7. Cabrillo National Monument Rocky Intertidal Monitoring Location

2.2 Sampling Methods

2.2.1 Core Discharge Sampling Methods

Storm sampling of major outfalls was performed during the 2010–2011 Wet Weather Monitoring Season in anticipation of the ratified Special Protections by the State Board (expected fall, 2011). Once the Core Discharge Monitoring Program is implemented as part of the Special Protections, all responsible parties discharging to ASBS will be required to comply with the Program's monitoring provisions. Grab samples were collected during the peak of one storm event (February 16, 2011) from each of the five major storm drains that discharge to the ASBS (Figure 2-1). Core discharge samples were collected from storm drain effluent as it exited the storm drain on the beach (end of pipe), prior to mixing with the ocean receiving water at all sites, except site SDL-186. Because the outlet of site SDL-186 is generally not accessible during storm events, grab samples were collected via a manhole located on Torrey Pines Road using an extendable sampling pole. Field technicians wearing clean, disposable gloves collected samples at all sites by submerging the sample container just below the surface of the water. Field data sheets detailing weather conditions, site appearance, runoff characteristics, and flow parameters were completed for each core discharge site.

Samples were collected in bottles appropriate for the analysis to be conducted. After retrieval, the samples were placed on ice in a cooler and were delivered to Physis Environmental Laboratories, Inc. (Physis) within the required holding times for analysis. Core discharge samples collected on February 16, 2011, and March 11, 2011, were analyzed for general chemistry, total and dissolved metals, synthetic pyrethroids, and OP pesticides. Method numbers, detection limits, reporting limits, and applicable Ocean Plan WQOs for constituents measured in the 2010–2011 Core Discharge Monitoring Program are provided in Appendix B.

Flow was measured in SDL-186 over the course of the February 16, 2011 storm event. To measure flow, an area velocity sensor was secured to the bottom of the storm drain channel. The sensor was connected to a Sigma 920 flow meter, which logged water column height (stage) over the course of the storm. Stage was converted to flow using the Manning's equation as follows:

2.2.2 Ocean Receiving Water Sampling Methods

Post-storm ocean receiving water grab samples were collected following the end of the rain event (within 4 hours from the cessation of rain) on February 16, 2011 from the Pacific Ocean in front of each major storm drain site. Samples were collected from the intertidal mixing zone of the ocean receiving water within ASBS 29. Field technicians wearing clean, disposable gloves collected all samples by submerging the sample container just below the surface of the water. Field data sheets detailing weather conditions, site appearance, runoff characteristics, and flow parameters were completed for each ocean receiving water site (Appendix A).

Samples were collected in bottles appropriate for the analysis to be conducted. After retrieval, the samples were placed on ice in a cooler and delivered to Physis Environmental Laboratories, Inc. within the required holding times for analyses. Ocean receiving water was analyzed for general chemistry, total and dissolved metals, synthetic pyrethroids, and OP pesticides. Chemical analysis methods, detection limits, reporting limits, and applicable Ocean Plan WQOs for constituents measured in ocean receiving water samples are provided in Appendix B.

In addition to samples collected for water chemistry, ocean receiving water quality was also assessed during the post-storm monitoring. A handheld YSI multi-probe water quality meter (Model 6920 V2) was used to measure several water quality parameters in the field. The meter was submerged in the surf zone at the same location of the receiving water monitoring. Parameters measured and recorded on field data sheets (Appendix A) included water temperature, salinity, pH, conductivity, turbidity, and dissolved oxygen (DO). In addition, observations were recorded on the field data sheets, including weather and ocean conditions, beach characteristics, and runoff characteristics. Photographs were taken and recorded where appropriate.

2.2.3 Pollutograph Sampling Methods

Samples were collected throughout the course of the February 16, 2011 storm event from SDL-186, a tide pool located below the SDL-186 outfall pipe within the ASBS receiving water, and the receiving water of Cabrillo National Monument. Water from storm drain from SDL-186 was collected using a clean sampling bucket that was filled by lowering it into the storm drain manhole on Torrey Pines Road. Samples were collected every 15 to 30 minutes over the course of the storm event. Aliquots from the sampling bucket for each sample were then poured into

appropriate laboratory sample containers, labeled, and placed into coolers on ice for transport to the laboratory.

Water samples were collected from the rocky intertidal zone at the same time as those collected from storm drain SDL-186. Samples were collected directly in front of the storm drain's outfall (as shown in Figure 2-6) from a tide pool in the rocky intertidal zone located at a tidal height of approximately +2 feet. The approximate location of the tide pool is depicted on Figure 2-8, which shows the degree to which the tide pool is exposed over the course of a tidal cycle. The type of sample collection was dependent on the tide. Spring tides (maximal low and high tides within the 30-day tidal period) were occurring on the day of the storm event with a low tide of – 1.2 feet at 2:06 p.m. and a high tide of + 4.3 feet at 8:25 p.m. On the day of the storm, rainfall began at approximately 2:30 p.m., which occurred just after low tide and continued until approximately 7:00 p.m., just before the peak of the high tide. Grab samples were collected by hand from the tide pool shown on Figure 2-8 from the onset of rain until approximately 4:30 p.m., when the tide had reached a height of approximately +1 feet.

At the point the site was inaccessible and samples were collected with an autosampler secured to the cliff face adjacent to the SD-186 outfall (Figure 2-6). The autosampler was connected via tubing to a submerged strainer secured to the tide pool inner wall and programmed to collect samples every 20 minutes. In this way, samples were collected from the same location over the course of the tidal cycle (low tide to high tide, approximately six hours).

At the Cabrillo National Monument reference site, there are no storm drains that discharge to the immediate area. At this site, ocean receiving water samples were collected during the February 16, 2011 storm event, coincident with those collected at the ASBS 29 site. Samples were collected from a tide pool at the same approximate tidal height (approximately +2 feet) as the ASBS 29 site. Grab samples were collected manually at intervals of approximately 20 minutes over the course of the storm, using a clean sampling bucket. Aliquots from the sampling bucket were then poured into appropriate laboratory sample containers, labeled, and placed into coolers on ice for transport to the laboratory.

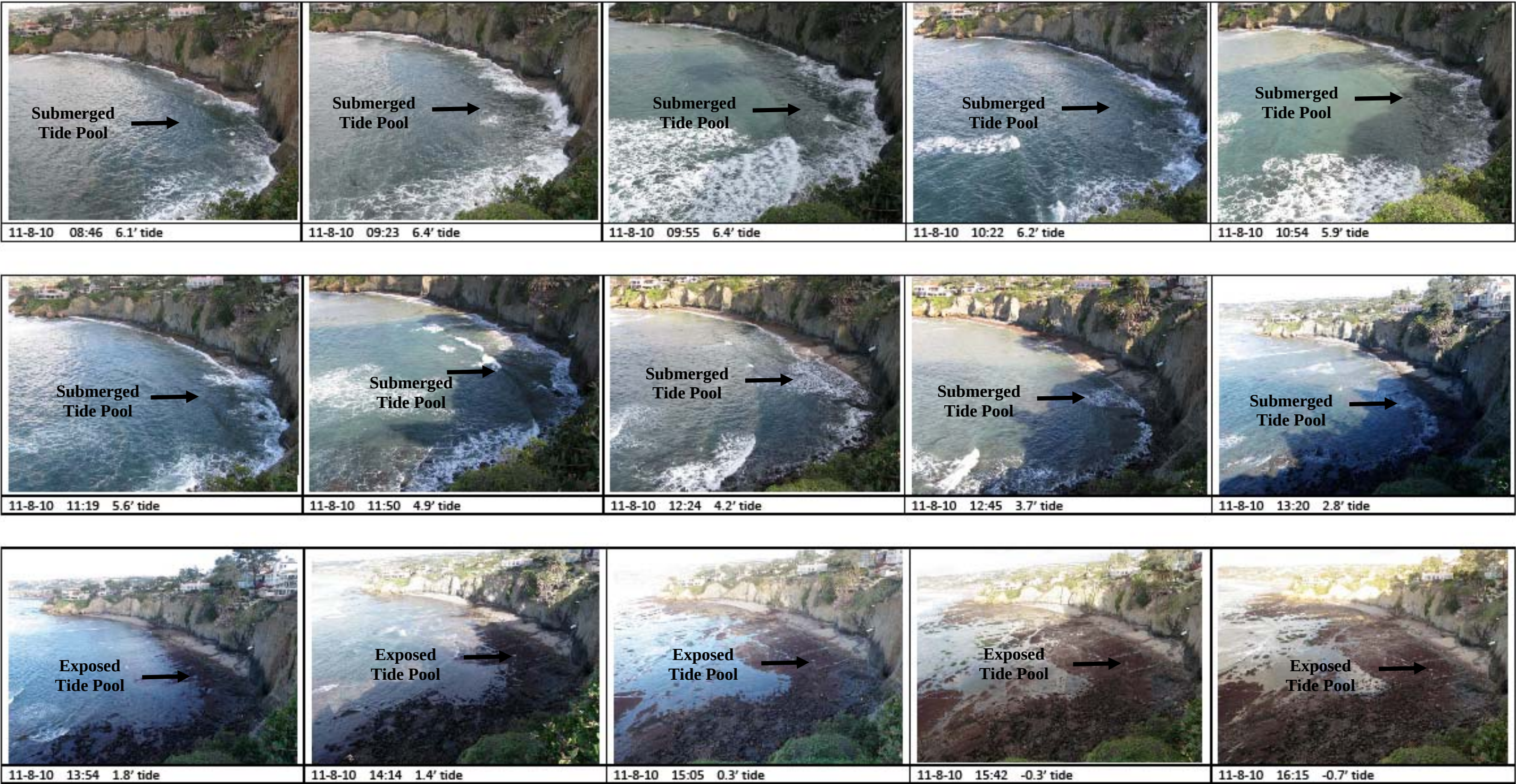


Figure 2-8. Tidal Cycle at Rocky Intertidal Zone Below SDL-186 on November 8, 2010, Showing Approximate Location of Tide Pool Monitored During February 16, 2011 Storm Event

2.2.4 Post-Storm Sediment Sampling Methods

Post-storm sediment samples were collected on March 25, 2011, following storm events on March 21, 2011 and March 24, 2011. Sediment samples were collected from the upper and lower intertidal zones during low tide from locations in line with the storm water runoff stream leading from each of the five major storm drain outfalls along the beach to the ASBS. Sediment was collected at each location using a clean, stainless steel spoon and mixing bowl. Only the top 5 cm of sediment was collected into the mixing bowl, homogenized using the spoon, and placed into 8-oz. laboratory-



Figure 2-9. Sediment Collection and Homogenization

certified clean glass jars for chemical analysis (Figure 2-9). A 100-g aliquot of sediment was placed into a ZiplocTM bag from each site for grain size analysis. All samples were placed in a cooler on ice and were shipped to Physis within the required holding times for chemical analysis and to Weston for grain size analysis.

2.2.5 Biological Surveys Sampling Methods

Biological surveys were also conducted as part of this study. Researchers from California State University, Fullerton conducted two surveys of the algae and meiofauna (small benthic invertebrates) communities in rocky intertidal habitats at three sites: ASBS 29 in front of SDL-186, the Cabrillo National Monument reference site, and Sunset Cliffs. The complete report is available in Appendix F and is summarized in the Results Section.

2.3 Sample Analyses

Laboratory analysis of samples was performed in accordance with currently accepted standard methods and procedures by laboratories accredited by ELAP. Table 2-1 provides a list of analyses performed for each sample type collected in the 2010-2011 La Jolla ASBS Regional Compliance Monitoring Study. The laboratory that performed the analysis is summarized in Table 2-2. Samples were analyzed in accordance with methods listed in Appendix B.

Table 2-1. Analyses Performed on Core Discharge, Receiving Water, Storm Water and Rocky Intertidal Pollutograph, and Sediment Samples

Constituent Group	Analyte	Core Discharge	Receiving Water	Storm Water and Rocky Intertidal Pollutograph	Sediment
General Chemistry	Ammonia-N	x	x		
	DOC	x	x	x	
	Nitrate-N	x	x		
	Nitrite-N	x	x		
	TKN	x	x		
	Salinity	x	x	x	
	Hardness	x	x	x	
	Percent Solids				x
	TOC				x
	Total Phosphorus	x	x		
	TSS	x	x	x	
Total and Dissolved Metals	Arsenic	x	x	x	x
	Cadmium	x	x	x	x
	Chromium	x	x	x	x
	Copper	x	x	x	x
	Lead	x	x	x	x
	Nickel	x	x	x	x
	Selenium	x	x	x	x
	Silver	x	x	x	x
	Zinc	x	x	x	x
Pyrethroids	Allethrin	x	x	x	x
	Bifenthrin	x	x	x	x
	Cyfluthrin	x	x	x	x
	Cypermethrin	x	x	x	x
	Danitol	x	x	x	x
	Deltamethrin	x	x	x	x
	Esfenvalerate	x	x	x	x
	Fenvalerate	x	x	x	x
	Fluvalinate	x	x	x	x
	L-Cyhalothrin	x	x	x	x
	Permethrin, cis-	x	x	x	x
	Permethrin, trans-	x	x	x	x
	Parallethrin	x	x	x	x
Pesticides	Organophosphorus Pesticides	x	x	x	x
	Aroclor PCBs				x
	PCB congeners				x

Table 2-1. Analyses Performed on Core Discharge, Receiving Water, Storm Water and Rocky Intertidal Pollutograph, and Sediment Samples

Constituent Group	Analyte	Core Discharge	Receiving Water	Storm Water and Rocky Intertidal Pollutograph	Sediment
PAHs	PAHs				x
Grain Size	Grain Size				x
Toxicity Testing	Abalone	x*			
	Bivalves	x*			
	Mysids	x*			
	Echinoderms	x*			
	Diatoms	x*			

x* core discharge samples from SDL-186

Table 2-2. Analytical Laboratories Used for Sample Analysis

Analytical Laboratory	Location	Analyses
Weston Solutions, Inc.	Carlsbad, CA	Grain Size, Toxicity
Physis Environmental Labs, Inc.	Anaheim, CA	Water and Sediment Chemistry

2.3.1 Toxicity Analyses

Storm water was collected in clean 3.6-L glass sample bottles from SDL-186 and the Cabrillo National Monument reference site during the peak of the February 16, 2011 storm event and used for toxicity testing. The following five bioassay tests were performed on each sample: a 48-hour echinoderm fertilization test, a 48-hour bivalve development test, a 96-hour mysid acute survival test, a 48-hour abalone fertilization test, and a 48-hour diatom growth test. Methods for conducting each bioassay were modified to simulate exposure to storm water effluent that rocky intertidal organisms might experience over a typical tidal cycle. In each test, organisms were exposed to varying concentrations of storm water over a 6-hour time period. After the 6-hour exposure, different methods were incorporated to place the organisms into seawater control exposures for the remainder of the tests.

2.3.1.1 Echinoderm Fertilization Test

Adult sea urchins (*Strongylocentrotus purpuratus*) sperm were exposed for 20 minutes to different concentrations of storm water in a static test and then were tested for their ability to fertilize eggs. Sperm was inoculated into four replicates each of different concentrations of sample water collected from the two sites. Following a 20-minute exposure, eggs were inoculated into the chambers for an additional 20-minute exposure during which fertilization took place. Control chambers using sperm exposed to laboratory seawater were run with each test.

Injections of potassium chloride were used to induce spawning. The eggs were collected into a 1-L beaker and stored at 12°C. Sperm was transferred by pipette into a culture tube and kept on ice. A target concentration of 1,120 eggs/mL of seawater was prepared by counting the eggs using a compound microscope and a Sedgewick-Rafter counting chamber and diluting the egg stock with seawater until the approximate target concentration was reached. Appropriate sperm density was determined by conducting a trial fertilization test during which the lowest sperm-to-egg ratio resulting in 90% fertilization in control water was chosen for the test. At the end of the 40-minute test, larvae in each chamber were preserved with 1 mL of 10% formalin. To determine the percentage fertilization, 100 random eggs were counted in each replicate. Fertilization membrane elevation was the criterion used to determine fertilization.

2.3.1.2 48-Hour Bivalve Development Test

Bivalve (*Mytilus galloprovincialis*) larvae (less than 4 hours old) were exposed for 48 hours in a static test. Four replicate test chambers, each containing approximately 15–30 larvae per mL of test substance, were used for each test concentration. Five test concentrations were used in each test (i.e., 6.25%, 12.5%, 25%, 50%, and 100% test substance unless brine controls were employed). Salt controls were used to account for any toxic effects caused by the addition of salt to the test samples to bring them within the acceptable salinity range for the bivalve larvae. Control chambers using laboratory seawater were run with each test.

Temperature shock was used to induce spawning of adult bivalves and test chambers were inoculated with an embryo suspension (approximately 300 embryos per 10 mL) within 4 hours of fertilization. After 48 hours, the test was terminated by adding 1 mL of buffered formalin to the test chambers. The percentage of normal (D-shaped shell) and abnormal larvae (meatball shaped) (Figure 2-10) and the percentage of larvae that survived were determined for each test concentration using a compound microscope. A reference toxicant test was run concurrently with the test to assess the health and sensitivity of the test organisms. Tests were deemed acceptable if at least 50% of bivalve larvae survived in control chambers and at least 90% of bivalve larvae had normal shell development.

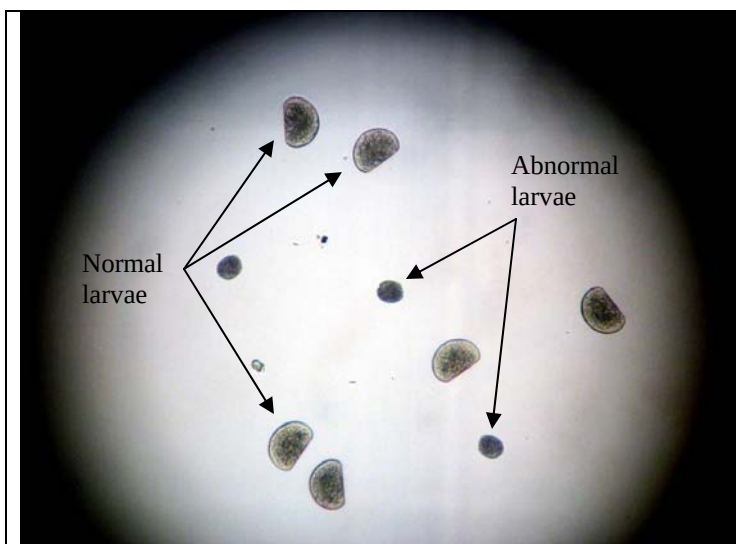


Figure 2-10. Example of Normal and Abnormal Bivalve Larvae from the Bivalve Development Test

2.4 Quality Assurance/Quality Control Procedures

Field measurements for pH, conductivity, and temperature were made using an YSI 6920 V2 water quality probe in accordance with the manufacturer's specifications. The instruments were calibrated before each sampling event.

Quality assurance (QA) and quality control (QC) for sampling processes included proper collection of the samples to minimize the possibility of contamination. Sampling personnel wearing powder-free nitrile gloves collected all samples in laboratory-supplied, laboratory-certified, contaminant-free sample bottles. All sampling personnel were trained in accordance with the field sampling standard operating procedures (SOPs). Field personnel were informed of the significance of the project detection limits and the requirement to avoid contamination of samples at all times. A temperature blank was used to ensure sample holding temperatures were maintained from sample collection to laboratory delivery. In addition, field duplicate and blank samples were collected and analyzed in accordance with Surface Water Ambient Monitoring Program (SWAMP) protocols.

2.5 Chain-of-Custody Procedures

Chain-of-custody (COC) procedures were used for all samples throughout the collection, transport, and analytical process. Samples were considered to be in custody if they were (1) in the custodian's possession or view, (2) retained in a secured place (under lock) with restricted access, or (3) placed in a container and secured with an official seal such that the sample could not be accessed without breaking the seal. The principal documents used to identify samples and to document possession were COC records, field logbooks, and field tracking forms.

The COC procedures were initiated during sample collection. A COC record was provided with each sample or group of samples. Each person who had custody of the samples signed the form and ensured the samples were not left unattended unless properly secured. Documentation of sample handling and custody included the following:

- Sample identifier.
- Sample collection date and time.
- Any special notations on sample characteristics or analysis.
- Initials of the person collecting the sample.
- Date the sample was sent to the analytical laboratory.
- Shipping company and waybill information.

Completed COC forms were placed in a plastic envelope and kept inside the cooler with the samples. Once delivered to the analytical laboratory, the COC form was signed by the person receiving the samples. The condition of the samples (i.e., confirming all samples were accounted for and properly labeled, the temperature of the samples, and integrity of the sample jars) was noted and recorded by the receiver. COC records were included in the final reports prepared by the analytical laboratories and are considered an integral part of the report.

3.0 RESULTS AND DISCUSSION

3.1 Core Discharge Monitoring Results

Storm water grab samples from five core discharge monitoring sites (major storm drains that discharge into ASBS 29, as shown on Figure 2-1) were collected on February 16, 2011 during the peak of the storm. A second storm was sampled on March 11, 2011 from SDL-186. Photographs taken during the storm at two sites are presented on Figure 3-1. Core discharge monitoring samples were analyzed for general chemistry, including ammonia, salinity, DOC, nitrate, nitrite, TKN, hardness, and total phosphorus, total and dissolved metals, OP pesticides, and pyrethroids.



Figure 3-1. Storm Water Runoff at SDL-157 (A) and at SDL-062 (B) (Avenida de la Playa) during the February 16, 2011 Storm Event

3.1.1 General Chemistry

Ammonia, nitrate, and nitrite concentrations varied only slightly among the five storm drain outfalls. Ammonia concentrations were one order of magnitude below the instantaneous maximum value of 6.0 mg/L across all storm drains, ranging from 0.19 mg/L at SDL-063 to 0.57 mg/L at SDL-063B. Ammonia is the only general chemistry constituent that has a WQO listed in the Ocean Plan. Nitrate ranged from 0.5 mg/L to 0.7 mg/L while nitrite concentrations were all below the reporting limit across all sites. Total Kjeldahl nitrogen was approximately three times higher at SDL-157 (6.4 mg/L) than at any of the other four sites. Total hardness varied somewhat between sites, ranging from 42.5 mg/L at SDL-186 to 115.2 mg/L at SDL-063. DOC concentrations were relatively consistent across the five storm drains. DOC ranged between 10 and 19 during the February 16, 2011 storm event. TSS and total phosphorus concentrations were highest at SDL-186. TSS was 352 mg/L at SDL-186 while at all other sites it ranged from

73 mg/L to 110 mg/L. Similarly, total phosphorus concentrations at SDL-186 were 0.7 mg/L while at the other four sites total phosphorus ranged between 0.34 mg/L and 0.45 mg/L. Salinity was below 1 ppt across all core discharge sites.

3.1.2 Metals

3.1.2.1 Dissolved Metals

Dissolved metal concentrations of arsenic, chromium, copper, lead, nickel, and zinc were detected in all of the storm drain outfalls during the monitored storm event. The Ocean Plan does not provide water quality objectives for dissolved metals. Dissolved cadmium, dissolved selenium and dissolved silver concentrations were less than reporting limits in all storm drain samples. Dissolved copper, chromium, and zinc concentrations varied the most among the storm drain outfall sites. Copper concentrations ranged from 21.4 µg/L at SDL-063 to 48.5 µg/L at SDL-063B, while chromium concentrations ranged from 0.79 µg/L at SDL-063B to 10.4 µg/L at SDL-186, and zinc concentrations ranged from 10.4 µg/L at SDL-186 to 34.3 µg/L at SDL-157.

3.1.2.2 Total Metals

Concentrations of total chromium, copper, lead, and zinc were above Ocean Plan Daily Maximum and Instantaneous Maximum WQOs during peak flow conditions at one or more core discharge sites (Figure 3-2, Table 3-1). Site SDL-186 had concentrations of total chromium, copper, lead, and zinc that were above the Instantaneous Maximum WQO and had the highest concentrations of chromium, lead, and zinc among the five discharge sites. Site SDL-063 was above the Ocean Plan Daily Maximum WQO for total chromium, lead, and zinc, and was above the Instantaneous Maximum WQO for copper. Sites SDL-062, SDL-063B, and SDL-157 were above the Ocean Plan Daily Maximum WQO for total zinc and the Ocean Plan Instantaneous Maximum WQO for copper. SDL-063B had the highest copper concentration among the five sites, though all sites had concentrations above the Ocean Plan Instantaneous Maximum WQO for copper. Chromium, lead, zinc, and nickel concentrations were generally two fold or more higher at SDL-186 than at any of the other four discharge sites during the February 16, 2011 storm event. Nearly all metal concentrations were slightly lower at SDL-186 during the March 11, 2011 storm event than during the February 16, 2011 storm event.

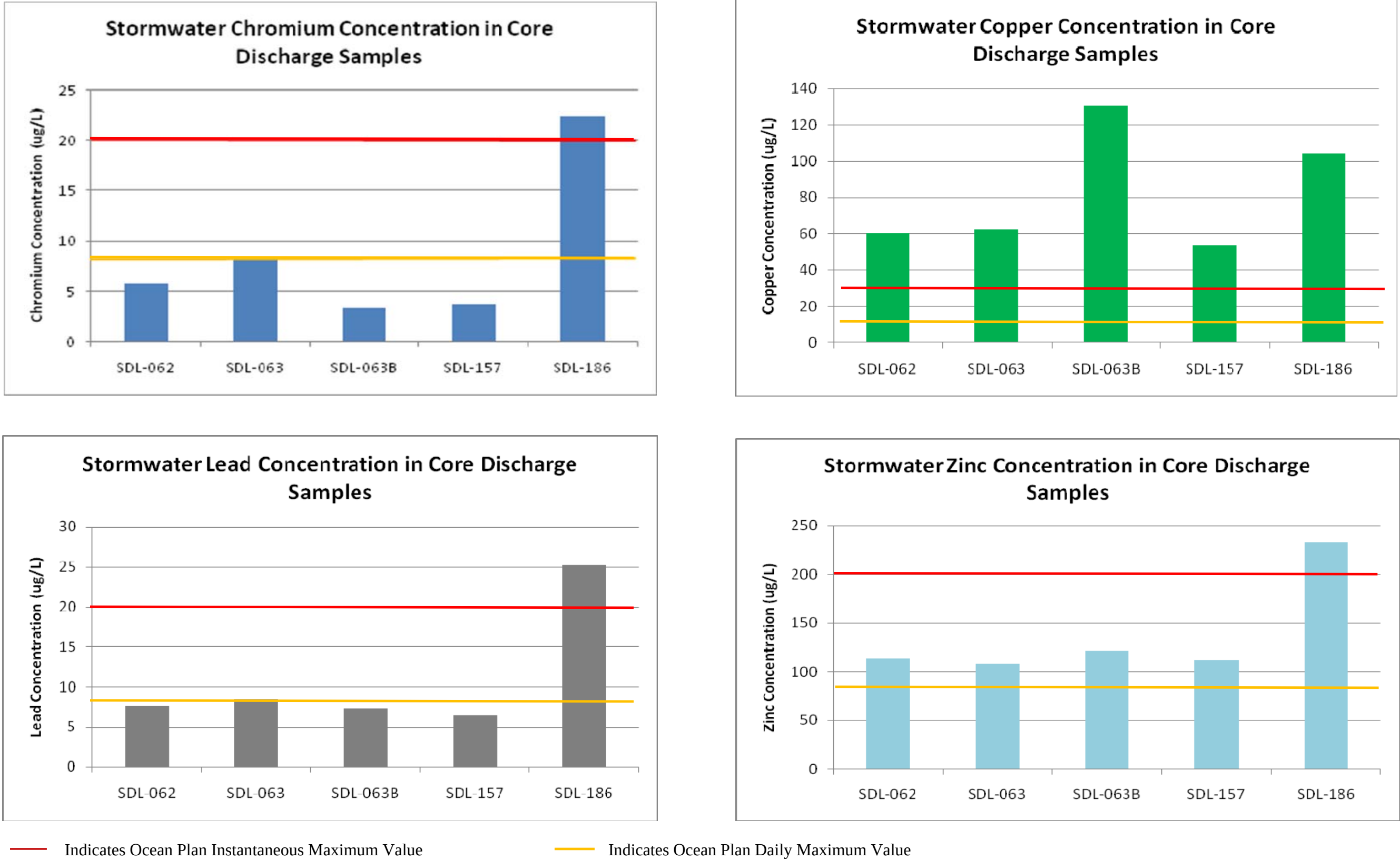


Figure 3-2. Total Copper, Chromium, Lead, and Zinc Concentrations Measured in Core Samples and Compared to Ocean Plan Water Quality Objectives

Table 3-1. Summary of Core Chemistry Results for Five Storm Drain Outfalls that Drain to ASBS 29

Analyte		Ocean Plan WQO			Date of Storm Event	SDL-062	SDL-063	SDL-063B	SDL-157	SDL-186
		Six-Month Median	Daily Maximum	Instantaneous Maximum						
Total arsenic (µg/L)		8	32	80	2/16/11	1.69	2.23	1.96	2.98	3.77
					3/11/11	NS	NS	NS	NS	4.36
Total cadmium (µg/L)		1	4	10	2/16/11	<0.2	<0.2	<0.2	<0.2	0.386J
					3/11/11	NS	NS	NS	NS	0.266J
Total chromium (µg/L)		2	8	20	2/16/11	5.76	8.19	3.41	3.78	22.4
					3/11/11	NS	NS	NS	NS	18.0
Total copper (µg/L)		3	12	30	2/16/11	60.1	62.7	130	53.9	104
					3/11/11	NS	NS	NS	NS	44.0
Total lead (µg/L)		2	8	20	2/16/11	7.65	8.39	7.35	6.42	25.2
					3/11/11	NS	NS	NS	NS	17.3
Total nickel (µg/L)		5	20	50	2/16/11	4.43	4.73	3.81	4.69	8.77
					3/11/11	NS	NS	NS	NS	9.06
Total selenium (µg/L)		15	60	150	2/16/11	0.382J	1.36	0.486J	0.221J	3.33
					3/11/11	NS	NS	NS	NS	0.214J
Total silver (µg/L)		0.7	2.8	7	2/16/11	<0.5	<0.5	<0.5	<0.5	<0.5
					3/11/11	NS	NS	NS	NS	<0.5
Total zinc (µg/L)		20	80	200	2/16/11	114	108	122	112	233
					3/11/11	NS	NS	NS	NS	113
OP pesticides (ng/L)		No values listed in Ocean Plan for protection of marine aquatic life			2/16/11	ND	ND	ND	ND	ND
					3/11/11	NS	NS	NS	NS	ND
Pyrethroids (ng/L)	Bifenthrin	4.0 ng/L 96-h LC ₅₀ for Mysid shrimp*			2/16/11	516	434	1,514	779	1,818
					3/11/11	NS	NS	NS	NS	107
	Cyfluthrin	2.42 ng/L 96-h LC ₅₀ for Mysid shrimp*			2/16/11	235	122	417	89.8	140
					3/11/11	NS	NS	NS	NS	<0.5
	Cypermethrin	36.0 ng/L 96-h LC ₅₀ for <i>Penaeus sp.</i> **			2/16/11	123	<0.5	254	158	196
					3/11/11	NS	NS	NS	NS	<0.5

Values exceeding daily maximum and Instantaneous Ocean Plan WQOs are highlighted in yellow and orange, respectively.

Values exceeding the pyrethroid LC₅₀ value for marine organisms are highlighted in purple.

J = Indicates value is above MDL but below method reporting limit (MRL).

NA = Indicates analysis was not performed for a given analyte.

ND = Indicates value was below MDL.

NS = Indicates site was not sampled.

* USEPA, 2002.

** CDFG, 2000.

3.1.3 Organophosphorus Pesticides

Results from core discharge samples collected during two monitored storm events indicated that no organochlorine pesticides were detected at any of the five storm drain outfalls during the February 16, 2011 or March 11, 2011 storm events. Currently, no WQOs are provided in the Ocean Plan for OP pesticides with regard to the protection of marine life.

3.1.4 Synthetic Pyrethroids

The synthetic pyrethroids Bifenthrin, Cyfluthrin, Cypermethrin, and trans-Permethrin were detected at every core discharge location, with the exception of Cypermethrin at SDL-063, during the February 16, 2011 storm event (Figure 3-3). Fluvalinate, Deltamethrin, and cis-Permethrin were also detected in high concentrations at one or more sites, while allethrin, L-Cyhalothrin, and Parallethrin were detected at a single site in relatively low concentrations. Although the Ocean Plan does not provide WQOs for pyrethroids, toxicity studies have been performed on the effects of Bifenthrin, Cyfluthrin, and Cypermethrin exposures to marine species (USEPA, 2002). LC_{50} values (the concentration of a toxicant that kills 50% of the test organism) of 4 ng/L and 2.42 ng/L have been derived for the mysid shrimp (*Americamysis bahia*) in exposures to Bifenthrin and Cyfluthrin, respectively (USEPA, 2002). During the February 16, 2011, storm event, Bifenthrin and Cyfluthrin concentrations ranged from 108 to 454 times the mysid shrimp LC_{50} value for Bifenthrin and from 37 to 172 times the LC_{50} value for Cyfluthrin. The highest concentration of Bifenthrin was measured in SDL-186 during the February 16, 2011, storm, while the highest concentration of Cyfluthrin was measured in SDL-062. Cypermethrin concentrations ranged from below the LC_{50} value to seven times the LC_{50} value for *Penaeus* shrimp; the highest concentration of Cypermethrin was measured in SDL-063B.

Storm drain SDL-186 had substantially higher concentrations of Fluvalinate, a restricted-use pesticide that is used as an insecticide for mites, than any of the other storm drains. This supports pyrethroid results from the 2009-2010 Wet Weather Season, in which Fluvalinate concentrations were substantially higher at SDL-186 than at any of the other monitored storm drains. Cis-Permethrin and Deltamethrin were detected only at SDL-063B, and were detected at relatively high concentrations (2,837 ng/L and 6,481 ng/L, respectively). Cis-permethrin is found in the restricted-use pesticide Asana, and is used as an insecticide for crop protection while Deltamethrin, is an insecticide used in landscape settings.

Despite the relatively high concentrations of synthetic pyrethroids detected with respect to established toxicity benchmarks, it should be noted that the pulse of pyrethroid compounds entering the ASBS during a storm event typically occurs over a short time period. During each of three storm events monitored in the fall of 2008 through the spring of 2009, pyrethroid concentrations returned to non-detect levels (i.e., less than 0.5 ng/L) within 2 hours following peak flow (Weston, 2009). Similar results were observed in rocky intertidal pollutograph monitoring during this study.

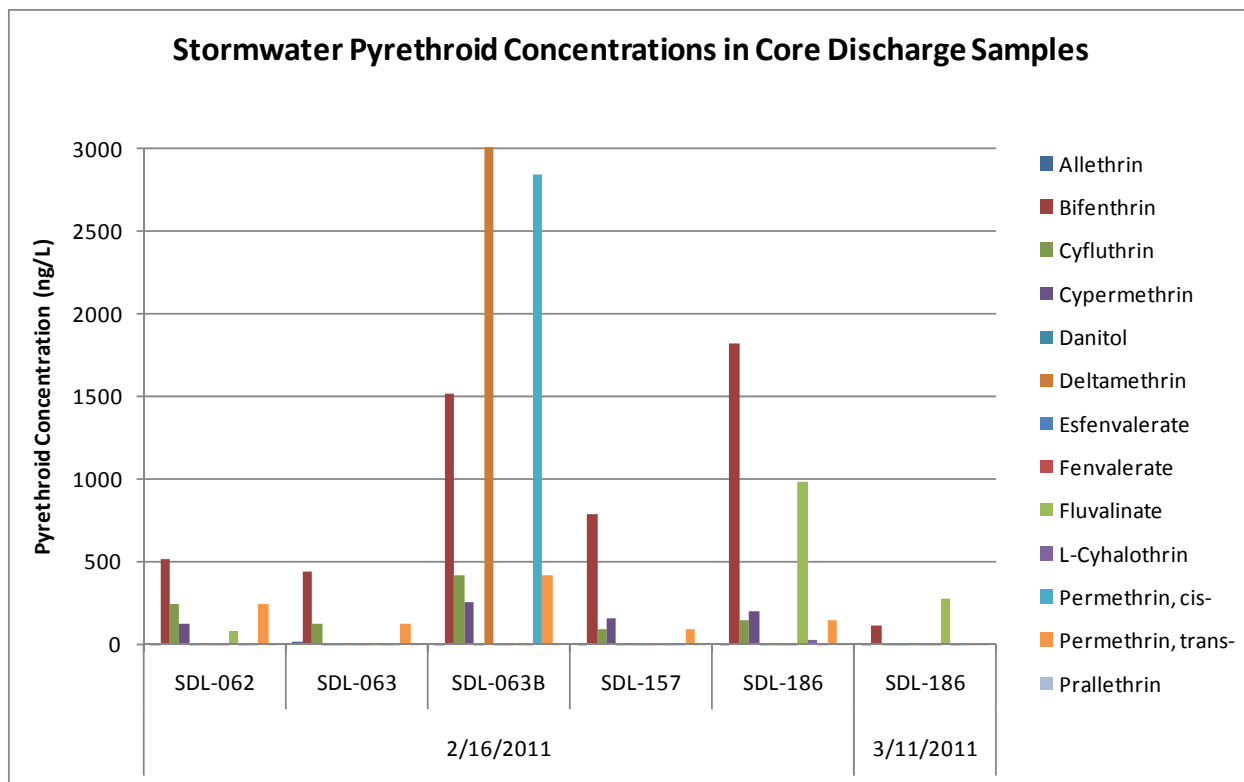


Figure 3-3. Core Discharge Concentrations of Synthetic Pyrethroids during Two Storm Events

3.2 Ocean Receiving Water Post-Storm Monitoring Results

Post-storm ocean receiving water monitoring samples were collected following the storm events of February 16, 2011 from the ocean receiving water in front of each of the five major storm drains that discharge into ASBS 29. Ocean receiving water at the Cabrillo National Monument reference site was collected following the storm event of March 11, 2011. A summary of the results for each analytical grouping are discussed below. To view the complete ocean receiving water dataset, please see Appendix C.

3.2.1 General Chemistry

General chemistry parameters monitored in the post-storm ocean receiving waters included total suspended solids (TSS), metals, salinity, dissolved organic carbon (DOC), ammonia, OP pesticides, synthetic pyrethroids, and nutrients (total Kjeldahl nitrogen (TKN), nitrate, nitrite, and total phosphorus). In general, concentrations of these parameters were low in the receiving waters and were similar to concentrations observed previously in pre-storm and post-storm compliance monitoring during the 2009-2010 wet weather season at SDL-062. The data are presented in Appendix C. Post-storm concentrations of nutrients were low; ammonia and nitrite were below reporting limits at each of the receiving water sites, while nitrate was above the reporting limit at only one site (receiving water at SDL-186) and TKN was slightly above the reporting limit at two sites (receiving water at SDL-063B and SDL-157). DOC and salinity concentrations were nearly uniform across all sites, ranging from 2.0 mg/L to 3.5 mg/L and from

30.8 ppt to 32.6 ppt, respectively. TSS was relatively low across all sites, ranging from 6.7 mg/L to 39.6 mg/L, and was comparable to TSS values measured in pre-storm monitoring in 2009–2010.

The reference site at Cabrillo National Monument had slightly higher salinity (35.8 ppt) and slightly lower DOC (1.5 mg/L) and TSS (5.5 mg/L) than the five monitored receiving water sites along ASBS 29.

3.2.2 Metals

3.2.2.1 Dissolved Metals

Detectable concentrations of dissolved arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc were present in all post-storm receiving water samples. Dissolved metal concentrations were relatively low and fairly consistent across all ocean receiving water sites (Figure 3-4). Dissolved zinc varied the most in concentration among the sites, ranging from 0.965 mg/L at SDL-063B to 1.649 mg/L at SDL-186.

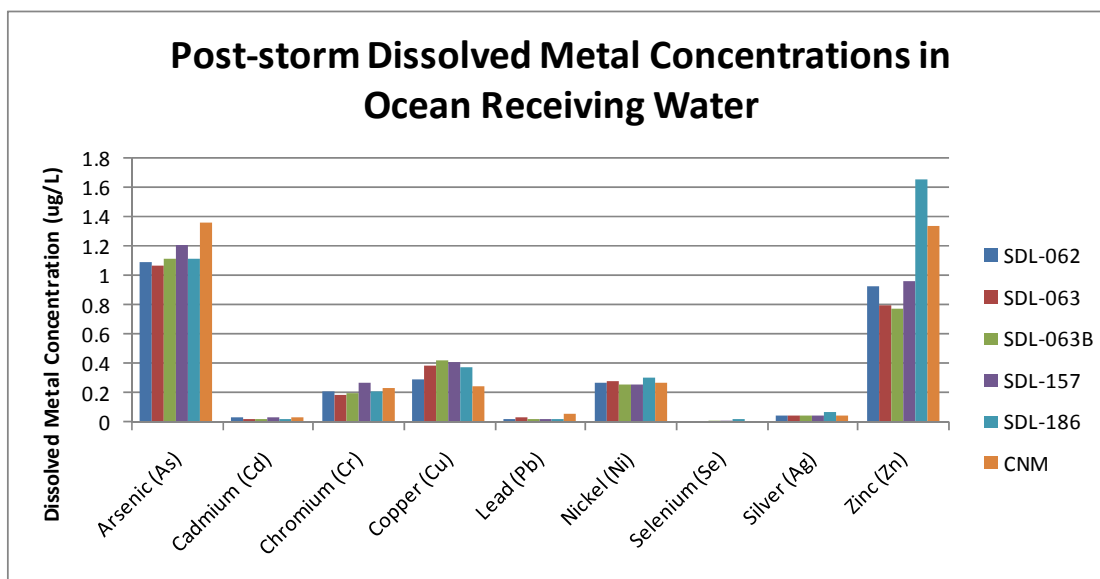


Figure 3-4. Dissolved Metal Concentrations in Post-storm Ocean Receiving Water

3.2.2.2 Total Metals

Detectable concentrations of total arsenic, cadmium, chromium, copper, lead, nickel, selenium, silver, and zinc were present in all post-storm receiving water samples. Total metal concentrations were low and relatively consistent across all ocean receiving water sites (Figure 3-5). Total metal concentrations were similar to, or slightly lower than, reference concentrations measured at the CNM reference site and were one or more orders of magnitude below Ocean Plan Daily Maximum and Instantaneous Maximum criteria at all sites (Table 3-2).

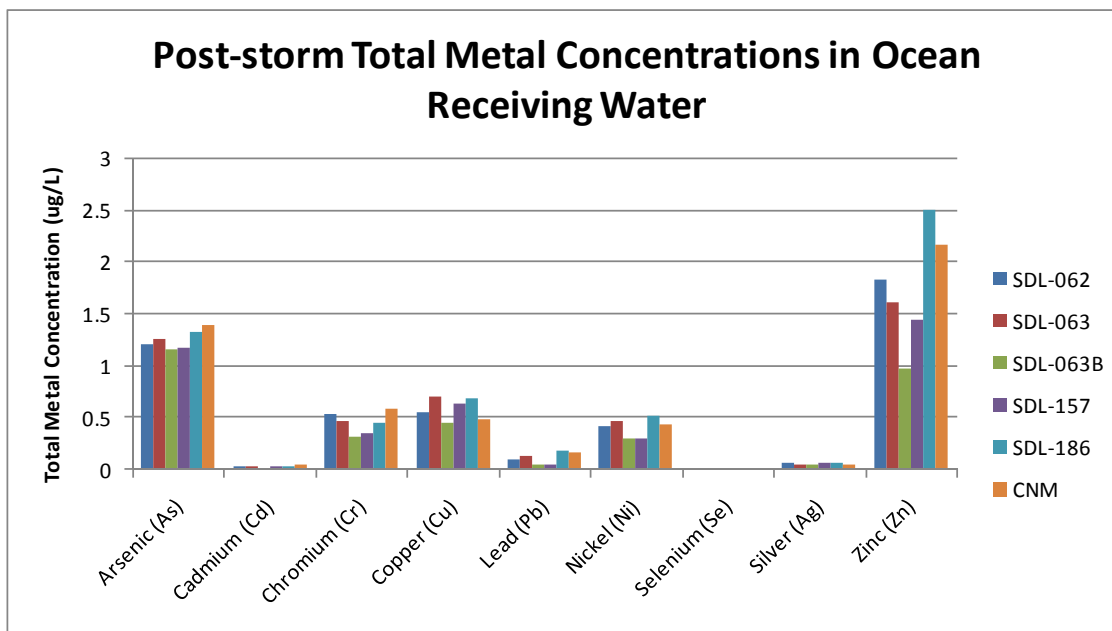


Figure 3-5. Total Metal Concentrations in Pre-Storm and Post-Storm Receiving Water Samples

3.2.3 Organophosphorus Pesticides and Synthetic Pyrethroids

OP pesticides and synthetic pyrethroids were not detected in post-storm receiving water samples. Because the Ocean Plan does not provide WQOs for pyrethroids, established toxicity values for Bifenthrin, Cyfluthrin, and Cypermethrin, based upon a literature review, are presented in Table 3-2 as a means for comparison.

Table 3-2. Total Metal, TSS, OP Pesticide, and Synthetic Pyrethroid Concentrations in Post-storm Ocean Receiving Water Samples

Analyte	Ocean Plan WQO			SDL-062	SDL-063	SDL-063B	SDL-157	SDL-186	CNM
	Six-Month Median	Daily Maximum	Instantaneous Maximum						
Total arsenic (µg/L)	8	32	80	1.205	1.255	1.153	1.177	1.32	1.394
Total cadmium (µg/L)	1	4	10	0.035	0.026	0.018	0.031	0.026	0.041
Total chromium (µg/L)	2	8	20	0.532	0.465	0.321	0.352	0.451	0.593
Total copper (µg/L)	3	12	30	0.551	0.711	0.454	0.64	0.69	0.478
Total lead (µg/L)	2	8	20	0.104	0.126	0.05	0.049	0.176	0.174
Total nickel (µg/L)	5	20	50	0.423	0.468	0.297	0.305	0.512	0.427
Total Selenium (ug/L)	15	60	150	0.016	0.017	0.012J	0.013J	0.016	0.015
Total Silver (ug/L)	0.7	2.8	7	0.066	0.054	0.054	0.063	0.072	0.05
Total zinc (µg/L)	20	80	200	1.828	1.609	0.965	1.435	2.496	2.158
TSS (mg/L)	No values listed in Ocean Plan for protection of marine aquatic life			6.7	35.3	22	19	39.6	5.5
OP pesticides (ng/L)	No values listed in Ocean Plan for protection of marine aquatic life			ND	ND	ND	ND	ND	ND
Pyrethroids (ng/L)	Bifenthrin	4.0 ng/L 96-h LC ₅₀ for Mysid shrimp**		ND	ND	ND	ND	ND	ND
				ND	ND	ND	ND	ND	ND
				ND	ND	ND	ND	ND	ND
	Cyfluthrin	2.42 ng/L 96-h LC ₅₀ for Mysid shrimp**		ND	ND	ND	ND	ND	ND
				ND	ND	ND	ND	ND	ND
				ND	ND	ND	ND	ND	ND
	Cypermethrin	36.0 ng/L 96-h LC ₅₀ for <i>Penaeus</i> sp.***		ND	ND	ND	ND	ND	ND
				ND	ND	ND	ND	ND	ND
				ND	ND	ND	ND	ND	ND

Values exceeding daily maximum and Instantaneous Ocean Plan WQOs are highlighted in yellow and orange, respectively.

J = Indicates value is above method detection limit (MDL) but below method reporting limit (MRL).

ND indicates value was below MDL.

** USEPA, 2002.

*** CDFG, 2000.

3.3 Pollutograph Monitoring Results

Pollutograph samples were collected over the course of the February 16, 2011 storm event from SDL-186, the receiving water at SDL-186, and the receiving water at Cabrillo National Monument. Sampling began at approximately 14:30 at the SDL-186 storm drain and receiving water sites shortly after the onset of the storm. There was a negative 1.3 ft tide at the time sampling began in the receiving waters at SDL-186. The tide continued to rise over the 6-hour sampling event to a height of 4.4 ft at 20:30. The flow meter installed inside SDL-186 indicated that storm flow runoff peaked twice over the course of the storm event: the initial peak of 0.7 cubic feet per second (cfs) occurred approximately 30 minutes after the rain began to cause runoff (15:00). Storm flow runoff then dropped off to less than 0.1 cfs between 15:30 and 16:00 before quickly rising to a sustained height of 0.8 cfs between 16:30 and 17:30. Flow dropped to less than 0.1 cfs at 17:30 and remained low until approximately 20:00 when runoff from the storm ended. Analytical results from pollutograph samples are discussed below.

3.3.1 General Chemistry

3.3.1.1 SDL-186 Storm Drain Effluent

TSS concentrations displayed a first flush effect with high concentrations at the beginning of the storm, then dropped somewhat before reaching a plateau around 700 mg/L for the first portion of the storm (Figure 3-6 and Table 3-3). The TSS concentration increased slightly during the second period of peak flow before tapering off at the end of the storm event. TSS concentrations ranged from 970 mg/L at the beginning of the storm to 160 mg/L at the storm's conclusion. DOC and salinity remained relatively stable throughout the storm event. DOC ranged from 9.6 mg/L to 18.1 mg/L, while salinity ranged from 0.1 ppt to 0.5 ppt.

3.3.1.2 Rocky Intertidal Receiving Water at SDL-186

In the rocky intertidal receiving waters, TSS displayed a first flush effect as well (Figure 3-6 and Table 3-4). A graph of the TSS concentration in the receiving water mirrors that displayed in the SDL-186 effluent, though concentrations are lower (approximately 60% of those in the effluent). TSS concentrations began to drop as the tide reached the intertidal area where the receiving water was being collected (17:50) and as the storm flow decreased. DOC and salinity concentrations were relatively consistent until the tide reached the tide pool. DOC ranged from 9.4 mg/L to 15.5 mg/L from the beginning of the storm event until 17:50. After 17:50, DOC fell to 5.4 mg/L and continued to slowly decrease through the end of the storm event. Similarly, salinity, with the exception of the first sample, was low throughout the first portion of the storm (ranging from 0.2 ppt to 2.5 ppt) prior to the tide reaching the tide pool where samples were collected. After 17:50, salinity rose to 25.1 ppt and continued to rise before throughout the remainder of the storm, reaching a plateau at 31 ppt at the end of the storm.

3.3.1.3 Rocky Intertidal Receiving Water at CNM

TSS was highest during the first flush and during the period of peak rainfall (17:15 to 17:45). TSS was substantially lower at CNM than at SDL-186, ranging from 2.4 mg/L to 32.8 mg/L (Table 3-5). DOC remained relatively stable throughout the storm event, ranging from 2.8 mg/L to 3.7 mg/L. Salinity was also relatively stable, with one exception. A low salinity value of 22.9 ppt was recorded at 17:15 during the period of time when rainfall was greatest. The single low value may be indicative of a freshwater lens that developed on the water's surface during this time. Throughout the rest of the storm event, salinity ranged from 30.3 ppt to 32.7 ppt.

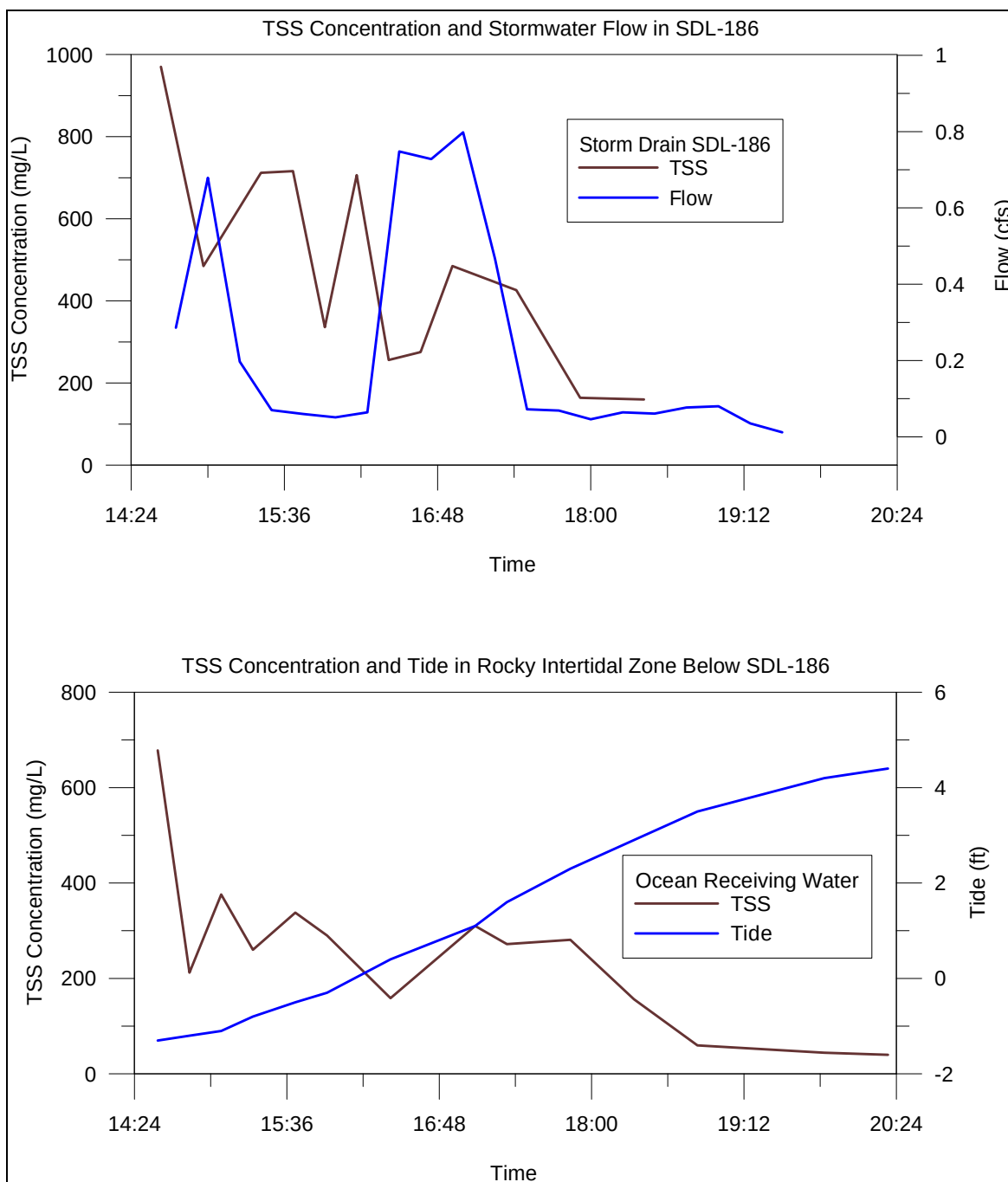


Figure 3-6. TSS Concentrations in Storm Drain SDL-186 (top) and the Rocky Intertidal Receiving Water below SDL-186 (bottom)

Table 3-3. Summary of Storm Water Pollutograph Results for SDL-186 Storm Drain Effluent

Analyte		Ocean Plan WQO			SDL-186-SD-1	SDL-186-SD-2	SDL-186-SD-3	SDL-186-SD-4	SDL-186-SD-5	SDL-186-SD-6	SDL-186-SD-7	SDL-186-SD-8	SDL-186-SD-9	SDL-186-SD-10	SDL-186-SD-11	SDL-186-SD-12
		Six-Month Median	Daily Maximum	Instantaneous Maximum	14:38	14:58	15:25	15:40	15:55	16:10	16:25	16:40	16:55	17:25	17:55	18:25
TSS (mg/L)		No values listed in Ocean Plan for protection of marine aquatic life			970	485	712	716	336	706	256	275	485	426	164	160
DOC (mg/L)					13.1	13.3	15.6	15.6	18.1	12.8	10.3	9.7	9.6	13.4	13.3	12.9
Salinity (ppt)					0.1J	0.1J	0.3	0.3	0.5	0.1J	0.1J	0.1J	0.1J	0.1J	0.2	0.3
Total arsenic (µg/L)		8	32	80	7.62	6.98	7.25	8.51	7.97	4.59	3.61	3.88	5.01	5.12	5.24	4.80
Total cadmium (µg/L)		1	4	10	1.05	0.53	0.376J	0.308J	0.263J	0.761	0.441	0.563	0.254J	0.207J	<0.2	<0.2
Total chromium (µg/L)		2	8	20	34.5	32.8	25.3	23.4	20.7	10.8	18.9	23.1	24.2	15.8	10.3	7.42
Total copper (µg/L)		3	12	30	206	146	102	76.5	62.8	149	132	84.7	83.3	71.0	55.8	41.4
Total lead (µg/L)		2	8	20	103	51.9	27.3	26.5	21.0	55.2	24.2	17.3	17.1	16.0	10.4	14.6
Total nickel (µg/L)		5	20	50	20.9	15.8	12.6	11.8	9.87	14.7	8.54	7.92	7.97	7.12	5.08	4.47
Total selenium (µg/L)		15	60	150	3.22	6.15	7.11	11.4	9.41	3.76	3.20	2.05	4.40	3.26	3.76	2.93
Total silver (µg/L)		0.7	2.8	7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total zinc (µg/L)		20	80	200	819	384	221	155	132	597	284	185	154	118	76.4	60.3
OP Pesticides (ng/L)		No values listed in Ocean Plan for protection of marine aquatic life			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrethroids (ng/L)	Bifenthrin	4.0 ng/L 96-h LC ₅₀ for Mysid shrimp*			2,357	13,961	2,890	3,068	3,046	2,361	1,041	6,282	2,622	1,780	1,171	810
	Cyfluthrin	2.42 ng/L 96-h LC ₅₀ for Mysid shrimp*			255	59.1	28.7	<0.5	22.3	33.6	95.9	55.5	38.3	29.5	25.5	17.4
	Cyper-methrin	36.0 ng/L 96-h LC ₅₀ for <i>Penaeus sp.</i> **			211	87.7	35.8	<0.5	50.5	222	131	162	75.1	60.3	41.2	37.2

Values exceeding daily maximum and Instantaneous Ocean Plan WQOs are highlighted in yellow and orange, respectively.
Pyrethroid concentrations that exceeded LC₅₀ values in the literature for marine invertebrate organisms are highlighted in purple.
ND = Indicates value was below MDL.
* USEPA, 2002.
** CDFG, 2000.

Table 3-4. Summary of Rocky Intertidal Receiving Water Pollutograph Results In Rocky Intertidal Receiving Waters below SDL-186 Outfall

Analyte		Ocean Plan WQO			SDL-186- RW-1	SDL-186- RW-2	SDL-186- RW-3	SDL-186- RW-4	SDL-186- RW-5	SDL-186- RW-6	SDL-186- RW-7	SDL-186- RW-8	SDL-186- RW-9	SDL-186- RW-10	SDL-186- RW-11	SDL-186- RW-12	SDL-186- RW-14	SDL-186- RW-15	SDL-186- RW-16
		Six-Month Median	Daily Maximum	Instant- aneous Maximum	14:35	14:50	15:05	15:20	15:40	15:55	16:25	17:05	17:20	17:50	18:20	18:50	19:50	20:20	20:50
TSS (mg/L)		No values listed in Ocean Plan for protection of marine aquatic life			678	212	376	260	338	290	159	310	272	281	156	59.4	44.2	39.8	34.8
DOC (mg/L)					12.3	11.8	13.7	14.7	15.1	15.5	10.9	9.4	11.4	5.4	3.5	2.4	2.2	1.6	1.6
Salinity (ppt)					10.5	0.7	1.0	1.6	1.9	2.5	1.0	0.2	0.2	25.1	29.6	30.5	31.2	31.4	31.2
Total arsenic (µg/L)		8	32	80	11.7	6.88	7.27	7.20	7.60	8.29	7.17	4.82	5.32	3.62	2.11	1.56	1.30	1.28	1.35
Total cadmium (µg/L)		1	4	10	0.884	0.514	0.364J	<0.2	0.204J	<0.2	0.362J	0.244J	<0.2	0.253	0.126	0.072	0.035	0.046	0.035
Total chromium (µg/L)		2	8	20	31.0	36.3	27.6	18.2	18.8	18.0	18.9	22.3	20.3	7.84	3.19	1.65	0.969	0.925	1.01
Total copper (µg/L)		3	12	30	156	144	108	75.2	67.2	56.7	84.6	70.9	72.6	31.2	12.5	3.57	1.13	1.15	0.982
Total lead (µg/L)		2	8	20	73.0	41.2	24.8	13.5	14.6	12.0	27.2	13.3	11.5	15.1	6.48	1.86	0.406	0.394	0.385
Total nickel (µg/L)		5	20	50	19.3	13.9	11.7	7.70	8.23	7.40	10.0	6.79	5.71	4.59	2.34	1.05	0.683	0.684	0.759
Total selenium (µg/L)		15	60	150	6.40	3.91	5.80	3.79	5.55	5.48	3.03	4.73	3.98	0.164	0.092	0.057	0.031	0.044	0.032
Total silver (µg/L)		0.7	2.8	7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.086	0.069	0.054	0.058	0.057	0.052
Total zinc (µg/L)		20	80	200	613	362	240	148	131	102	273	132	106	99.7	38.4	12.3	3.70	3.30	3.59
OP Pesticides (ng/L)		No values listed in Ocean Plan for protection of marine aquatic life			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrethroids (ng/L)	Bifenthrin	4.0 ng/L 96-h LC ₅₀ for Mysid shrimp*			748	287	5,242	3,499	1,121	580	434	445	256	243	38.9	9.5	<0.5	<0.5	<0.5
	Cyfluthrin	2.42 ng/L 96-h LC ₅₀ for Mysid shrimp*			15.2	64.9	25.4	13.1	7.8	3.9	13.3	12.1	8.8	15.3	2.8	<0.5	<0.5	<0.5	<0.5
	Cyper-methrin	36.0 ng/L 96-h LC ₅₀ for <i>Penaeus sp.</i> **			164	51.5	21.8	16.3	10.1	8	99	26.8	13.3	19.8	11.5	<0.5	<0.5	<0.5	<0.5

Values exceeding daily maximum and Instantaneous Ocean Plan WQOs are highlighted in yellow and orange, respectively.
Pyrethroid concentrations that exceeded LC₅₀ values in the literature for marine invertebrate organisms are highlighted in purple.
ND = Indicates value was below MDL.
* USEPA, 2002.
** CDFG, 2000.

Table 3-5. Summary of Ocean Receiving Water Results at Cabrillo National Monument

Analyte	Ocean Plan WQO			CNM-1	CNM-2	CNM-3	CNM-4	CNM-5	CNM-9	CNM-11
	Six-Month Median	Daily Maximum	Instantaneous Maximum	16:15	16:30	16:45	17:00	17:15	17:30	17:45
TSS (mg/L)	No values listed in Ocean Plan for protection of marine aquatic life			17.5	3.3J	25.2	2.4J	25.3	4.6J	32.8
DOC (mg/L)				3.6	3.5	4	2.8	2.9	2.8	3.7
Salinity (ppt)				32.7	32	32.3	32	22.9	31.1	30.3
Total arsenic (µg/L)	8	32	80	1.36	1.19	1.07	1.17	1.24	1.24	1.18
Total cadmium (µg/L)	1	4	10	0.070	0.032	0.094	0.037	0.025	0.034	0.030
Total chromium (µg/L)	2	8	20	0.420	0.503	0.289	0.345	0.716	0.459	0.747
Total copper (µg/L)	3	12	30	0.766	0.502	0.564	0.475	0.673	0.568	0.644
Total lead (µg/L)	2	8	20	9.65	0.077	0.119	0.215	0.345	0.354	0.945
Total nickel (µg/L)	5	20	50	0.564	0.433	0.379	0.391	0.666	0.657	0.647
Total selenium (µg/L)	15	60	150	0.024	0.021	0.019	0.016	0.017	0.021	0.021
Total silver (µg/L)	0.7	2.8	7	0.055	0.055	0.064	0.053	0.063	0.057	0.050
Total zinc (µg/L)	20	80	200	4.11	1.76	1.87	2.40	2.57	2.35	2.64
OP Pesticides (ng/L)	No values listed in Ocean Plan for protection of marine aquatic life			ND	ND	ND	ND	ND	ND	ND
Pyrethroids (ng/L)	Bifenthrin	4.0 ng/L 96-h LC ₅₀ for Mysid shrimp*		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Cyfluthrin	2.42 ng/L 96-h LC ₅₀ for Mysid shrimp*		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
	Cypermethrin	36.0 ng/L 96-h LC ₅₀ for <i>Penaeus</i> sp.**		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Values exceeding daily maximum and Instantaneous Ocean Plan WQOs are highlighted in yellow and orange, respectively.

Pyrethroid concentrations that exceeded LC₅₀ values in the literature for marine invertebrate organisms are highlighted in purple.

ND = Indicates value was below MDL.

* USEPA, 2002.

** CDFG, 2000.

3.3.2 Metals

3.3.2.1 SDL-186 Storm Drain Effluent

Metal concentrations in SDL-186 displayed a typical first flush pattern in which concentrations were highest during the initial period of runoff. This pattern can be seen in the pollutographs for chromium, copper, lead, and zinc presented in Figure 3-7 and Figure 3-8. Following the first flush, metal concentrations in the storm drain fell dramatically as flow decreased. Concentrations of copper, lead, and zinc increased ahead of the rise in storm flow, while chromium concentrations rose at approximately the same time as the rise in storm flow. Chromium, copper, lead, and zinc were the only metals that were above Ocean Plan Instantaneous Maximum WQOs (Table 3-3). Nickel concentration was above the Ocean plan Daily Maximum WQO during the initial flush but remained below Ocean Plan WQOs during the remainder of the storm event.

3.3.2.2 Rocky Intertidal Receiving Water at SDL-186

Metal concentrations in the rocky intertidal receiving water below the SDL-186 outfall displayed a typical first flush pattern that was similar to that seen in the storm drain effluent. The concentrations were highest during the initial portion of the storm, before falling dramatically as runoff flow decreased after the first peak in the hydrograph as seen in the pollutographs for chromium, copper, lead, and zinc presented in Figure 3-7 and Figure 3-8. Concentrations of chromium, lead, and zinc in the receiving water leveled off during the interlude between the first and second peaks on the hydrograph, at concentrations slightly below their respective Ocean Plan Instantaneous Maximum WQOs. Copper concentrations remained above the Ocean Plan Instantaneous Maximum WQO until after the tide reached the intertidal sampling point. The tide reached the sampling point between 17:20 and 17:50, raising the salinity from 0.2 ppt to 25.1 ppt. As this occurred, metals concentrations of copper and chromium declined by approximately 50% while zinc and lead remained relatively constant. By 18:20 however, all metal concentrations fell by approximately 50% and were below the Ocean Plan Instantaneous Maximum WQO; only copper remained above the Ocean Plan Daily Maximum WQO. The dual effect of the decreasing runoff from SDL-186 and the rising tide effectively diluted all metal concentrations to the point that all were approximately one order of magnitude or more below the Ocean Plan Instantaneous Maximum WQO by 18:50.

3.3.2.3 Rocky Intertidal Receiving Water at CNM

Metal concentrations in the ocean receiving waters at Cabrillo National Monument remained relatively stable throughout the storm event on February 16, 2011 (Table 3-5). Total nickel, which had a high concentration initially, was the only metal that was above the Ocean Plan Daily Maximum WQO. Total nickel concentrations declined by approximately two orders of magnitude following the first sample collection at 16:15 and were well below the Daily Maximum WQO for the remainder of the storm event. No other metal concentrations approached Daily Maximum or Instantaneous Maximum WQOs during the storm event.

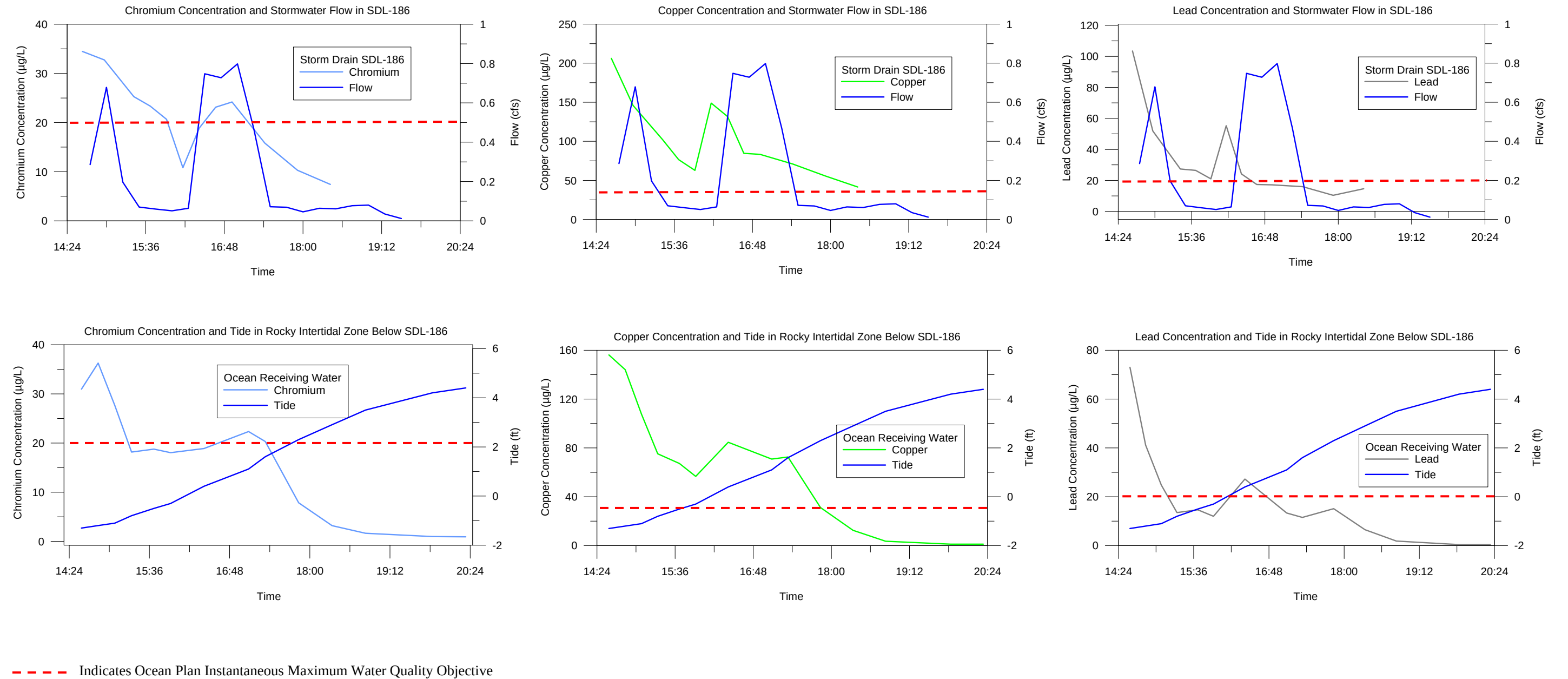
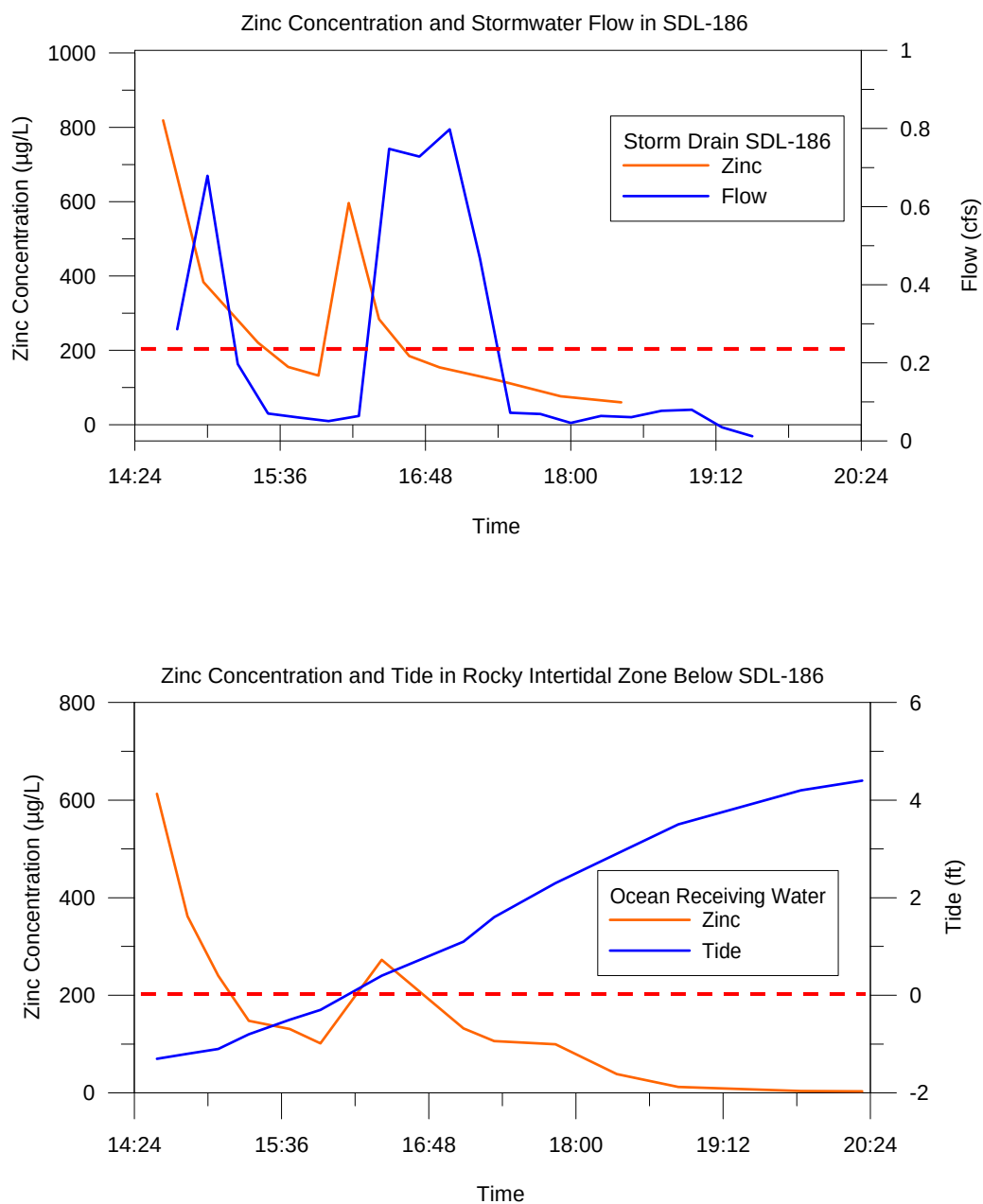


Figure 3-7. Pollutograph Results of Total Chromium, Copper, and Lead in Storm Drain SDL-186 (top) and the Rocky Intertidal Receiving Waters below SDL-186 (bottom)



--- Indicates California Ocean Plan Instantaneous Maximum Water Quality Objective

Figure 3-8. Pollutograph Results of Total Zinc in Storm Drain SDL-186 (top) and the Rocky Intertidal Receiving Water below SDL-186 (bottom)

3.3.3 Pyrethroids

3.3.3.1 SDL-186 Storm Drain Effluent

In general, pyrethroid concentrations in storm drain effluent from SDL-186 were highest during periods of high flow and lowest during periods of low flow, closely mirroring the pattern of the hydrograph, but diminishing over the second period of high flow (Figure 3-9 and Table 3-3). Bifenthrin, Cypermethrin, Cyfluthrin, and Fluvalinate were detected in all SDL-186 samples throughout the storm event, while Deltamethrin, Cyhalothrin, and cis- and trans-Permethrin were detected in some of the storm drain effluent samples. Bifenthrin concentrations were exceptionally high, ranging from 810 ng/L at the end of the storm to 13,961 ng/L during the initial portion of the storm. Since the Ocean Plan does not provide WQOs for pyrethroids, LC₅₀ values for marine invertebrate exposures to Bifenthrin, Cyfluthrin, and Cypermethrin were used in Table 3-3 for comparison purposes. Bifenthrin concentrations in SDL-186 effluent were several hundred to 2,000 times the LC₅₀ value for mysid shrimp provided in the literature (USEPA, 2002).

3.3.3.2 Rocky Intertidal Receiving Water at SDL-186

Pyrethroid concentrations in the rocky intertidal receiving water were substantially lower than those in the SDL-186 effluent. Initial receiving water concentrations of Bifenthrin and Cyfluthrin rose substantially within the first 30 minutes of sampling, while the Cypermethrin concentration fell substantially within the first 30 minutes of sampling, mirroring the pattern seen in SDL-186 effluent pyrethroid concentrations. Following the initial pyrethroid concentration peak during the first portion of the storm, the concentration of Bifenthrin leveled off and slowly diminished over the remainder of the storm. Cyfluthrin concentrations diminished after the initial peak and then rose slightly following the increased flow of effluent into the intertidal zone while Cypermethrin concentrations displayed a second peak during the increased effluent flow. Concentrations of all pyrethroids began to decline significantly at 18:20 as the effluent from SDL-186 slowed and the tide rose. By 19:50 no pyrethroids were detected in SDL-186 rocky intertidal receiving water. Concentrations of Bifenthrin were up to 1,300 times the LC₅₀ value for mysid shrimp while concentrations of Cyfluthrin were up to 27 times the LC₅₀ value for mysid shrimp) during the initial peak of the storm (USEPA, 2002). Both Bifenthrin and Cyfluthrin rocky intertidal receiving water concentrations remained above published LC₅₀ values for mysid shrimp for the first four hours of the storm event. Cypermethrin concentrations were above LC₅₀ values for Penaeid shrimp (CDFG, 2000) during the initial and secondary storm flow peaks.

3.3.3.3 Rocky Intertidal Receiving Water at CNM

Pyrethroids were not detected during any portion of the storm event in Cabrillo National Monument rocky intertidal receiving waters (Table 3-5).

3.3.4 Organophosphorus Pesticides

No OP pesticides were detected in any of the samples collected from SDL-186 storm water, SDL-186 rocky intertidal receiving water, or Cabrillo National Monument rocky intertidal receiving water during the storm event of February 16, 2011.

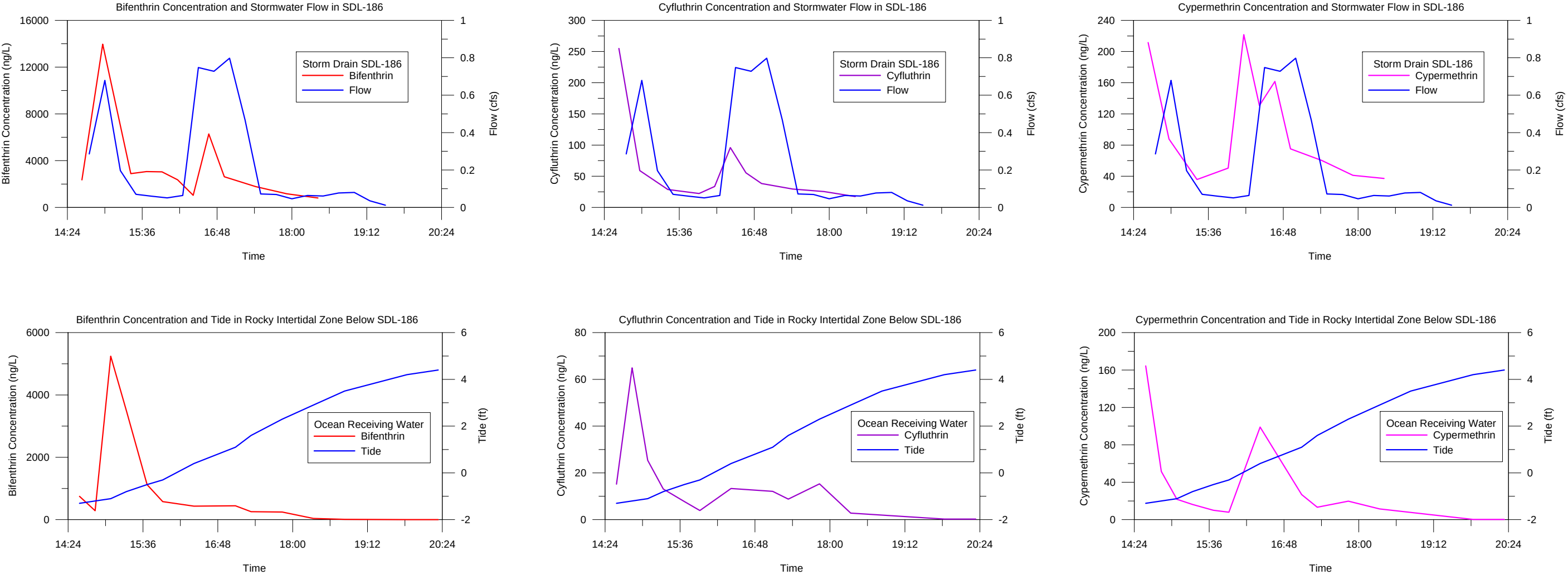


Figure 3-9. Pyrethroid Concentrations in Storm Drain SDL-186 (top) and the Rocky Intertidal Receiving Water below SDL-186 (bottom)

3.4 Toxicity Results

Toxicity testing was conducted using SDL-186 storm water effluent/seawater mixtures in exposures to five test species: the bivalve *Mytilus galloprovincialis*, the mysid shrimp *Americamysis bahia*, the echinoderm *Strongylocentrotus purpuratus*, the abalone *Haliotis rufescens*, and the diatom *Thalassiosira sp.* Results from each test are discussed below.

3.4.1 Bivalve Development

Bivalve development bioassay tests were conducted by exposing larvae from the bivalve *Mytilus galloprovincialis* to various concentrations of storm water effluent collected from SDL-186 during the February 16, 2011, and March 11, 2011, storm events. Storm water effluent was mixed with control sea water to produce a range of salinities that were used to simulate conditions that organisms living within the rocky intertidal zone might be exposed to during a storm event. The proportion of larvae with normal development (normality) was used as the endpoint in the bivalve development tests, as only these embryos will live past early developmental stages. In the February storm event, Steel's Many-One Rank Test was used to calculate both the no observed effect concentration (NOEC) and the lowest observed effect concentration (LOEC), while a Trimmed Spearman-Kärber Test was used to calculate the effective concentration for 50% of the population (EC₅₀). Bivalve embryos exposed to storm water collected on February 16, 2011 had a NOEC normality endpoint of 17.9 ppt, a LOEC endpoint of 14.9 ppt and an EC₅₀ of 16.9 ppt (Figure 3-10). Bivalve embryos exposed to seawater control (clean seawater collected prior to the storm from the SIO Pier) mixed with freshwater (moderately hard water created in the laboratory) had a NOEC of 19.9 ppt, a LOEC of 17.9 ppt, and an EC₅₀ of 16.9 ppt (Figure 3-10). An additional bioassay test (salted storm water) was run using a standard series of storm water concentrations (6.25%, 12.5%, 25%, 50% and 100% storm water) that were brought to a salinity of 32 ppt using artificial sea salts. No toxicity was observed in the salted storm water test: the NOEC was 100% storm water concentration (Dunnett's Test), the LOEC was greater than 100% storm water concentration (Dunnett's Test), and the EC₅₀ was greater than 100% storm water concentration (Linear Interpolation).

Bivalve development bioassay results from the March 11, 2011, storm event were similar to those reported for the February 16, 2011 storm event (Figure 3-11). In the bivalve development tests run using water from the March 11, 2011 storm, the NOEC was 22 ppt (Dunnett's Test), the LOEC was 20.3 ppt (Dunnett's Test), and the EC₅₀ was 16.3 ppt (Maximum Likelihood-Probit).

An additional toxicity test was conducted with artificial sea salts added to the storm water sample to produce a salinity of 32 ppt. The purpose of this test was to determine the toxicity of storm water to marine organisms without the effect of the fresh water toxicant. No toxicity was observed in the salted storm water test: the NOEC was 100% storm water concentration (Dunnett's Test), the LOEC was greater than 100% storm water concentration (Dunnett's Test), and the EC₅₀ was greater than 100% storm water concentration (Linear Interpolation).

Control samples in each of the tests met acceptance criteria (greater than 90% normal shell development in surviving controls), and results of reference toxicant tests run in conjunction with the bioassay tests indicated that the test animals fell within the normal range of sensitivity. Detailed toxicity reports for the simulated tidal exposure experienced by rocky intertidal organisms during a storm event are provided in Appendix E.

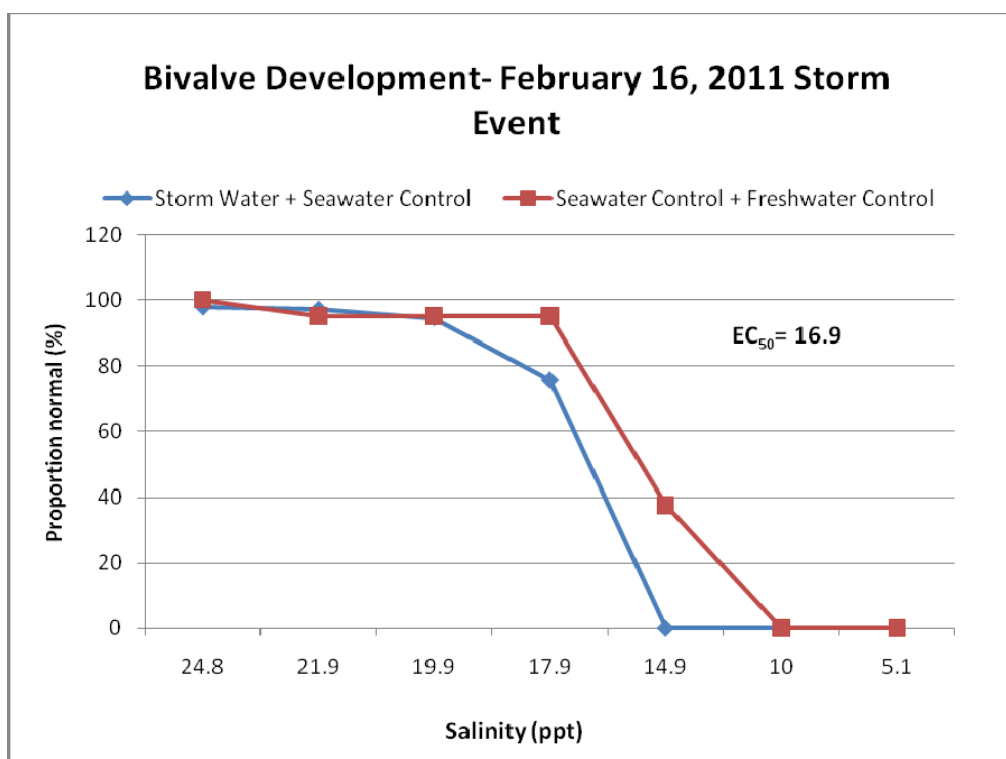


Figure 3-10. Bivalve Development Dose Response Curve from Exposure to Storm Water Collected from SDL-186 on February 16, 2011 and from Exposure to Control Water

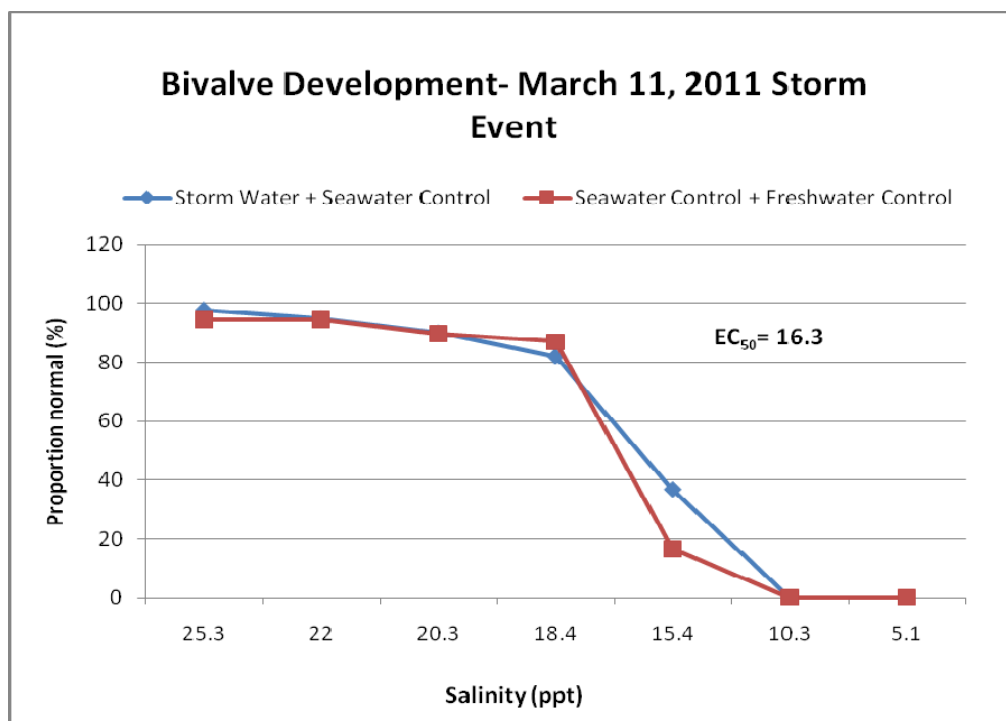


Figure 3-11. Bivalve Development Dose Response Curve from Exposure to Storm Water Collected from SDL-186 on March 11, 2011 and from Exposure to Control Water

3.4.2 Mysid Survival

Mysid shrimp survival bioassay tests were conducted by exposing test organisms to different concentrations of storm water effluent. Storm water effluent was collected from SDL-186 during storm events on February 16, 2011, and March 11, 2011. Storm water effluent was mixed with control sea water to produce a range of salinities that were used to simulate conditions that organisms living within the rocky intertidal zone might be exposed to during a storm event. Survival was used as the sole endpoint in the 96-hour mysid bioassay tests. In the February storm event, Dunnett's Test was used to calculate both the NOEC and LOEC, while Linear Interpolation was used to calculate the EC₅₀. Mysids exposed to storm water collected on February 16, 2011 had a NOEC value of 12.9 ppt, a LOEC of 10.1 ppt and an EC₅₀ of 10.6 ppt (Figure 3-12). Mysids exposed to control seawater mixed with control freshwater had a NOEC of 13.1 ppt, a LOEC of 10.0 ppt, and an EC₅₀ of 10.6 ppt (Figure 3-12).

Bioassay results for mysid shrimp survival from the March 11, 2011, storm event were similar to those reported for the February 16, 2011 storm event (Figure 3-13). In the mysid tests run using water from the March 11, 2011 storm, the NOEC was 13 ppt (Steel's Many-One Rank Test), the LOEC was 10.1 ppt (Steel's Many-One Rank Test), and the EC₅₀ was 10.4 ppt (Linear Interpolation).

The "salted storm water" bioassay was run using a standard series of storm water concentrations (6.25%, 12.5%, 25%, 50% and 100% storm water) that were brought to a salinity of 32 ppt using artificial sea salts. As with the bivalve test, no toxicity was observed in the salted storm water test for mysid shrimp: the NOEC was 100% storm water concentration (Steel's Many-One Rank Test), the LOEC was greater than 100% storm water concentration (Steel's Many-One Rank Test), and the EC₅₀ was greater than 100% storm water concentration (Linear Interpolation).

Control samples in each of the tests met acceptance criteria (greater than 90% normal shell development in surviving controls), and results of reference toxicant tests run in conjunction with the bioassay tests indicated that the test animals fell within the normal range of sensitivity. Detailed toxicity reports for the simulated tidal exposure experienced by rocky intertidal organisms during a storm event are provided in Appendix E.

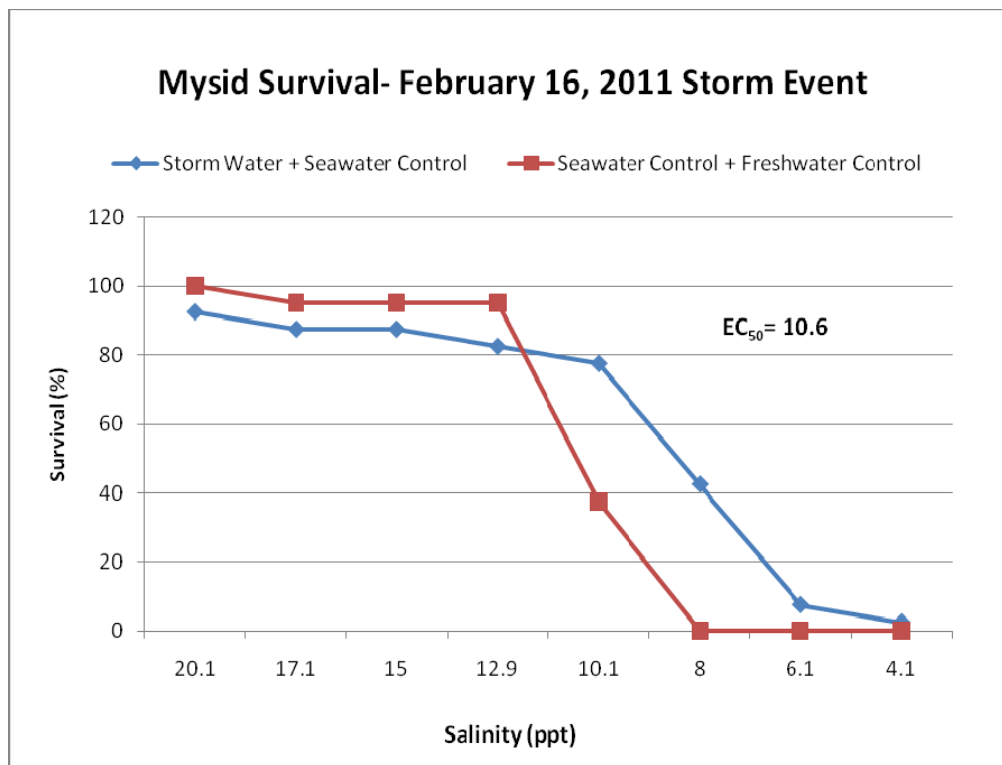


Figure 3-12. Mysid Survival Dose Response Curve from Exposure to Storm Water Collected from SDL-186 on February 16, 2011 and from Exposure to Control Water

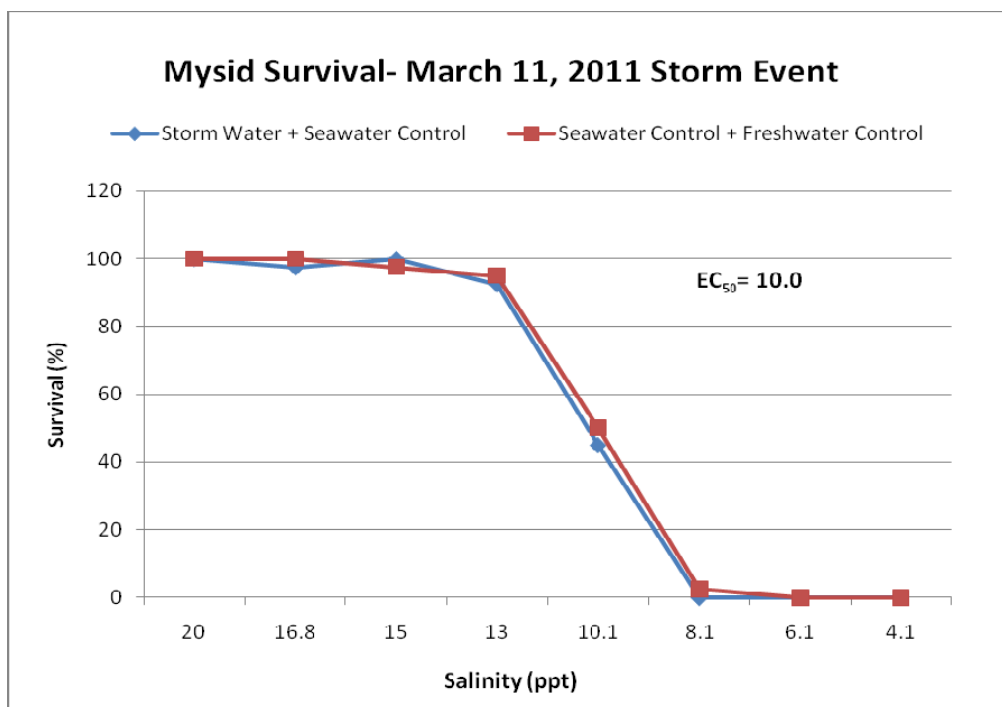


Figure 3-13. Mysid Survival Dose Response Curve from Exposure to Storm Water Collected from SDL-186 on March 11, 2011 and from Exposure to Control Water

3.4.3 Echinoderm Development

Echinoderm development bioassay tests were conducted by exposing larvae from the purple sea urchin to various concentrations of storm water effluent collected from SDL-186 during the February 16, 2011, and March 11, 2011, storm events. Storm water effluent was mixed with control sea water to produce a range of salinities that were used to simulate conditions that organisms living within the rocky intertidal zone might be exposed to during a storm event. The proportion of normally developing larvae (normality) was used as the endpoint in the echinoderm development tests, as only these embryos will live past early developmental stages. In the February storm event, the larvae did not develop, possibly as a result of a test modification in which embryos were transferred after a 6-hour exposure to a larger test chamber containing control sea water. Echinoderm embryos may have attached to the surface of the initial test chamber and did not get transferred to the larger test chamber. In any event, the test was not successful, and there is not echinoderm development data for the February 16, 2011 storm event. An additional bioassay test (salted storm water) was attempted using artificial sea salts, but control sample exposures did not meet acceptance criteria. This result was expected, as in previous tests that used echinoderm larvae and artificial sea salts, lab controls did not pass.

The echinoderm development bioassay was successful for the March 11, 2011, storm event. In this test, pipettes were used to transfer the embryos from the 6-hour exposure chamber to the control sea water chamber to ensure the embryos were not attached to the surface of the container. In the echinoderm development test that was run using SDL-186 effluent from the March 11, 2011 storm, the NOEC for normality was 22.2 ppt (Dunnett's Test), the LOEC for normality was 20.2 ppt (Dunnett's Test), and the EC₅₀ was 21.2 ppt (Trimmed Spearman-Kärber) (Figure 3-14). The echinoderm test that was run using control seawater and control freshwater had a NOEC for normality of 22.2 ppt, a LOEC for normality of 20.2, and an EC₅₀ of 21.4 ppt (Figure 3-14).

Control samples in both the March 11, 2011 storm water and control seawater test and in the control freshwater and control seawater tests met acceptance criteria (greater than 90% normal shell development in surviving controls). Results of reference toxicant tests run in conjunction with the bioassay tests indicated that the test animals fell within the normal range of sensitivity. Detailed toxicity reports for the simulated tidal exposure experienced by rocky intertidal organisms during a storm event are provided in Appendix E.

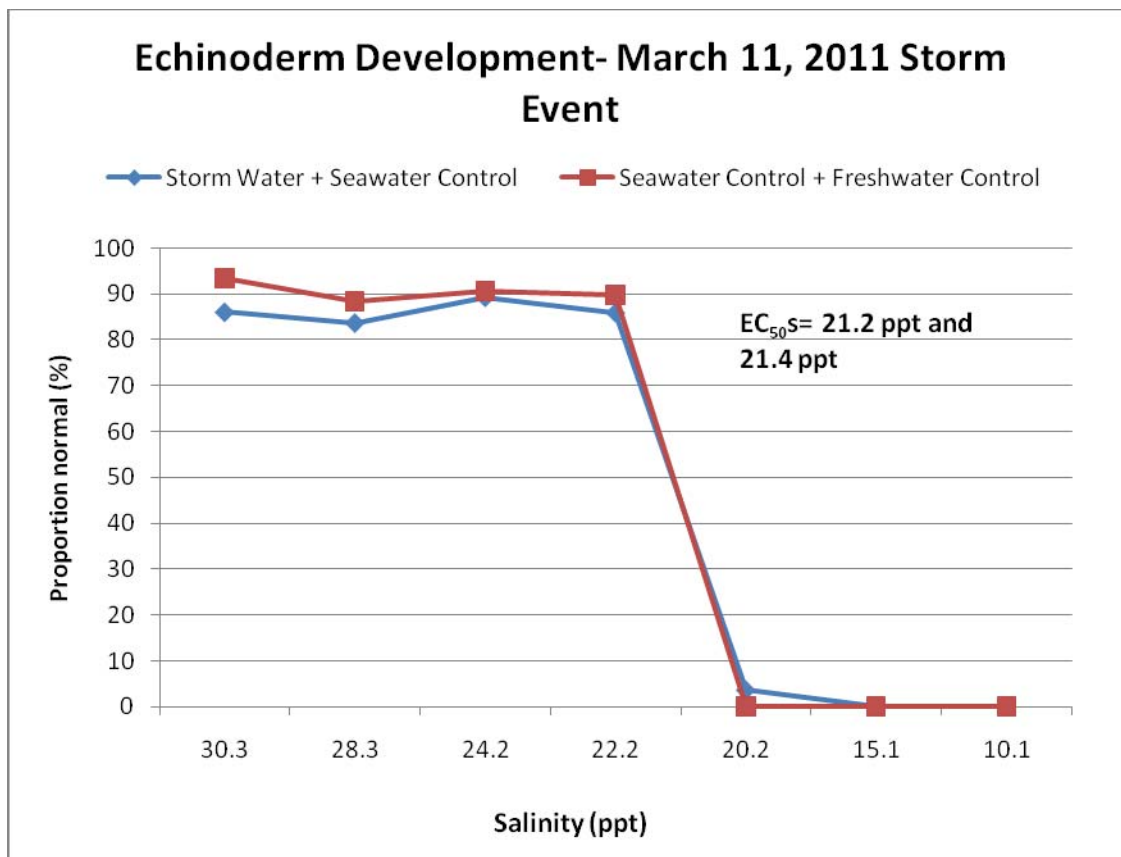


Figure 3-14. Echinoderm Development Dose Response Curve from Exposure to Storm Water Collected from SDL-186 on March 11, 2011 and from Exposure to Control Water

3.4.4 Abalone Development

Abalone development bioassay tests were conducted by exposing larvae from the red abalone to various concentrations of storm water effluent collected from SDL-186 during the February 16, 2011, and March 11, 2011, storm events. Storm water effluent was mixed with control sea water to produce a range of salinities that were used to simulate conditions that organisms living within the rocky intertidal zone might be exposed to during a storm event. The proportion of larvae which were observed developing normally (normality) was used as the endpoint in the abalone development tests, as only these embryos will live past early developmental stages. In the February storm event, Dunnett's Test was used to calculate both the NOEC and LOEC, while a Maximum Likelihood-Probit was used to calculate the EC_{50} . Abalone embryos exposed to storm water collected on February 16, 2011 had a NOEC normality endpoint of 26.8 ppt, a LOEC normality endpoint of 24.8 ppt and an EC_{50} of 25.7 ppt. Abalone embryos exposed to control seawater mixed with control freshwater had a NOEC of 26.8 ppt, a LOEC of 24.9 ppt, and an EC_{50} of 25.4 ppt. An additional bioassay test (salted storm water) was attempted using artificial sea salts, but control sample exposures did not meet acceptance criteria. This result was expected, as in previous tests using abalone and artificial sea salts, lab controls did not pass.

Abalone development bioassay results from the March 11, 2011, storm event were similar to those reported for the February 16, 2011 storm event. In the abalone development tests run using

water from the March 11, 2011 storm, the NOEC was 27.3 ppt (Dunnett's Test), the LOEC was 25.4 ppt (Dunnett's Test), and the EC₅₀ was 26.0 ppt (Maximum Likelihood-Probit). The abalone development test that was run using control seawater and control freshwater had a NOEC for normality of 27.3 ppt, a LOEC for normality of 25.4, and an EC₅₀ of 26.0 ppt.

Control samples in the storm water and control seawater tests and in the control freshwater and control seawater tests met acceptance criteria (greater than 90% normal shell development in surviving controls). Results of reference toxicant tests run in conjunction with the bioassay tests indicated that the test animals fell within the normal range of sensitivity. Detailed toxicity reports for the simulated tidal exposure experienced by rocky intertidal organisms during a storm event are provided in Appendix E.

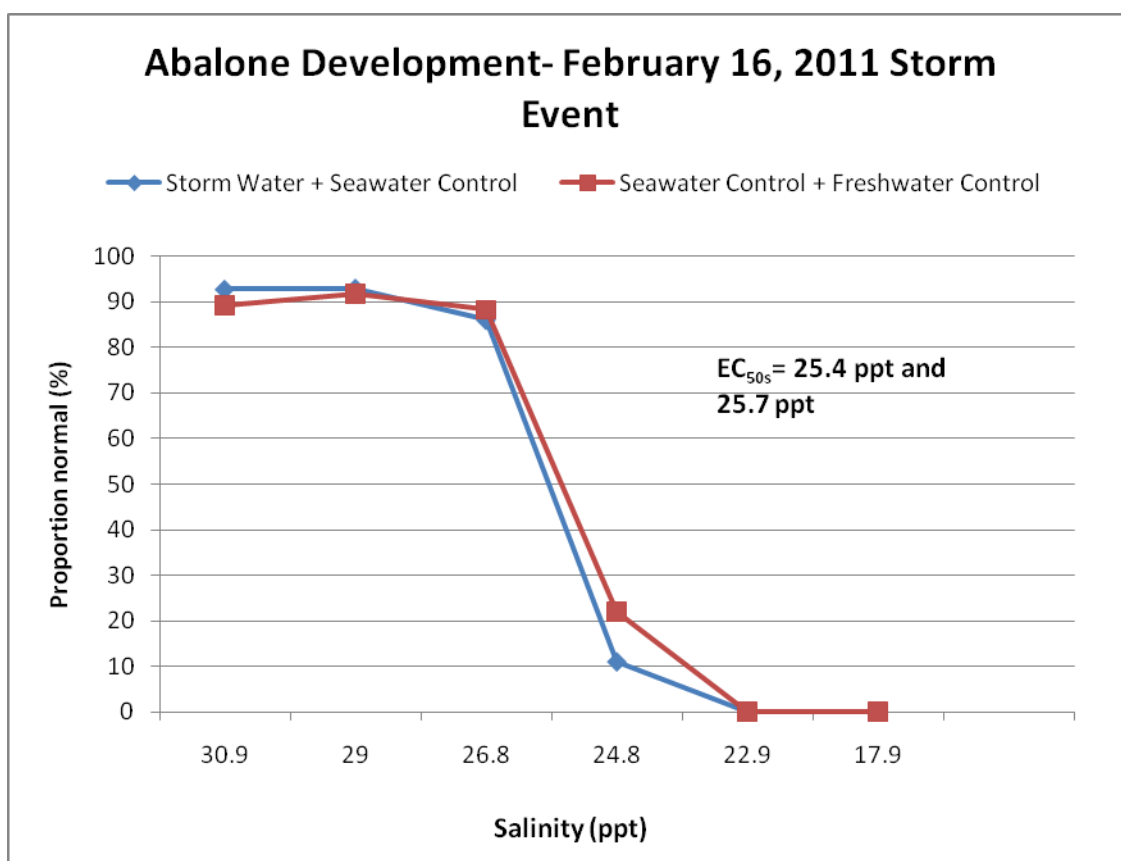


Figure 3-15. Abalone Development Dose Response Curve from Exposure to Storm Water Collected from SDL-186 on February 16, 2011 and from Exposure to Control Water

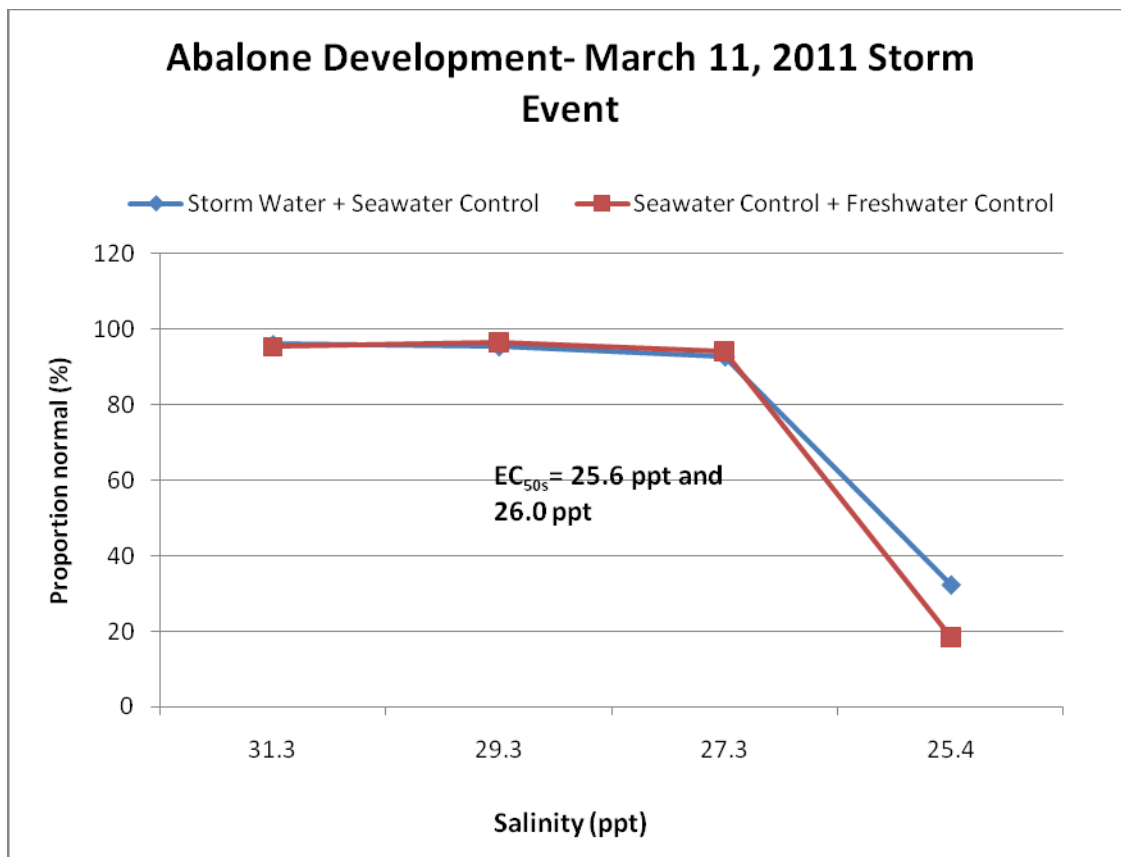


Figure 3-16. Abalone Development Dose Response Curve from Exposure to Storm Water Collected from SDL-186 on March 11, 2011 and from Exposure to Control Water

3.4.5 Diatom Growth

A marine algal growth bioassay was conducted using the diatom species *Thalassiosira*. Cultured diatoms were exposed to storm water and sea water control mixtures and to freshwater control and seawater control mixtures. Storm water collected from SDL-186 during the February 16, 2011 storm event was used in the marine algal growth bioassay. Results of the diatom growth test for SDL-186 storm water effluent are as follows: the NOEC was 30 ppt, the LOEC was greater than 30 ppt, and the EC₅₀ was greater than 30 ppt, indicating that no toxicity was observed. Results of the diatom growth test using control fresh water mixed with control seawater are as follows: the LOEC was greater than 30 ppt, and the EC₅₀ was greater than 30 ppt, indicating that no toxicity was observed. Although no toxicity was observed in either the storm water or the control water tests, enhanced algal growth was observed in the storm water test as compared to the control test as shown in Figure 3-17 and Figure 3-18.

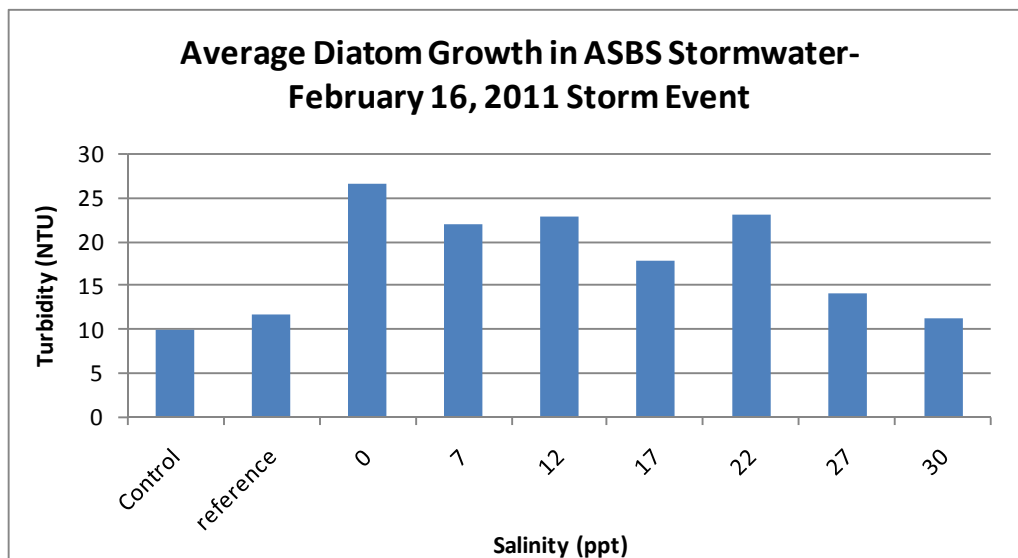


Figure 3-17. Diatom Growth During Exposure to Storm Water Collected from SDL-186 on February 16, 2011

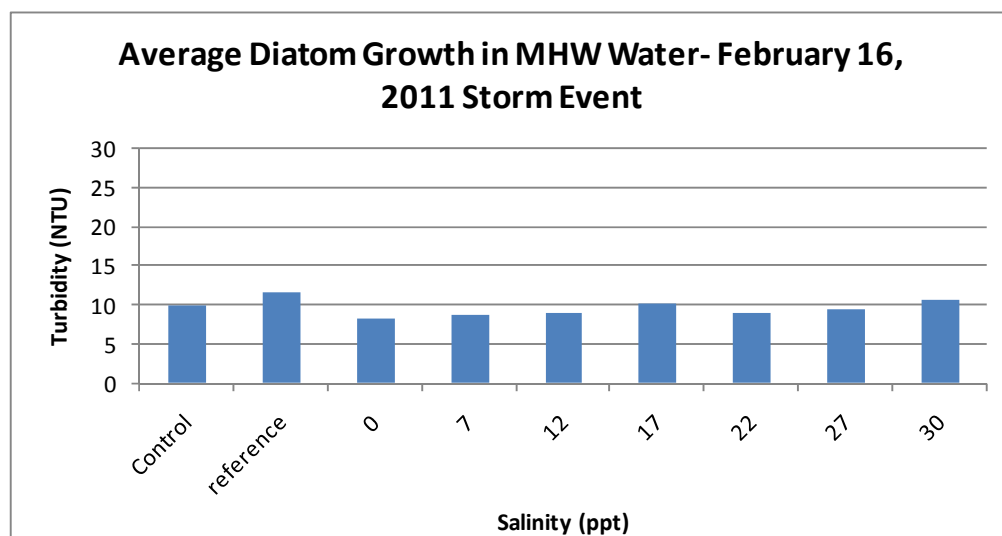


Figure 3-18. Diatom Growth During Exposure to Control Water

3.5 Post-storm Sediment Monitoring Results

Sediment samples were collected from the upper and lower intertidal zone between each major storm drain outfall and the Pacific Ocean on March 25, 2011 (Figure 3-19). Sediment was also collected from the upper and lower intertidal zone at Cabrillo National Monument. Samples were analyzed for percent solids, TOC, grain size, OP pesticides, PCBs, PAHs, pyrethroids, and metals. Storm events occurring on March 21, 2011 and March 24, 2011 preceded the sediment sampling event.

Summary chemistry results from post-storm sediment samples are provided in Table 3-6. Sediment results were compared to Effects-Range Low and Effects Range Medium values established by Long et al. (1995).

Briefly, these values were developed from a large data set where results of both sediment bioassays and chemical analysis were available. The ER-L was calculated as the lower tenth percentile of the observed effects concentrations, and the ER-M as the 50th percentile of the observed effects concentrations. These values are useful for identifying elevated sediment associated contaminants but should not be used to infer toxicity.

Sand and gravel comprised the vast majority of the sediment collected from upper and lower intertidal locations across all sites. Grain size composition ranged from 96.4% to 99.1% sand and gravel and percent solids ranged from 75.3% to 83.2%. TOC was low across all sites, but was highest at SDL-186 in both the upper and lower intertidal zones (0.105% and 0.374%, respectively). No OP pesticides, PCBs, or pyrethroids were detected in either the upper or lower intertidal zone at any of the sites. Trace amounts of PAHs were detected at several sites, but were four orders of magnitude below ER-M values. Metals were detected at all sites; however, concentrations were significantly below both ER-L and ER-M values.



**Figure 3-19. Intertidal Sediment Sampling at
SDL-062**

Table 3-6. Summary of Sediment Results from Upper and Lower Intertidal Zone Following a Storm Event

Analyte	ER-L	ER-M	Upper Intertidal						Lower Intertidal					
			SDL-062	SDL-063	SDL-063B	SDL-157	SDL-186	CNM	SDL-062	SDL-063	SDL-063B	SDL-157	SDL-186	CNM
General Chemistry (%)														
Percent Solids	NA	NA	75.3	80.4	77.8	80.6	83.0	83.2	78.1	77.5	77.9	80.6	83.1	81.9
TOC	NA	NA	0.047J	0.031J	0.024J	<0.02	0.105	0.099	0.027J	<0.02	0.039J	<0.02	0.374	0.086
Total Metals (µg/dry g)														
Arsenic	8.2	70	1.56	1.75	1.58	1.42	2.94	2.06	1.43	1.42	1.45	1.30	4.81	2.29
Cadmium	1.2	9.6	0.029J	0.036J	0.034J	<0.025	0.027J	<0.025	<0.025	<0.025	<0.025	<0.025	0.027J	<0.025
Chromium	81	370	7.37	12.0	9.96	7.21	5.78	2.36	4.46	4.18	5.08	4.74	7.53	2.30
Copper	34	270	1.18	1.33	1.30	0.97	3.26	0.70	1.07	0.92	1.20	0.90	3.22	0.73
Lead	46.7	218	1.19	2.81	1.58	1.10	2.76	0.93	0.83	0.77	0.89	0.82	1.96	1.00
Nickel	20.9	51.6	1.50	1.89	1.71	1.36	2.82	0.93	1.36	1.23	1.32	1.23	3.45	0.92
Selenium	No value	No value	<0.025	<0.025	<0.025	<0.025	0.134	0.041J	<0.025	<0.025	<0.025	<0.025	0.12	0.07
Silver	1	3.7	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Zinc	150	410	6.12	6.92	6.46	5.39	15.9	5.62	6.70	5.37	5.74	4.93	17.3	5.72
Polychlorinated Biphenyls (PCBs) (ng/ dry g)														
Total PCBs	22.7	180	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Polynuclear Aromatic Hydrocarbons (PAHs) (ng/ dry g)														
Total PAHs (ng/g)	4,022	44,792	1.1	1.4	<1	<1	1.4	1.4	5.3	<1	<1	<1	1.1	1.9
Organophosphorus (OP) Pesticides (ng/ dry g)														
Organophosphorus Pesticides	No value	No value	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pyrethroid Pesticides (ng/ dry g)														
Bifenthrin	No value	No value	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cyfluthrin	No value	No value	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Cypermethrin	No value	No value	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Grain Size (%)														
Sand and Gravel Composition	NA	NA	99.1	98.5	99.1	99.1	96.4	98.2	98.9	99.1	98.6	98.9	97.5	98.2

3.6 Biological Survey Results

Biological surveys were conducted as part of this study to characterize the biological communities in the rocky intertidal habitats at the storm drain-influenced site (SDL-186 within ASBS 29) and two sites that are not influenced by storm drains (Cabrillo National Monument reference site and a site at Sunset Cliffs that has minimal storm drain influence). The complete report can be found in Appendix E and is summarized briefly below.

Comparisons of the biodiversity and community structure of macrophytes (macroscopic algae), macroinvertebrates, and meiofauna (small, macroscopic invertebrates that live within the sediments) were conducted at the three rocky intertidal locations. Results revealed that each site was significantly different from each other using numerous parameters. Biodiversity of macrophytes and macroinvertebrates was lowest at the ASBS site while patterns were mixed for meiofaunal diversity, with diversity sometimes being higher at the ASBS site. Multi-variate statistical analyses of community structure of macrophytes and macroinvertebrates, as well as meiofauna, revealed that the ASBS site was clearly differentiated from the other two sites, but all three sites grouped separately, which suggests that the sites may differ due to several factors, not just the presence of storm drain runoff. The percent cover of a list of species also differed among sites with some of these species being large contributors to the differences in overall community structure found in multi-variate analyses.

Disturbance-tolerant macrophytes (indicators of potential impairment) were more abundant at the ASBS site, but patterns of responses of all disturbance indicator species were not consistent. Furthermore, there were no distinct patterns in the meiofaunal community, even with taxa expected to be indicators of disturbance. Comparisons of turf depth in the field and in collected turf cores also revealed that the ASBS site had significantly lower turf depth and marginally lower sand accumulation.

Despite some differences, evidence of obvious and consistent storm water impacts at the storm drain-influenced site in the ASBS relative to the reference sites is relatively weak. However, differences among sites warrant possible future examinations in a more robust manner using multiple impacted and non-impact sites and concentrating some sampling on non-turf habitats, such as intertidal tidepools.

4.0 SUMMARY AND CONCLUSIONS

Four main questions were posed by this study. Each question is addressed below.

1. What are the conditions of storm water effluent in the storm drain prior to being discharged to the ocean receiving waters?

To answer this question, “end of pipe” storm drain effluent samples (prior to mixing with the ocean receiving waters) were collected from each of the five major storm drain outfalls that drain to ASBS 29. Samples were collected during the peak of the storm event and were analyzed for a suite of analytes including general chemistry constituents, metals, synthetic pyrethroids, and OP pesticides. Constituent concentrations from samples collected from each of the major storm drains were compared to WQOs in the Ocean Plan, in accordance with the draft ASBS Special Protections.

The results of the storm drain effluent monitoring of the five major storm drains that drain to ASBS 29 indicate that all five storm drains had concentrations of total copper above Ocean Plan Instantaneous Maximum WQOs. Four of five storm drains had concentrations of zinc above Ocean Plan Daily Maximum WQOs, while storm drain SDL-186 had a zinc concentration above the Ocean Plan Instantaneous Maximum WQO. Although OP pesticides were not detected at any of the five sites, pyrethroid concentrations were extremely high. Concentrations of the pyrethroid, Bifenthrin, were hundreds of times greater than established LC₅₀ values for mysid shrimp, while concentrations of Cyfluthrin and Cypermethrin were also many times greater than LC₅₀ values for marine invertebrates. Although WQOs for synthetic pyrethroids are not currently listed in the Ocean Plan, the Special Protections document, which will likely be enforced in the near future, specifies that “all dischargers must comply with the requirement that their discharges into the affected ASBS maintain natural water quality.” To “maintain natural water quality,” it is presumed that pyrethroid levels would need to be significantly reduced or eliminated from storm water effluent entering the ASBS receiving waters. Reductions in copper and zinc concentrations would also be required to meet compliance regulations.

2. Are short-duration exposures to contaminants during storm events toxic to species living within the rocky intertidal zone?

The results of the pollutograph monitoring indicate that concentrations of some metals exceeded the Ocean Plan WQOs designed to protect marine life. In addition, synthetic pyrethroid concentrations exceeded values in the literature shown to be toxic to marine organisms, by as much as three orders of magnitude. Elevated concentrations of these constituents were measured in the storm water effluent taken directly from the storm drain as well as in the tide pools in the ocean receiving waters. Toxicity evaluations indicated that storm water effluent was toxic to native marine species at concentrations observed in the receiving waters. Storm water mixed with varying concentrations of clean sea water produced LC₅₀ values ranging from 10.0 to 26.0 ppt for marine invertebrates. However, further evaluations, where artificial sea salts were added to storm water samples to a salinity of 32 ppt (typical sea water salinity), produced no toxic effect for the two species evaluated (bivalves and mysids). These results suggest that the freshwater associated with storm water runoff may be the predominant source of toxicity

observed in this study. The lack of toxicity in exposures to storm water with salinities of 32 ppt, suggests that the high pyrethroid concentrations measured in storm water may not be bioavailable to bivalve larvae or mysid shrimp. Pyrethroids are known to be extremely hydrophobic and were likely strongly bound to sediment particles and DOC, which were present in high concentrations in the storm water samples. This binding may have taken the pyrethroids out of solution, reducing bioavailability and the expected toxic response.

Additional studies examining the toxicity of pyrethroids in ocean waters and waters high in TSS may be warranted, as the toxicity tests presented in this study appear to demonstrate that high pyrethroid concentrations in seawater do not necessarily elicit toxic responses in echinoderms, mysid shrimp, abalone, bivalves, or diatoms.

3. Do sediment contaminant concentrations differ between ASBS sites adjacent to storm water discharges and reference sites?

To answer this question, surficial sediment samples were collected from the upper and lower intertidal zone in front of each of the five major storm drain outfalls that discharge to ASBS 29 following a storm event. Samples were analyzed for percent solids, grain size, TOC, OP pesticides, PCB congeners, aroclors PCBs, PAHs, metals, and pyrethroids and compared to ER-L and ER-M values developed by Long, et al (1995). Chemistry results indicated that sediments had low concentrations of the constituents analyzed. No PCBs, OP pesticides, pyrethroids, or PAHs were measured above reporting limits and metal concentrations were one or more orders of magnitude below ER-L values. The grain sizes of all upper and lower intertidal sediment samples consisted of greater than 95 % sand and gravel. Because most of the contaminants of concern that were analyzed in this study (i.e. metals, pyrethroids, and OP pesticides) have an affinity for binding to fine-grained organic materials, elevated contaminant loads would generally not be expected in the coarse grained environments of the La Jolla Shores intertidal zone. Contaminant loads resulting from storm water runoff plumes are likely to be quickly carried off shore by the actions of high energy surf and nearshore currents. The results of this study suggest that contaminants associated with storm water runoff are not accumulating in the intertidal sediments of the ASBS. Additional data will be necessary to confirm if these results are consistent over varying spatial and temporal gradients.

4. Do the rocky intertidal biological communities differ between sites that are influenced by storm water runoff and those that are not?

To answer this question, surveys were conducted to characterize the biological communities in the rocky intertidal habitats at the storm drain-influenced site (SDL-186 within ASBS 29) and two sites that are not influenced by storm drains. Results revealed that each site was significantly different from each other using numerous parameters. Biodiversity of macrophytes and macroinvertebrates was lowest at the ASBS site while patterns were mixed for meiofaunal diversity, with diversity sometimes being higher at the ASBS site. Multi-variate statistical analyses revealed that the ASBS site was clearly differentiated from the other two sites, but the sites may differ due to several other factors, not just the presence of storm drain runoff. Disturbance-tolerant macrophytes (indicators of potential impairment) were more abundant at the ASBS site, but a similar pattern was not seen in the meiofaunal community.

Despite some differences, evidence of obvious and consistent storm water impacts at the storm drain-influenced site in the ASBS relative to the reference sites is relatively weak. However, differences among sites warrant possible future examinations in a more robust manner using multiple impacted and non-impact sites and concentrating some sampling on non-turf habitats, such as intertidal tidepools.

5.0 RECOMENDATIONS

Based on the study results, key recommendations that may be considered are as follows:

- Tier I – Develop and implement a data management system to consolidate data, track activities, load reductions, and determine effectiveness of storm water program efforts.
- Tier I – Conduct education and outreach programs to keep the public informed about protection of the ASBS and what they can do to help reduce toxicity to aquatic marine life.
- Tier I – Continue to monitor the ASBS receiving waters during storm events to be in compliance with State Board regulations and to fill data gaps needed to implement BMPs that may be required for load reductions.
- Tier I – Assess the potential for impacts to the rocky intertidal biological community adjacent to the discharge from SDL-186, where elevated concentrations of some constituents have been detected.
- Tier II – Implement aggressive street sweeping in areas likely to have high contaminant loads as a means of reducing pollutant loads to the ASBS.
- Tier II – Continue development of a pollutant loading model and load reduction calculations for the La Jolla Shores Coastal Watershed.
- Tier III – Conduct effectiveness monitoring of existing BMPs to assess success in complying with ASBS discharge regulations.

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