Proposition 84 Grant Evaluation Report: Assessing Pollutant Reductions to Areas of Biological Significance

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SCCWRP Technical Report 858

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EXECUTIVE SUMMARY

California coastal ecosystems are a valuable economic and ecological resource, which is why the State Water Resources Control Board (SWRCB) created 34 Areas of Special Biological Significance (ASBS) along the state's coastline as marine water quality protected areas. Despite its mandate of "no discharge of waste", the SWRCB identified over 1,650 outfalls that discharge to ASBS, most of which were stormdrain outfalls with dry and/or wet weather flows. In 2006, the voters of California passed Proposition 84 authorizing up to $32 million in grants to reduce or remove discharges to ASBS. The goal of this study was to assess the effectiveness of this grant program by answering the question: **What is the reduction in pollutant loads to ASBS as a result of the Proposition 84 grant program?** To answer this question, the study collated the monitoring data required of each grantee and determined volume reductions, assessed treated effluent concentrations, and then quantified pollutant load reductions for the target time period Calendar Year 2013 (CY2013).

Of the 14 grants awarded, only eight grantees successfully completed their construction and monitoring requirements. The primary reasons for lack of success included delays in engineering design and challenges selecting contractors. Grantees that already had well-developed engineering designs and processes, and those who had experience with monitoring, were best able to accomplish their grant requirements.

Of the eight grantees, 12 different Best Management Plans (BMPs), or combinations of BMPs were evaluated. These BMPs fell into three categories including biotreatment (swales, treatment wetlands), filters (sometimes with treatment media), or diversions (to sanitary sewer or for infiltration). Generally speaking, biotreatment and filter BMPs were flow-through systems, while diversion BMPs were full-capture devices. All BMPs evaluated were designed for low flows during dry weather, storm flows during wet weather, or both.

In general, full-capture BMPs were the most effective, reducing discharge volumes and pollutant loads by 100%. However, these systems are generally small because capturing large volumes is much more difficult. Of the flow-through systems utilized for wet or dry weather, grassy swales had the greatest load reduction efficiency. The grantee that installed this BMP used them in a distributed fashion, spread throughout their watershed. One grantee installed a single, but larger biotreatment wetland system at the end of their watershed. This BMP was exceptionally effective during dry weather low flows and outperformed swales, but was overwhelmed during wet weather and provided no benefit.

Proposition 84 ASBS grantees cumulatively removed an estimated 250 to 300 million liters (L) of discharge volume in CY2013 for both wet and dry weather. In addition, the Proposition 84 ASBS grantees cumulatively removed an estimated 6,150 kg of suspended sediments. For context, the volume captured would roughly half-fill the Rose Bowl in Pasadena and require five Ford F-150 pick-up trucks to haul that much sediment. Finally, the Proposition 84 grantees cumulatively removed nearly 20 kg of trace metals, with over 85% of this load comprised of zinc, selenium, nickel and copper. Changes in loads for organic constituents, including polycyclic aromatic hydrocarbons (PAHs) and pyrethroids pesticides, were more modest because of a universally high frequency of non-detectable values in both influent and effluent.

Pollutant reductions should continue as these BMPs function in future years. This will provide additional value to the Proposition 84 investments. As noted by several grantees, this will require ongoing maintenance for most BMPs to ensure that they are performing at initial design standards. However, there is currently no monitoring specifically required or planned to ensure maintenance occurs or to quantify future pollutant reductions.

ACKNOWLEDGEMENTS

This project was funded by the State Water Resources Control Board though a Proposition 84 grant. Any mention of trade names does not constitute an endorsement. The authors wish to thank the grantees for providing data and other information on their BMPs.

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1.0 INTRODUCTION

California has a unique and vibrant ocean ecosystem unlike any other coastline in the country. With over 550 species of fish (Miller and Lea 1972), some of California's coastal ecosystems are amongst the most productive in the world (Dailey *et al*. 1993). California's coastline supports a thriving economy, generating an estimated $150 B and 90,000 jobs during 2013 for natural resource extraction (e.g., fishing) and leisure (e.g., tourism) based sectors combined (http://www.oceaneconomics.org/).

To help preserve the state's unique and valuable ocean resources, the State Water Resources Control Board (SWRCB) created 34 Areas of Special Biological Significance (ASBS) in the mid-1970's (Figure 1.0-1). ASBS are marine water quality protected areas where the water quality regulations stipulate "no discharge of waste" and "maintenance of natural water quality" (SWRCB 2012). The SWRCB has remained vigilant and virtually no industrial or municipal wastewater outfalls exist in ASBS. However, over 1,650 storm drain outfalls along ASBS shorelines were identified in 2003 (SCCWRP 2003).

In 2006, Proposition 84 was passed by the people of California authorizing up to $32M in water quality improvement projects, including stormdrains that discharge to ASBS. This proposition directed public grant funds to capital improvement projects, specifically to reduce or eliminate waste discharges to ASBS. Seventeen grant applications were received by the SWRCB and, after review by the ASBS Task Force, the SWRCB approved 14 grant projects worth $30M located from Trinidad ASBS in Humboldt County to La Jolla ASBS in San Diego County (Table 1.0-1). Each approved project consisted of a Best Management Project (BMP) composed of either a diversion, filtration, or biotreatment (i.e., swale, wetland, etc.). Each of these BMP types aims to remove, slow down, or treat a discharge that would otherwise make it into the ASBS. These BMPs focused on dry weather, wet weather, or both.

The goal of this project was to work with each of the 14 Proposition 84 ASBS grantees to assess the effectiveness of the grant program. Specifically, this project was designed to answer one fundamental question: ***What is the reduction in pollutant loads to ASBS as a result of the Proposition 84 ASBS grant program?*** To answer this question, the study collated the monitoring data required of each grantee and determined volume reductions, assessed treated effluent concentrations, and then quantified pollutant load reductions for the target time period Calendar Year 2013 (CY2013). Ultimately, the SWRCB may want to use the information on BMP effectiveness for directing future funding or remediation efforts.

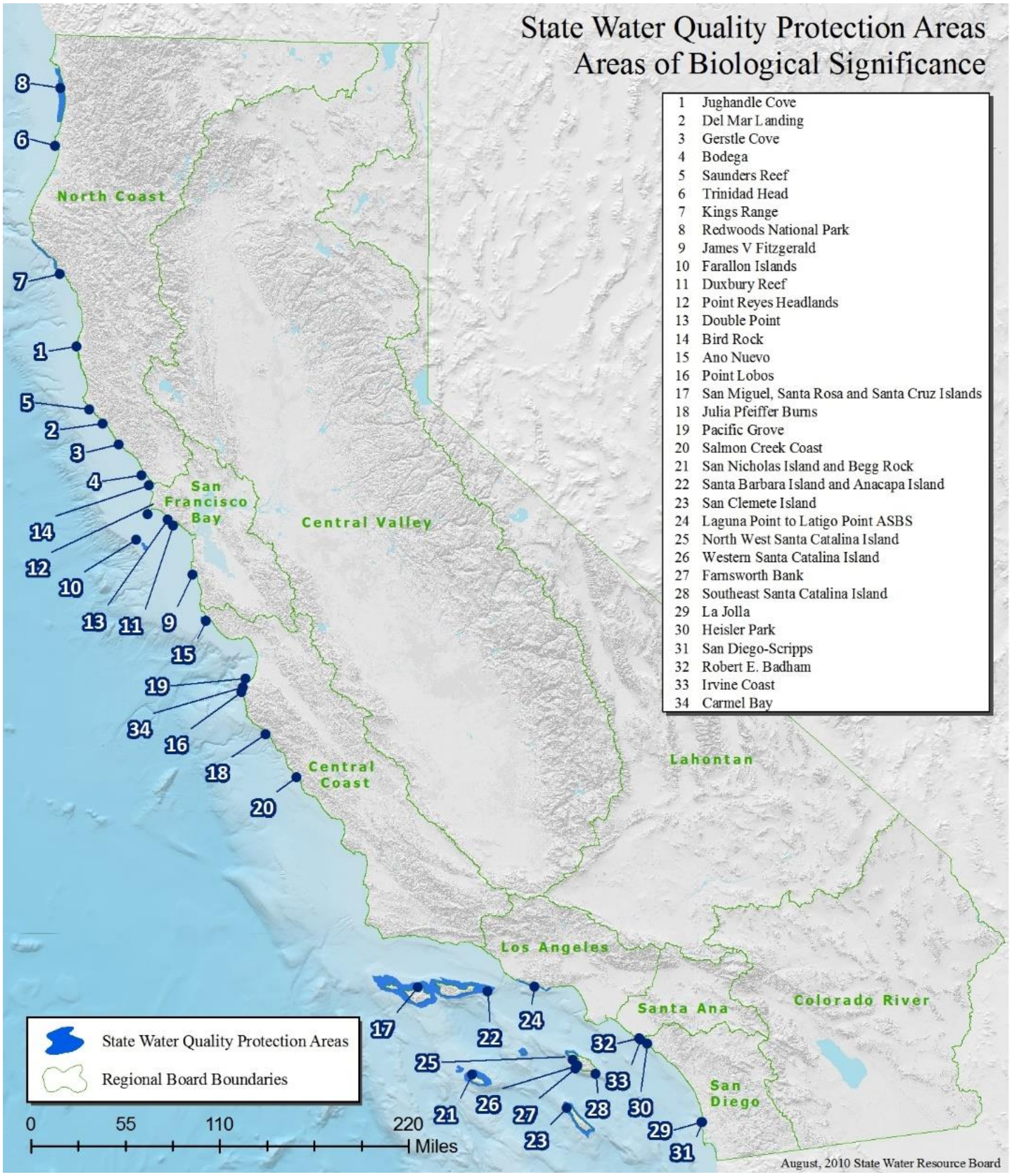

Figure 1.0-1. Map of California's Areas of Special Biological Significance.

Table 1.0-1. List of Proposition 84 Area of Special Biological Significance (ASBS) projects, lead grantee agency, ASBS receiving water, and Regional Water Quality Control Board (RWQCB) region.

Project Title	Agreement Number	Applicant Name	ASBS	RWQCB
James V. Fitzgerald ASBS Pollution Reduction Program	10-402-550	San Mateo County	James V. Fitzgerald (ASBS 9)	2
Duxbury Reef ASBS and Point Reyes Headlands ASBS Source Control Project	10-403-550	Marin County	Duxbury Reef (ASBS 11) and Point Reyes Headlands (ASBS 12)	2
Reducing Nutrient, Pathogen and Sediment Pollution from Livestock Facilities into ASBS (aka Livestock and Land Program)	10-404-550	San Mateo County Resource Conservation District	James V. Fitzgerald (ASBS 9) and Carmel Bay (ASBS 34)	2 and 3
Urban Runoff Diversion Phase III	10-406-550	City of Pacific Grove	Pacific Grove (ASBS 19)	3
Wildlife Road Treatment and ASBS Focused Outreach	10-407-550	City of Malibu	Laguna Point to Latigo Point (ASBS 24)	4
Carmel Bay ASBS Projects	10-408-550	City of Carmel-by-the-Sea	Carmel Bay (ASBS 34)	3
Trinidad Pier Reconstruction	10-409-550	City of Trinidad	Trinidad Head (ASBS 6)	1
Heisler Park ASBS Protection and Preservation Project - Phase III	10-410-550	City of Laguna Beach	Heisler Park (ASBS 30)	9
Broad Beach Road Biofiltration	10-411-550	City of Malibu	Laguna Point to Latigo Point (ASBS 24)	4
Septic System Replacement Program at Zuma and Point Dume Beaches	10-412-550	County of Los Angeles	Laguna Point to Latigo Point (ASBS 24)	4
La Jolla ASBS Protection Implementation Program	10-413-550	City of San Diego	La Jolla (ASBS 29) and San Diego-Scripps (ASBS 31)	9
Newport Coast ASBS Protection Implementation Program	10-414-550	City of Newport Beach	Robert E. Badham (ASBS 32) and Irvine Coast (ASBS 33)	8
Trinidad Head ASBS Stormwater Management Improvement Project	10-427-550	City of Trinidad	Trinidad Head (ASBS 6)	1
Carmel Bay ASBS Projects - Scenic Drive Diversion	10-428-550	Monterey County Public Works	Carmel Bay (ASBS 34)	3

2.0 METHODS

Since this study is a compilation of grantee projects, it has four design elements:

- Ensuring comparability among grantees prior to study initiation
- Compiling monitoring data generated by each grantee
- Summarizing grantee monitoring information
- Estimating load reductions for the target Calendar Year 2013 (CY2013)

Ensuring comparability among each of the grantee monitoring programs accomplished a crucial goal of minimizing bias and enhancing completeness when compiling data from the different BMPs and then contrasting their relative performance. This was accomplished by reviewing each grantee's Monitoring Plan and/or Quality Assurance (QA) Plan prior to data collection. This was supplemented with an on-site audit of planned monitoring activities.

Compiling monitoring data accomplished two goals. First, it defined which grantees actually completed their construction and monitoring. Second, data compilation was accomplished using SWRCB's California Environmental Data Exchange Network (CEDEN) formats. This allows for future storage and public use of the BMP monitoring data.

Summarizing monitoring information accomplished the goal of preparing data for analysis. Data preparation was necessary for creating a sample inventory including if wet or dry weather was monitored, flow results and the need for estimating unmeasured volumes, as well as averaging influent and/or effluent concentrations within and among monitored events. There were two factors of particular importance for this study. The first was flow data because most grantees were deft at chemistry sampling and analysis, but many were less adroit at hydrodynamic measurements. Ultimately, some sort of flow estimation was needed for every BMP evaluated. The second was identifying the subset of chemical parameters that all grantees measured. While up to 352 parameters were quantified, a subset of 24 were used for comparing among BMPs.

Load calculation and load reduction, the hallmark of this project, were estimated for each BMP. For comparison purposes, each BMP was compared for final effluent concentration, load removal (in mass units such as grams or kilograms), and percent reduction in both concentration and load. Final load estimates were calculated from the summarized information for the index period CY2013.

The document is structured with a separate section detailing the summarized monitoring information and load estimations for each BMP, then a final synthesis section comparing and contrasting the effectiveness of each BMP.

2.1 Overview of BMPs and Monitoring Designs

There were 14 Proposition 84 grantees proposing 29 different BMPs for this study. Of these, only eight grantees completed their proposed construction and monitoring activities enabling the evaluation of 13 different BMPs or BMP combinations (Table 2.1-1). One grantee withdrew their grant agreement. Two grantees did not complete their construction activities in time for this report. For example, Pacific Grove required a re-design and was delayed by one year. Two grantees completed construction, but did not complete all of the necessary monitoring. For example, the City of Trinidad is completing their monitoring this wet season, so the data were unavailable for this report. Finally, San Mateo County completed a public demonstration project, which was not amenable to a load reduction monitoring design.

The 13 BMPs evaluated for this study included either wet weather or dry weather runoff diversions, filtration, or biotreatment systems. Diversions, whether they were to the sanitary system (i.e., Heisler Park, La Jolla), or to subterranean infiltration galleries (Carmel, Trinidad Pier, Irvine Coast), each effectively eliminated the discharge. Biotreatment systems were sometimes used in combination with infiltration (Robert Badham), or alone utilizing different types of vegetation (Fitzgerald). Filtration came in two forms; the first was a catch basin insert (Fitzgerald) and the second was porous pavement, sometimes referred to as permeable pavers (Duxbury, Irvine Coast).

Two basic study designs were used for estimating load reductions (Table 2.1-2). The first study design was an **influent-effluent design**, where flow and chemical concentrations are measured entering the BMP, then compared to flow and chemical concentrations exiting the BMP. The second study design was a **preconstruction-postconstruction design**, where effluent flow and chemical concentrations are measured prior to installation of the BMP, then compared to flow and chemical concentrations after installation of the BMP. Of the eight grantees that completed construction and monitoring, six used the influent-effluent design and the remaining two used the preconstruction-postconstruction design.

Table 2.1-1. List of grantees, type of BMP proposed, successful completion of construction and monitoring, and study design. BMP types in BOLD were evaluated in this study.

Project Title	Agreement Number	Applicant Name	BMP Type	Construction and Monitoring Completed?	BMP Study Design
Carmel Bay ASBS Projects - Scenic Drive Diversion	10-428-550	Monterey County Public Works	1. Stormwater diversion	Withdrawn	-
Trinidad Head ASBS Stormwater Management Improvement Project	10-427-550	City of Trinidad	1. Stormwater diversion to infiltration galleries 2. Vegetated infiltration strips	No	-
Carmel Bay ASBS Projects	10-408-550	City of Carmel-by-the-Sea	**1. Dry weather runoff diversions** **2. Stormwater storage**	Yes	Influent-Effluent
Newport Coast ASBS Protection Implementation Program	10-414-550	City of Newport Beach	**1. Infiltration gallery and porous pavement** **2. Stream bank stabilization, bioretention cells and constructed wetland**	Yes	Influent-Effluent
Urban Runoff Diversion Phase III (Pacific Grove)	10-406-550	City of Pacific Grove	1. Dry weather diversion to sanitary sewer 2. Treatment wetland	No	-
Wildlife Road Treatment and ASBS Focused Outreach	10-407-550	City of Malibu	1. Bioretention and filter media, 2. Infiltration galleries	No	-
Broad Beach Road Biofiltration	10-411-550	City of Malibu	1. Porous pavement in parking areas 2. Engineered media 3. Vegetated biofiltration units 4. Smart irrigation controllers	No	-
La Jolla ASBS Protection Implementation Program	10-413-550	City of San Diego	**1. Porous pavement in beach parking lot.** **2. Dry weather runoff diversion.**	Yes	Influent-Effluent
Heisler Park ASBS Protection and Preservation Project - Phase III	10-410-550	City of Laguna Beach	**1. Dry weather runoff diversion to sanitary sewer system**	Yes	Influent-Effluent
Reducing Nutrient, Pathogen and Sediment Pollution from Livestock Facilities into ASBS	10-404-550	San Mateo County Resource Conservation District	1. Technical assistance and training to land owners	No	Demonstration Project

Table 2.1-1. Continued.

Project Title	Agreement Number	Applicant Name	BMP Type	Construction and Monitoring Completed?	BMP Study Design
Septic System Replacement Program at Zuma and Point Dume Beaches	10-412-550	County of Los Angeles	**1. Replace septic system at beach restrooms**	Yes	Pre- and Post-construction
Trinidad Pier Reconstruction	10-409-550	City of Trinidad	1. Replace pier **2. Install infiltration galleries**	Yes	Influent-Effluent
Duxbury Reef ASBS and Point Reyes Headlands ASBS Source Control Project	10-403-550	Marin County	**1. Porous pavement at beach parking lot.** 2. Cattle exclusion fencing. 3. Stairway replacement	Yes	Influent-Effluent
James V. Fitzgerald ASBS Pollution Reduction Program	10-402-550	San Mateo County	**1. Native grass sod swale** **2. Mixed native plant swale with underdrain** **3. StormFilter®** **4. BioClean Filter®**	Yes	Influent-Effluent

2.2 Monitoring Plan and Quality Assurance Plan Review

Each of the 14 grantees' monitoring plan and/or QA plan was reviewed for its ability to answer the study question (Table 2.1-2). The reviews included four elements: a) flow, b) water quality sampling, c) analytical constituents, and d) reporting. Initial reviews were followed up with phone calls to project managers for clarifications and to resolve any deficiencies in their study design for estimating load reductions.

In general, grantees (or their contractors) with the most experience monitoring had very successful reviews. Their monitoring designs were typically more robust, providing more accurate assessments of BMP efficiencies. In addition, the implementation of their monitoring was generally more successful. Monitoring plan and QA plan reviews for less experienced grantees typically identified one or more issues requiring resolution. To be clear, every grantee responded to the recommendations provided, and every grantee was interested in providing the most accurate data to assess BMP performance. However, less experienced grantees typically designed monitoring programs with less meaningful data, targeted less data overall, or were less successful at collecting the desired data. In a minority of cases, grantees were unaware that a monitoring question to address load reduction was a goal. This is an important consideration for the SWRCB, to ensure that future grant monitoring requirements are addressed at the beginning of the grant period and not at the end, when time and funds are unavailable.

Table 2.2-1. Summary of Monitoring Plan and Quality Assurance (QA) Plan review for answering the monitoring question about pollutant load reduction. All grantees ultimately produced effective Plans.

Project Title	BMPs	Initial Assessment Based on Monitoring Documents				Assessment Following Discussions with Grantee	Changes Made Following Discussions with Grantee
		Overall Assessment	Sampling Design Evaluation	Analyte Evaluation	Reporting		
James V. Fitzgerald ASBS Pollution Reduction Program	Flume filtration, storm cartridge, green parking lot, native grass sod swale, and mixed native plant swale	Effective	Adequate	Adequate	Adequate	-	-
Duxbury Reef ASBS and Point Reyes Headlands ASBS Source Control Project	Cattle-exclusion fencing; cattle crossing	Ineffective	Inadequate	Adequate	Adequate	Effective	Grantee will install continuous flow monitoring devices
	Parking lot pervious concrete & toilet relocation	Ineffective	Inadequate	Adequate	Adequate	Effective	Multiple grabs are to be collected each storm. Flow is to be measured continuously. Grantee will develop a mass discharge model during the first year, and apply the model during the second storm season.
Reducing Nutrient, Pathogen and Sediment Pollution from Livestock Facilities into ASBS	Providing technical assistance and training on construction of BMPs to livestock owners	Effective	Adequate	Adequate	Adequate	-	-
Pacific Grove Urban Runoff Diversion Phase III	Diversion of dry weather runoff to sewers;	Effective	Adequate	Adequate	Adequate	-	Grantee to collect dry weather samples during the early morning, when lawns are typically watered. Multiple grabs are to be collected
	Stormwater treatment wetlands	Effective	Adequate	Adequate	Adequate	-	Grantee will collect composite samples

Table 2.2-1. Continued.

Project Title	BMPs	Initial Assessment Based on Monitoring Documents				Assessment Following Discussions with Grantee	Changes Made Following Discussions with Grantee
		Overall Assessment	Sampling Design Evaluation	Analyte Evaluation	Reporting		
Wildlife Road Treatment and ASBS Focused Outreach	Bioretention and filter media, and installation of infiltration galleries, if the surrounding geology permits	Ineffective	Inadequate	Adequate	Adequate	Effective	Grantee will measure flow on a continuous basis. Three sampling events are now planned. Multiple grabs will be collected. Constituents and reporting levels have been reconciled between QA Plan and Monitoring Plan.
Carmel Bay ASBS Projects	Flow diversion systems and water storage facilities	Effective	Adequate	Adequate	Adequate	-	-
Trinidad Pier Reconstruction	Replace pier with concrete deck; infiltrate runoff water	Effective	Adequate	Adequate	Adequate	-	-
Heisler Park ASBS Protection and Preservation Project - Phase III	Vegetated swales and islands; diversion to sanitary sewer system	Effective	Adequate	Inadequate	Inadequate	-	Grantee will add metals, pesticides and PAHs to the constituents measured
Broad Beach Road Biofiltration	Permeable pavement parking areas, engineered media, and planted vegetated biofiltration units, as well as use of "smart" water management controllers for irrigation	Effective	Adequate	Adequate	Adequate	-	-
Septic System Replacement Program at Zuma and Point Dume Beaches	Replace the existing septic system with an advanced treatment septic system	Effective	Adequate	Adequate	Inadequate	-	-

Table 2.2-1. Continued.

Project Title	BMPs	Initial Assessment Based on Monitoring Documents				Assessment Following Discussions with Grantee	Changes Made Following Discussions with Grantee
		Overall Assessment	Sampling Design Evaluation	Analyte Evaluation	Reporting		
La Jolla ASBS Protection Implementation Program	Storm drain diversions to the sanitary sewer	Ineffective	Inadequate	Inadequate	Adequate	Effective	Grantee will measure metals, bacteria and TSS. Analytes are to be measured in pre-construction samples. Three sampling events are now planned.
	Infiltration and bioretention	Ineffective	Inadequate	Adequate	Adequate	Effective	Three sampling events are now planned
Newport Coast ASBS Protection Implementation Program	Irrigation systems runoff reduction	Ineffective	Inadequate	Adequate	Adequate	Effective	Three sampling events are now planned
	Stream bank stabilization and wetland implementation	Ineffective	Inadequate	Adequate	Adequate	Effective	Three sampling events are now planned
	Infiltration	Ineffective	Inadequate	Inadequate	Adequate	Effective	Three sampling events are now planned. TSS will be measured.
	Parking lot porous pavers and bioretention	Ineffective	Inadequate	Adequate	Adequate	Effective	Three sampling events are now planned
Trinidad Head ASBS Stormwater Management Improvement Project	Swales, infiltration galleries	Effective	Adequate	Adequate	Adequate	-	-

2.3 Approach to Calculating BMP Load Reductions

Sampling Inventory

Each BMP was first evaluated for sampling events. This included number and location of sampling sites, number and dates of storm events for wet weather and/or number of low flow events for dry weather. Finally, each event was assessed for type of sampling including single grab samples, time-weighted composite samples, or flow-weighted composite samples. When multiple grab samples were collected for a single event, an arithmetic average was used to represent that event.

Flow Estimation

Runoff volume is a critical element of load estimation. Volume is typically computed as the flow rate over time. Flow measurement methods among the eight grantees varied. Some utilized sophisticated area-velocity, depth-integrated data loggers. Others utilized depth-to-flow transformations such as weir equations or rating curves. Some grantees used modeled flow or volume based on rainfall, catchment size, and other variables such as land use, antecedent rainfall, slope, etc. Of the eight grantees evaluated for load reductions, none had complete flow data for the index period of CY2013. Typically, only the volume for sampled events was measured or estimated, and reported. Therefore, estimates of flow and runoff volume for some and, at times, the entire index period were necessary.

Unmeasured storm flow for CY2013 was estimated by creating rainfall-runoff volume relationships for each BMP. Most BMPs did not measure rainfall and few had existing rain gauges nearby. Therefore, site-specific daily rainfall estimates were modeled by PRISM (Parameter-elevation Regressions on Independent Slopes Model) hosted at Oregon State University (http://prism.oregonstate.edu/). PRISM models geospatially explicit rainfall from climate-elevation regressions based on variables including location, elevation, coastal proximity, and topographic orientation, amongst others; PRISM verified these model estimates using measured rainfall at a 13,000 rain gauges network (Daly *et al*. 2008). Because most grantees sampled few storms ($N \leq 3$), a simple ratio of rainfall quantity to runoff volume was used as the rainfall-runoff translator. Finally, the runoff volume for each day was calculated as a function of the PRISM rainfall estimate and the rainfall-runoff translator according to Equation 1:

$$V_x = \sum(R_i * ((\sum(r_m/v_m))/ \sum m) \qquad \text{Eq. (1)}$$

where, V_x = annual volume 2013

x = site x

i = rain days in 2013

R = daily PRISM rainfall

r = daily PRISM rainfall for storm m

v = volume for storm m

m = individual storm collected at site x

For dry weather, daily volumes from sampled events reported by the grantee were averaged, and then applied to all days without measureable rainfall. In some cases, pump records for diversions were used as a surrogate for daily volumes.

Constituent Concentrations

Cumulatively, a total of 352 individual parameters were chemically measured across all of the BMPs with reported data. Of these, a subset of 82 individual parameters, lumped into 24 groups were selected. These parameters can be divided into five categories:

- General constituents: total suspended solids (TSS), turbidity, and oil & grease (O&G)
- Nutrients: ammonia, nitrate, ortho-phophorous (ortho-P), and total phosphorous (total P)
- Trace metals (unfiltered): arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc
- Organics: total Polynuclear Aromatic Hydrocarbons (sum of 28 different PAHs) and total pyrethroids pesticides (sum of 8 pyrethroids)
- Fecal indicator bacteria: *Enterococcus*, *Escherichia coli* (*E. coli*), and total coliforms

Some parameters that were excluded due to inconsistency across BMPs included chlorinated pesticides, organophosphorus pesticides, and organic carbon. Polychlorinated biphenyls (PCBs) were excluded because some programs measured PCBs as Arocolors and others as individual congeners. Nitrate+nitrite, sometimes measured instead of nitrate, was assumed to be equivalent to nitrate because nitrite values in stormwater are typically less than 10% of nitrate concentrations. Most grantees reported *E. coli* for bacterial measurements, but one measured fecal coliforms (of which *E. coli* is typically the primary species); consequently, fecal coliform was treated as *E. coli*.

Quality Assurance Plans were evaluated (see previous section) prior to monitoring initiation and all chemistry data quality objectives including sensitivity (detection limits), accuracy (matrix spikes, reference materials), and precision (duplicate samples) were within specifications requested by the SWRCB's grant program guidelines. Therefore, it was assumed that these data quality objectives were achieved, and no QA checks of the chemistry data were conducted prior to load analysis.

Load Estimation

Influent and effluent concentrations were reported directly by the grantees. Where multiple samples were collected per storm event, an arithmetic average was used to estimate mean storm concentration. Mean storm concentration was reported for each event, then a grand arithmetic mean and 95% confidence interval was estimated if multiple storm events were monitored by the grantee. The concentration grand mean was then applied to all storm events for the target year CY2013. A similar process was used for dry weather, except for the grand mean of non-storm samples was applied to the discharge volume of all days without rainfall.

Loads were calculated as the product of annual storm volume and storm grand mean concentration according to Equation 2:

$$L = \text{sum}(V * C) \qquad \text{Eq. (2)}$$

where, L = annual load

V = annual storm volume

C = mean storm concentration

Percent Removal

Percent removal was calculated in one of two fashions. For influent-effluent study designs, the percent removal was calculated as the ratio of the difference between influent and effluent relative to the influent concentration according to Equation 3:

$$R = 100 * ((I – E)/I) \qquad \text{Eq. (3)}$$

where, R = % removal efficiency

I = average influent concentration

E = average effluent concentration

For preconstruction-postconstruction study designs, a similar approach was taken. The percent removal was calculated as the ratio of the difference between the average preconstruction effluent concentration and the average postconstruction effluent concentration relative to the preconstruction effluent concentrations according to Equation 4:

$$R = 100 \times ((PR – PO)/PR) \qquad \text{Eq. (4)}$$

where: R = % removal efficiency

PR = average preconstruction concentration

PO = average postconstruction concentration

The only exception was for Zuma Beach septic tank replacement project, where effluent concentrations were not directly measured. In this case, nearby receiving water concentration data was used as a surrogate for effluent.

The calculations for percent removal were conducted individually for each constituent as the BMP effectiveness may vary by BMP type. These formulas work equally well for both concentration and for load estimates. Negative removal rates indicated that concentrations or loads increased as a result of the BMP. When bypass volumes were documented, these loads were added to annual estimates based on the influent concentration.

3.0 RESULTS

3.1 Trinidad Infiltration

BMP Description

This project focused on reducing pollution to the Trinidad ASBS located in Humboldt County (Figures 3.1-1 and 3.1-2). The Trinidad ASBS, which covers approximately 1.2 km^2, includes Trinidad Bay near the City of Trinidad. Trinidad Bay is home to seasonal marina facilities (i.e., a mooring field, vessel haul-out/launch facilities, and pier facilities) as well as the Humboldt State University Marine Lab. The Trinidad Bay pier, originally built in 1946, was proposed for renovation by removing the pier deck and replacing pilings, then building a new all cement pier deck. The renovated pier repaired structural deficiencies, improved pier utilities, and benefited the residents and visitors to Trinidad Bay. The water quality improvement BMP portion of this project was to route all of the runoff from the new pier to an oil-water separator, then drain to a large underground infiltration gallery. Effectively, the BMP was designed so that no runoff from the pier will be discharged to the Trinidad ASBS.

Design, Sample Inventory and Flow Estimates

This BMP utilized an influent-effluent study design. Because there was no discharge from the BMP (100% infiltration), there were no effluent measurements.

This grantee collected samples during three storm events, consistent with the goals in their Monitoring Plan (Figure 3.1-3). No samples were collected during dry weather because there was minimal to no flow without precipitation. The three sampled storms were moderate-sized events, neither the largest nor smallest events of the index period, ranging from 6 to 16 mm rainfall/day.

Three samples were collected across the three storm events (Table 3.1-1). All three samples were collected as flow-weighted composites, the preferred collection method for estimating average concentrations, particularly for estimating loads. The grantee measured 16 of the 24 parameters identified in this report for load reduction.

Commensurate with the flow-weighting, continuous flow data was collected for the three storm events. A rainfall-runoff volume translator was developed for estimating unmeasured flow during CY2013 (Table 3.1-2). The average rainfall to runoff volume for the three storm events was 1,101 L runoff/mm rainfall. The total rainfall for CY2013 was 701.4 mm based on PRISM estimates.

Concentration and Load Reduction

Mean influent concentrations consistently fluctuated more than an order of magnitude among the three storm events at this BMP (Table 3.1-3). For example, copper concentrations ranged from 35 to 826 µg/L among the three events. The third storm (March 27, 2013) consistently had the lowest concentrations among the three events. The first storm (January 26, 2013) frequently, but not always, had the greatest concentrations among the three events. The confidence interval for influent concentrations ranged from <50% to >150% of the grand mean, with confidence averaging approximately 100% of the grand mean influent concentration across all parameters.

Since this BMP had no effluent (100% capture), effluent concentrations and pollutant loads were always assumed to be zero. As a result, relative effluent concentrations and load reductions were also assumed to be 100% (Table 3.1-4). This BMP removed an estimated 0.8 x 10^6 million L, 33 kg of TSS, 6 kg of ammonia, and 0.3 kg of copper from entering the Trinidad ASBS during CY2013.

Figure 3.1-1. Map of infiltration BMP at the Trinidad ASBS. Shaded area represents the ASBS.

Figure 3.1-2. Trinidad ASBS, including historic lighthouse and Trinidad Bay (top), newly constructed pier in Trinidad Bay (middle), and oil-water separator at foot of pier that helps route pier runoff to the underground infiltration gallery (bottom).

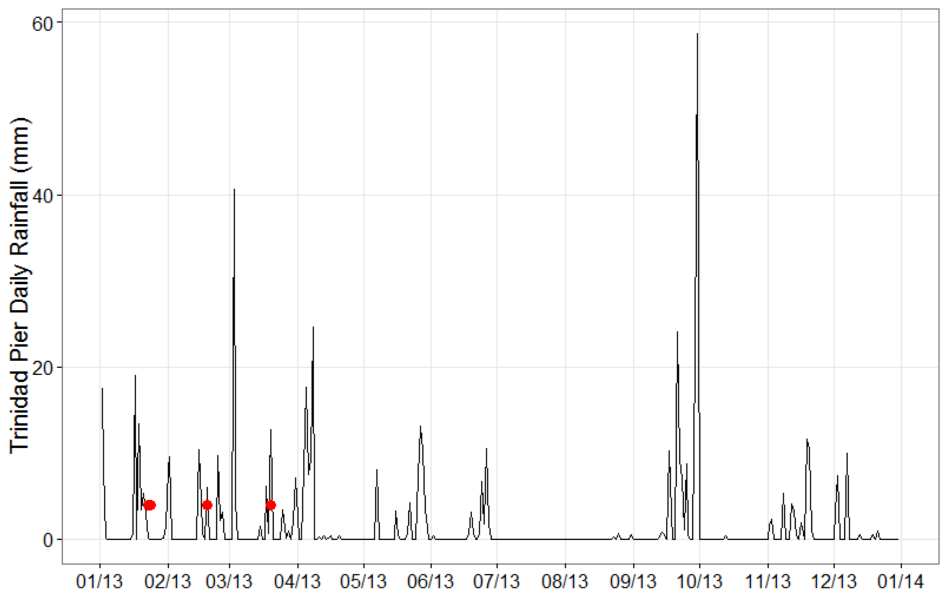

Figure 3.1-3. Daily rainfall at Trinidad Pier January 1, 2013 through January 1, 2014. Red symbols indicate sampled events.

Table 3.1-1. Sample inventory for the Trinidad Pier BMP. Three flow-weighted composite samples were collected across three storm events.

Parameter	Number of Wet Weather Samples	Number of Dry Weather Samples	Total Number of Samples
TSS	3	0	3
Turbidity	3	0	3
Oil and Grease	0	0	0
Nitrate	3	0	3
Ammonia	3	0	3
Ortho-P	0	0	0
Total P	3	0	3
Arsenic	3	0	3
Cadmium	3	0	3
Chromium	3	0	3
Copper	3	0	3
Mercury	3	0	3
Nickel	3	0	3
Lead	3	0	3
Selenium	3	0	3
Silver	3	0	3
Zinc	3	0	3
Total PAH	3	0	3
Total Pyrethroid	0	0	0
Total PBDE	0	0	0
Total DDT	0	0	0
Enterococcus	0	0	0
E. coli	0	0	0
Total Coliforms	0	0	0

Table 3.1-2. Rainfall-runoff relationship at the Trinidad Pier BMP for estimating volumes during Calendar Year 2013.

Storm Date	Storm Rainfall (mm)	Storm Volume (L)	Rainfall to Runoff Translator (L/mm)
23-Jan	14.99	19476	1299
19-Feb	7.37	5698	773
19-Mar	8.38	10316	1231
Average			1101
95% CI			324

Table 3.1-3. Influent and effluent concentration and concentration reduction estimates for the Trinidad Pier BMP. Because this was a full-capture BMP, effluent concentrations are null and concentrations reductions are 100%.

Parameter	Units	26-Jan-13		26-Feb-13		27-Mar-13		Influent		Effluent	Concentration Reduction (%)
		Influent	Effluent	Influent	Effluent	Influent	Effluent	Average	95% CI	Average	
TSS	mg/L	82.0	-	46.0	-	0	-	42.7	46.5	-	100
Turbidity	NTU	57.2	-	21.4	-	5.2	-	27.9	30.1	-	100
Oil and Grease	mg/L	-	-	-	-	-	-	-	-	-	-
Nitrate	mg/L	0.064	-	0.025	-	0.087	-	0.059	0.035	-	100
Ammonia	mg/L	6.7	-	14.9	-	1.7	-	7.8	7.5	-	100
Ortho-P	mg/L	-	-	-	-	-	-	-	-	-	-
Total P	mg/L	1.82	-	0.74	-	0.42	-	1.00	0.80	-	100
Arsenic	µg/L	11.45	-	6.40	-	1.38	-	6.40	5.70	-	100
Cadmium	µg/L	2.19	-	0.79	-	0.088	-	1.00	1.20	-	100
Chromium	µg/L	5.87	-	1.87	-	1.21	-	3.00	2.90	-	100
Copper	µg/L	826.0	-	458.0	-	35.4	-	439.8	447.7	-	100
Mercury	µg/L	0.0022	-	0.00284	-	0.0148	-	0.0066	0.0080	-	100
Nickel	µg/L	12.00	-	4.75	-	1.67	-	6.10	6.00	-	100
Lead	µg/L	27.70	-	3.25	-	0.97	-	10.60	16.80	-	100
Selenium	µg/L	1.8	-	0.8	-	0.9	-	1.2	0.6	-	100
Silver	µg/L	4.26	-	3.00	-	0.14	-	2.50	2.40	-	100
Zinc	µg/L	433.0	-	154.0	-	16.1	-	201.0	240.0	-	100
Total PAH	ng/L	0.312	-	0.093	-	0.079	-	0.161	0.148	-	100
Total Pyrethroid	ng/L	-	-	-	-	-	-	-	-	-	-
Total PBDE	ng/L	-	-	-	-	-	-	-	-	-	-
Total DDT	ng/L	-	-	-	-	-	-	-	-	-	-
Enterococcus	Log_{10} MPN/100 ml	-	-	-	-	-	-	-	-	-	-
E. coli	Log_{10} MPN/100 ml	-	-	-	-	-	-	-	-	-	-
Total coliforms	Log_{10} MPN/100 ml	-	-	-	-	-	-	-	-	-	-

Table 3.1-4. Load reduction estimates for the Trinidad Pier BMP. Because this was a full-capture BMP, load reductions are assumed to be 100%.

Parameter	Units	Influent		Effluent	Load Reduction	Reduction %
		Average	95% CI			
Volume	10^6 L	0.77	0.23	0	0.77	100
TSS	kg	33.0	10.6	0	32.95	100
Turbidity	NTU	21.6	6.8	0	21.57	100
Oil and Grease	kg	-	-	-	-	-
Nitrate	kg	0.05	0.01	0	0.05	100
Ammonia	kg	6.0	1.7	0	6.00	100
Ortho-P	kg	-	-	-	-	-
Total P	kg	0.8	0.2	0	0.77	100
Arsenic	g	5.0	1.3	0	4.95	100
Cadmium	g	0.8	0.3	0	0.79	100
Chromium	g	2.3	0.6	0	2.30	100
Copper	g	340	102	0	339.68	100
Mercury	g	0.0	0.0	0	0.01	100
Nickel	g	4.7	1.4	0	4.74	100
Lead	g	8.2	3.8	0	8.22	100
Selenium	g	0.9	0.1	0	0.90	100
Silver	g	1.9	0.5	0	1.91	100
Zinc	g	155	55	0	155.27	100
Total PAH	mg	0.12	0.03	0	0.12	100
Total Pyrethroid	mg	-	-	-	-	-
Total PBDE	mg	-	-	-	-	-
Total DDT	mg	-	-	-	-	-
Enterococcus	10^6 Log_{10} MPN	-	-	-	-	-
E. coli	10^6 Log_{10} MPN	-	-	-	-	-
Total Coliforms	10^6 Log_{10} MPN	-	-	-	-	-

3.2 Irvine Coast Infiltration

BMP Description

This project focused on reducing pollution to the Irvine Coast ASBS located in Orange County (Figure 3.2-1). The Irvine Coast ASBS, which covers approximately 3.8 km^2, stretches from Corona del Mar to Laguna Beach, and includes some of the last remaining undeveloped coastline in Orange County as well as a Marine Life Refuge and Marine Conservation Area. The Irvine Coast ASBS is home to Crystal Cove State Park featuring tide pools, kelp beds, and dolphin birthing grounds.

Crystal Cove State Park is a heavily used recreational area and the southern portion, called Reef Point, consists of two parking lots. The proposed BMP for this ASBS was to capture and treat stormwater runoff from the northern parking lot utilizing a combination of porous pavement, biotreatment, and an infiltration gallery. The first BMP was a bioretention BMP designed by allowing parking lot runoff to flow into a sunken median planter (Figure 3.2-2a). The design of this BMP allows captured runoff to pond, then be removed through infiltration and evapotranspiration. Overflow outlets were also designed to avoid flooding if too much volume enters the BMP.

The second BMP was a treatment train that removed a portion of the parking lot asphalt, then replaced with porous pavement, and routed flow to an underground reservoir comprised of rock (Figure 3.2-2b). Perforated PVC pipe slowly drains the underground rock reservoir to a modular treatment wetland system that diminishes volume through evapotranspiration. All volume in the underground reservoir that is not evapotranspirated is slowly released to the storm drain system through a small orifice providing peak flow attenuation that should reduce downstream erosion. Cumulatively, the treatment train was designed to capture and treat storm events up to 32 mm (1.25 in).

Design, Sample Inventory and Flow Estimates

This BMP utilized and influent-effluent monitoring design. The influent sampling location was in the parking lot curb and gutter upstream of the porous pavement. The effluent sample location was at the small orifice draining the underground rock reservoir. The grantee also utilized a nearby rain gauge for measuring precipitation.

This grantee collected samples during two storm events (October 9 and November 23, 2013), consistent with the goals in their Monitoring Plan (Figure 3.2-3). No samples were collected during dry weather because there was minimal to no flow without precipitation. The two sampled storms included the third largest event (13 mm) and a median-sized event (8 mm) for the study year. Of the 16 storm events in CY2013, rainfall ranged from <0.1 to 24 mm.

In total, four samples were collected across the two storm events (Table 3.2-1). Each storm was composed of one influent and one effluent sample. All samples were collected as time-weighted composites, collected by hand using pre-cleaned bottles. The grantee measured 12 of the 24 parameters identified in this report for load reduction.

The grantee reported rainfall, flow, and volume for the two sampled storm events. Sheet flow from a parking lot is quite difficult to measure, so influent volume was estimated using EPA's Surface Water Management Model (SWMM, http://www2.epa.gov/water-research/storm-water-management-model-swmm). Effluent volume was measured using a level-logger and weir equation, utilizing a weir installed at the small orifice where the effluent sample was collected. A rainfall-runoff relationship was developed for estimating unmeasured storms (Table 3.2-2) based on influent volumes and measured rainfall for the two measured storm events. This grantee estimated the volume captured by the BMP, the volume infiltrated and not discharged from the BMP, the volume treated and discharged from the BMP, and finally the untreated volume that bypassed the BMP. These measurements were used by the grantee to estimate an average BMP capture volume of 20 m^3, of which 40% was assumed to be infiltrated. While the BMP capture volume was comparable between the two sampled events, the fraction infiltrated was more variable, presumably as a result of differing antecedent dry periods.

Concentration and Load Reduction

Except for total PAH, influent concentrations were remarkably similar between storm events (Table 3.2-3). Six out of nine trace metal concentrations varied by less than 10% between storm events. None of the remaining trace metals differed by more than a factor of three. For example, copper concentrations ranged from 279 to 339 µg/L between the two events. The first storm, which was also the first storm of the season, did not consistently have the greatest influent concentration. However, the first storm did have the greatest concentrationa of TSS and total PAH, exceeding the second storm by an order of magnitude.

Effluent concentrations were also quite comparable between storm events (Table 3.2-3). Nearly all effluent concentrations were different by less than a factor of two; even TSS and total PAH effluent concentration were different by less than a factor of three between storm events.

Concentration reductions from influent to effluent for most constituents exceeded 90% (Table 3.2-3). The trace metal concentration reductions ranged from 85% (for copper) to 100% (for silver). Total PAH concentrations were reduced by 81%. This BMP appeared to be less effective for TSS, reducing concentrations from influent to effluent by 9%.

This BMP removed an estimated 58 m^3 (58,000 L) of discharge volume, treating 69 m^3 (69,000 L), and bypassing 12 m^3 (12,000 L). As a result, this BMP removed 2.1 kg of TSS, 0.04 kg of copper, 0.03 g of PAH from entering the Irvine Coast ASBS during CY2013. Load reduction efficiencies were quite high, between 90 and 100% for all constituents except TSS. TSS load reduction efficiency was 51%, in large part due to reductions in volume through infiltration.

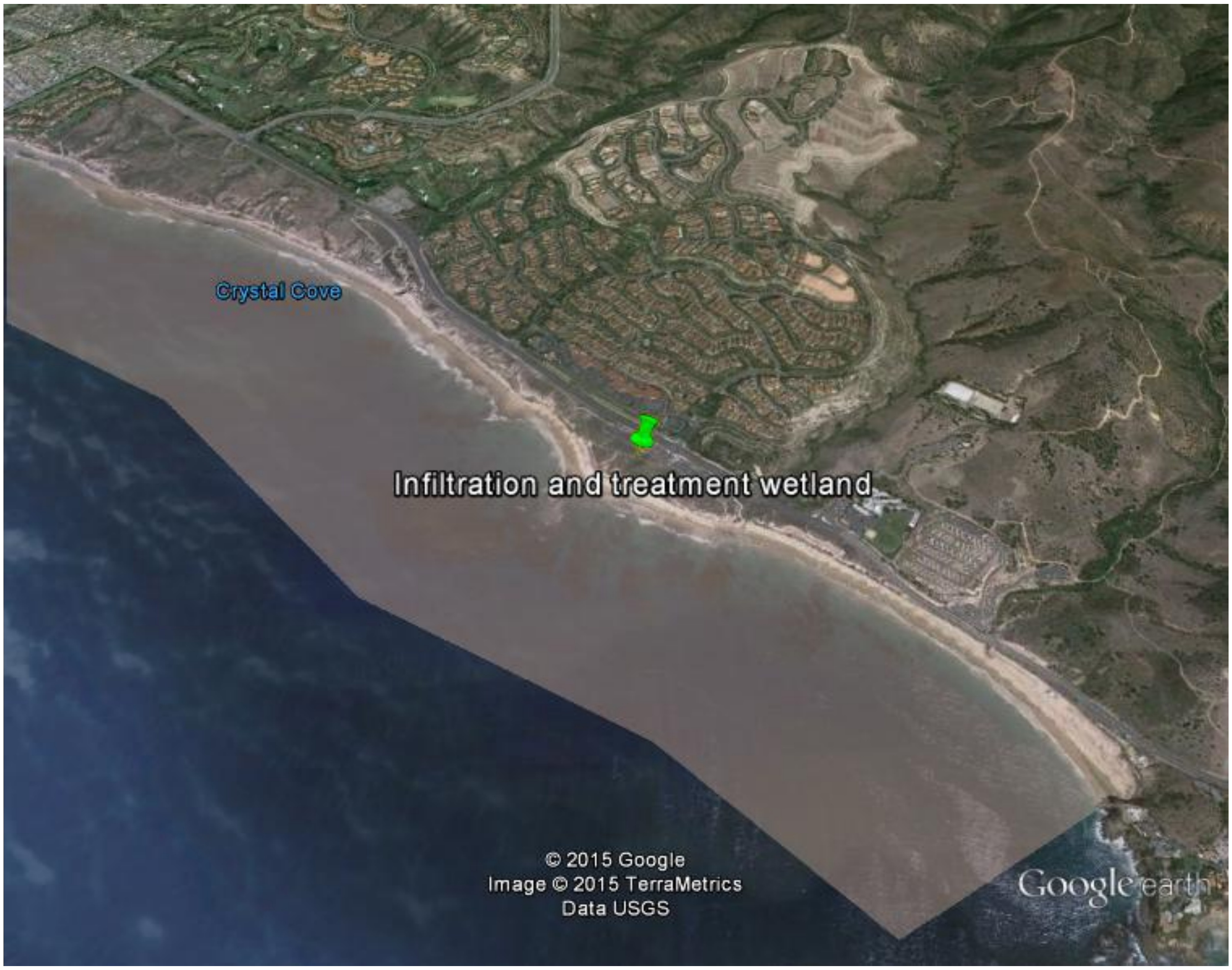

Figure 3.2-1. Map of the Irvine Coast ASBS and location of the infiltration and treatment wetland BMP. Shaded area represents the ASBS boundary.

a)

b)

Figure 3.2-2. Picture of Irvine Coast ASBS BMPs in the Reef Point parking lot: (a) biotreatement system in parking lot median, and; (b) porous pavement, curb, and gutter connected to an underground infiltration gallery and modular wetland treatment system.

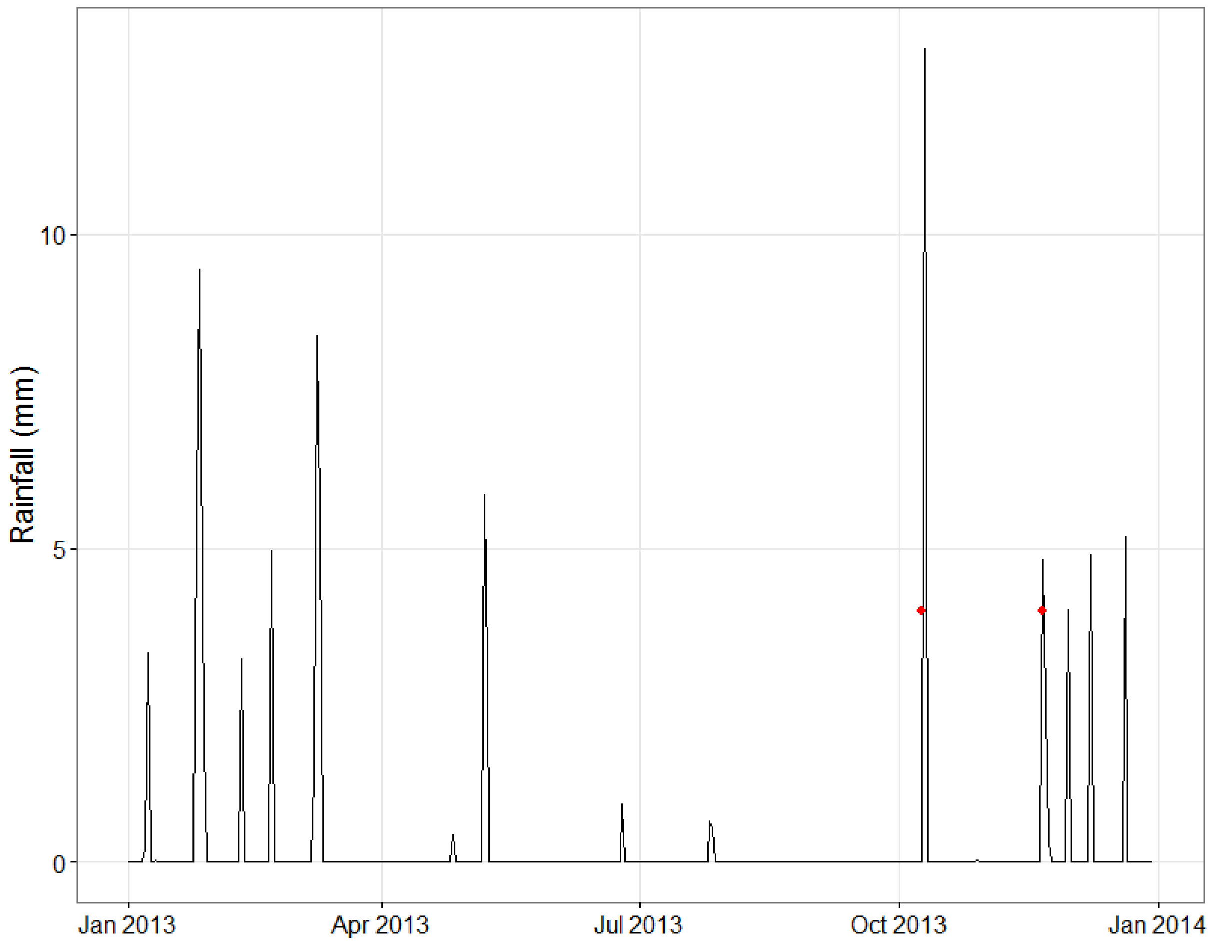

Figure 3.2-3. PRISM daily rainfall estimates for the Irvine Coast BMP. Red dots represent sampled storm events.

Table 3.2-1. Inventory of sampling effort for the Irvine Coast ASBS.

Parameter	Number of Wet Weather Samples	Number of Dry Weather Samples	Total Number of Samples
TSS	4	0	4
Turbidity	0	0	0
Oil and Grease	4	0	4
Nitrate	0	0	0
Ammonia	0	0	0
Ortho-P	0	0	0
Total P	0	0	0
Arsenic	4	0	4
Cadmium	4	0	4
Chromium	4	0	4
Copper	4	0	4
Mercury	0	0	0
Nickel	4	0	4
Lead	4	0	4
Selenium	4	0	4
Silver	4	0	4
Zinc	4	0	4
Total PAH	4	0	4
Total Pyrethroid	0	0	0
Total PBDE	0	0	0
Total DDT	0	0	0
Enterococcus	0	0	0
E. coli	0	0	0
Total Coliforms	0	0	0

Table 3.2-2. Runoff to rainfall ratio for the Irvine Coast ASBS BMP.

Sample Dates	Volume (L)	Rain (mm)	Ratio (L/mm)
10/9/2013	38,992	27	1,444
11/21/2013	20,388	17	1,196
Average			1,320

Table 3.2-3. Irvine Coast ASBS Chemistry results.

Parameter	Units	Storm 1 Mean Concentration (10/9/2013)		Storm 2 Mean Concentration (11/21/2013)		Wet Season Mean Concentration (95% CI)		Concentration Reduction (%)
		Influent	Effluent	Influent	Effluent	Influent	Effluent	
TSS	mg/L	59	17	7	42.8	33 (51)	29.9 (25.3)	9.39
Turbidity	NTU	-	-	-	-	-	-	-
Oil and Grease	mg/L	-	-	-	-	-	-	-
Nitrate	mg/L	-	-	-	-	-	-	-
Ammonia	mg/L	-	-	-	-	-	-	-
Ortho-P	mg/L	-	-	-	-	-	-	-
Total P	mg/L	-	-	-	-	-	-	-
Arsenic	µg/L	235	12.8	250	18.1	242 (15)	15.4 (5.2)	93.64
Cadmium	µg/L	216	0.457	220	0.267	218 (3.6)	0.362 (0.186)	99.83
Chromium	µg/L	221	15.8	205	8.44	213 (15.3)	12.1 (7.22)	94.32
Copper	µg/L	339	60.2	279	34	309 (59.5)	47.1 (25.7)	84.76
Mercury	µg/L	-	-	-	-	-	-	-
Nickel	µg/L	313	28	237	9.79	275 (74.9)	18.9 (17.8)	93.13
Lead	µg/L	209	1.39	203	0.83	206 (5.22)	1.11 (0.549)	99.46
Selenium	µg/L	221	7.05	214	5.08	218 (6.02)	6.06 (1.93)	97.22
Silver	µg/L	17.2	0	18.9	0	18.1 (1.72)	-	100
Zinc	µg/L	1580	60.4	639	14.2	1110 (919)	37.3 (45.3)	96.64
Total PAH	ng/L	519	74.1	42.2	30.2	281 (467)	52.2 (43)	81.42
Total Pyrethroid	ng/L	-	-	-	-	-	-	-
Total PBDE	ng/L	-	-	-	-	-	-	-
Total DDT	ng/L	-	-	-	-	-	-	-
Enterococcus	Log_{10} MPN/100mL	-	-	-	-	-	-	-
E. coli	Log_{10} MPN/100mL	-	-	-	-	-	-	-
Total Coliforms	Log_{10} MPN/100mL	-	-	-	-	-	-	-

Table 3.2-4. Estimated load reduction at the Irvine Coast ASBS Reef Point Parking Lot BMP.

Parameter	Load Units	Estimated 2013 Influent Load		Estimated 2013 Effluent Load		Estimated 2013 Load Reduction	
		Load	Load 95% CI	Load	95% CI	Load	%
Volume	m^3	128.28	-	69.91	-	58.37	45.50
TSS	kg	4.23	6.54	2.09	1.77	2.14	50.62
Turbidity	NTU	-	-	-	-	-	-
Oil and Grease	g	-	-	-	-	-	-
Nitrate	g	-	-	-	-	-	-
Ammonia	g	-	-	-	-	-	-
Ortho-P	g	-	-	-	-	-	-
Total P	g	-	-	-	-	-	-
Arsenic	g	31.04	1.92	1.08	0.36	29.97	96.53
Cadmium	g	27.96	0.46	0.03	0.01	27.94	99.91
Chromium	g	27.32	1.96	0.85	0.50	26.48	96.90
Copper	g	39.64	7.63	3.29	1.80	36.34	91.69
Mercury	g	-	-	-	-	-	-
Nickel	g	35.28	9.61	1.32	1.24	33.95	96.25
Lead	g	26.43	0.67	0.08	0.04	26.35	99.71
Selenium	g	27.96	0.77	0.42	0.13	27.54	98.48
Silver	g	-	-	-	-	-	-
Zinc	g	142.39	117.89	2.61	3.17	139.78	98.17
Total PAH	mg	36.05	59.91	3.65	3.01	32.40	89.88
Total Pyrethroid	mg	-	-	-	-	-	-
Total PBDE	mg	-	-	-	-	-	-
Total DDT	mg	-	-	-	-	-	-
Enterococcus	10^6 Log_{10} MPN	-	-	-	-	-	-
E. coli	10^6 Log_{10} MPN	-	-	-	-	-	-
Total Coliforms	10^6 Log_{10} MPN	-	-	-	-	-	-

3.3 Robert Badham Infiltration and Treatment Wetland

BMP Description

This project focused on reducing pollution to the Robert Badham ASBS located in Orange County (Figure 3.3-1). The Robert Badham ASBS, which covers approximately 0.9 km^2, extends offshore the small coastal city of Corona del Mar, and includes a Marine Life Refuge. The Robert Badham ASBS features coastal bluffs, tide pools, and kelp beds.

Buck Gully is a small (4.8 km^2) coastal watershed draining residential and commercial land uses, as well as transportation activities. Originally an ephemeral stream, Buck Gully is now perennial resulting largely from daily irrigation runoff. There were two BMPs constructed at this ASBS, which were treated separately for this report. The first BMP was designed to capture and infiltrate dry weather runoff emanating from the Shorecliff Drive neighborhood (called Shorecliff). This was accomplished by installing a sidewalk and curb-cut catch basin with porous pavement allowing for percolation into a subsurface rock-filled infiltration gallery, which slowly drains to the soil. This system was installed between the Shorecliff neighborhood and the stormdrain outfall at the beach (Figure 3.3-2).

The second BMP was designed to reduce erosion and treat wet and dry weather runoff from the Buck Gully watershed (called Buck Gully). Erosion reduction utilized a combination of bend-way weirs to stabilize and redirect flow away from erosive stream banks, followed by stepped gabions to control grade and reduce stream energy. In series with the stepped gabion structures was a subsurface flow treatment wetland, which helps improve water quality and reduce volume using natural processes (Figure 3.3-3).

Design, Sample Inventory and Flow Estimates

The Shorecliff Infiltration BMP utilized an influent-effluent monitoring design. The Shorecliff BMP influent was sampled upstream of the catch basins that redirect flow to the infiltration gallery, and the effluent was sampled downstream of the infiltration gallery at the 46 cm (18 inch) outfall draining to the coastal bluff. Samples were collected during two sampling events, November 13 and November 20, 2013, a period without rain that was preceded by at least 72 hours of antecedent dry conditions. Flow was measured at the influent and effluent sampling sites for at least a 24-hr period surrounding each sampling event using a level data logger mounted in front of a V-notch weir. A weir equation was then used to estimate flow.

In total, this grantee collected four samples for chemical analysis at the Shorecliff BMP consistent with their Monitoring Plan (Table 3.3-1). One influent and one effluent sample were collected during each of the two sampling events. At the Shorecliff BMP, the grantee measured 9 of the 24 parameters identified in this report for load reduction.

At the Shorecliff BMP, influent volume was measured upstream of the BMP prior to entering the catch basin that led to the infiltration basin, and then again downstream of the BMP. Flow was measured using a data logger and a v-notch weir using a weir equation.

The Buck Gully BMP utilized an influent-effluent study design. The Buck Gully BMP was sampled at five locations, starting upstream of the BMP, then at several locations within the treatment wetland BMP sequence of bend-way weirs and step gabions. The final site was located downstream of the BMP sequence. For this report, only two sites were utilized; the site just upstream (site 4) and the site just downstream (site 1) of the BMP sequence. This grantee collected postconstruction samples during one dry weather (June 13, 2013) and one storm event (October 9, 2013), consistent with the goals in their Monitoring Plan. The June 13 event was preceded by five weeks of antecedent dry period. The October 9 storm was the first storm of the year and totaled 0.84 cm.

In total, this grantee collected 10 samples for chemical analysis at the Buck Gully BMP composed of one sample from each of five sites for one dry weather and one wet weather event (Table 3.3-4). Because only the immediate upstream and immediate downstream sample locations were used for the influent-effluent sample design, the analysis for this report used four of the 10 samples. All samples were collected as time-weighted composites, collected by hand using pre-cleaned bottles. At the Buck Gully BMP, the grantee measured 15 of the 24 parameters identified in this report for load reduction.

At the Buck Gully BMP, flow was measured using a level data logger in combination with a stream rating curve that translates depth to flow. The rating curve was created by the grantee by comparing depth (from the data logger), cross-section specifications of the stream channel, and depth-integrated velocity using hand-held velocity meters. This process was repeated several times and at various depths to create the rating curve for both dry and wet weather.

Concentration and Load Reduction

At the Shorecliff BMP, influent trace metal concentrations varied little, never exceeding 40% difference between the two sampling events (Table 3.3-3). For example, influent copper concentrations ranged from 65 to 68 µg/L (4% difference). Correspondingly, effluent concentrations were also similar between sampling events. Effluent copper concentrations were nearly identical ranging from 50.7 to 51.1 µg/L (<1% difference). However, the concentration reductions from influent to effluent varied widely between metals. Concentration changes from influent to effluent ranged from a decrease of 30% (nickel) to an increase of 171% (zinc).

The Shorecliff BMP removed an estimated 0.5 x 10^6 L of runoff and 0.03 kg of copper from entering the Robert Badham ASBS during CY2013 (Table 3.3-3). The Shorecliff BMP reduced loads for every trace metal measured except for silver (which was nondetectable) and zinc. The load of zinc remained roughly the same, despite a 60% decrease in volume, as a result of increased zinc concentrations. One assumption is that there was a source of zinc somewhere within the BMP system.

At the Buck Gully BMP, dry weather effluent concentrations increased for seven constituents and decreased for seven constituents compared to influent concentrations (Table 3.3-5). For example, copper concentrations decreased by 14% between influent and effluent during dry weather. In contrast, lead concentrations increased by 38% from influent to effluent during dry weather. Turbidity increased the greatest relative percentage, almost a factor of seven. Silver was undetectable in both influent and effluent.

Wet weather concentration increased for 14 constituents and decreased for one constituent at the Buck Gully BMP (Table 3.3-5). Not only did the majority of constituents increase in concentration, they increased by a factor of two to ten. For example, copper concentrations increased by over 1200% (8 to 111 µg/L).

The Buck Gully BMP removed an estimated 285 x 10^6 L of dry weather runoff from entering the Robert Badham ASBS during CY2013 (Table 3.3-6). The BMP also reduced 649 kg of TSS, 0.6 kg loads of copper, and 1.2 kg of zinc during dry weather. Except for turbidity and pyrethroid pesticides, the Buck Gully BMP reduced the dry weather loads of every constituent measured, ranging from 40% (arsenic) to 87% (cadmium).

The Buck Gully BMP did not reduce volume or loads during wet weather (Table 3.3-6). This was from a combination of increases in flow and increases in concentration for most constituents. For example, stormwater runoff volume nearly doubled between the influent and effluent sampling sites, increasing by an estimated 59 x 10^6 L during storm events for CY2013. Constituent load increased between 2- to 25-fold during wet weather, depending on constituent. For example, the load of copper increased nearly 13 kg from influent to effluent during wet weather at the Buck Gully BMP. Clearly, there were additional inputs of storm runoff volume between the influent and effluent sampling sites. However, the increases in loads could be the result of these additional sources of runoff, or from generation within the stream channel and BMP (i.e., erosion, sequestered dry weather inputs).

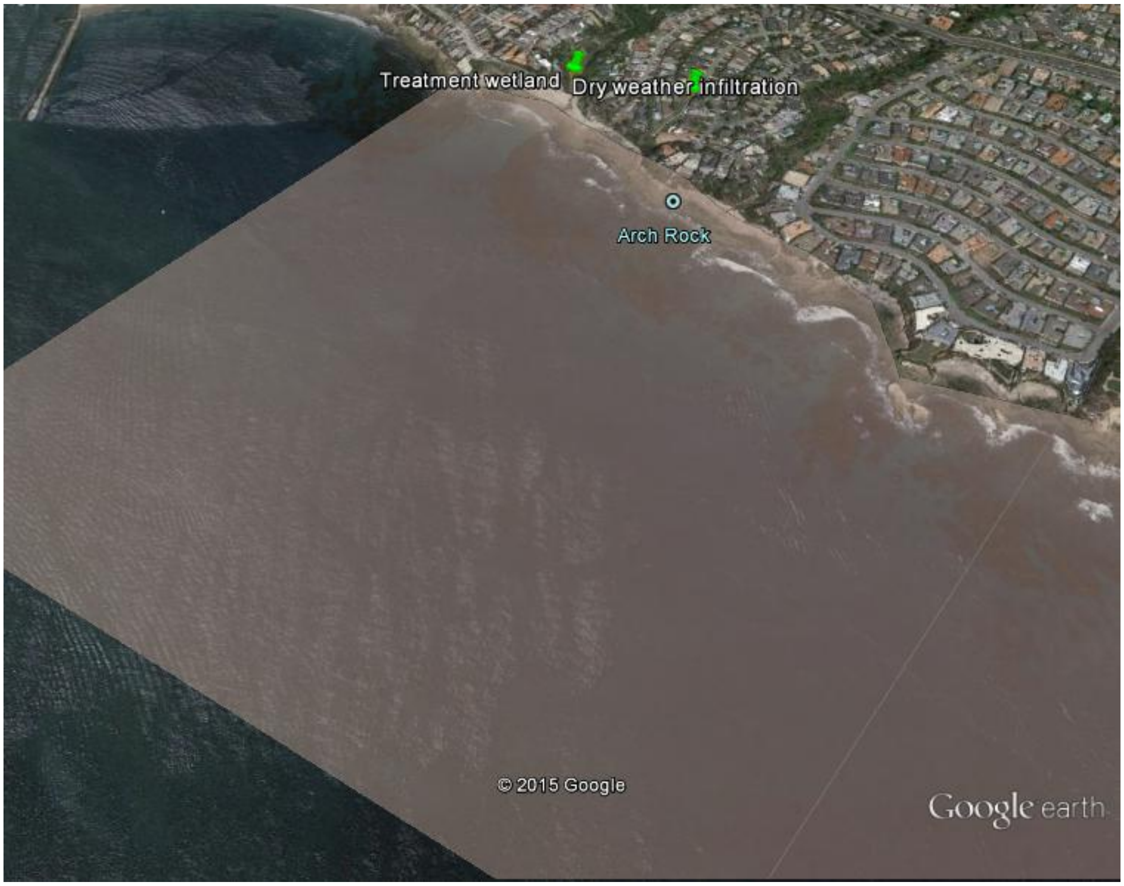

Figure 3.3-1. Map of Shorecliff Infiltration BMP and the Buck Gully Treatment Wetland in the Robert Badham ASBS. Shaded area represents the ASBS.

Figure 3.3-2. Photos of the entrance and exit of the Shorecliff Infiltration BMP.

Figure 3.3-3. Photos of the construction process at the Buck Gully treatment wetland BMP in the Robert Badham ASBS.

Table 3.3-1. Sampling inventory for the Shorecliff Infiltration BMP in the Robert Badham ASBS.

Parameter	Number of Wet Weather Samples	Number of Dry Weather Samples	Total Number of Samples
TSS	0	0	0
Turbidity	0	0	0
Oil and Grease	0	0	0
Nitrate	0	0	0
Ammonia	0	0	0
Ortho-P	0	0	0
Total P	0	0	0
Arsenic	0	4	4
Cadmium	0	4	4
Chromium	0	4	4
Copper	0	4	4
Mercury	0	0	0
Nickel	0	4	4
Lead	0	4	4
Selenium	0	4	4
Silver	0	4	4
Zinc	0	4	4
Total PAH	0	0	0
Total Pyrethroid	0	0	0
Total PBDE	0	0	0
Total DDT	0	0	0
Enterococcus	0	0	0
E. coli	0	0	0
Total Coliforms	0	0	0

Table 3.3-2. Chemistry results for the Shorecliff Infiltration BMP in the Robert Badham ASBS.

Parameter	Units	Nov 13, 2013		Nov 20, 2013		Average Dry Weather		Concentration Reduction (%)
		Influent	Effluent	Influent	Effluent	Influent	Effluent	
TSS	mg/L	-	-	-	-	-	-	-
Turbidity	NTU	-	-	-	-	-	-	-
Oil & Grease	mg/L	-	-	-	-	-	-	-
Nitrate	mg/L	-	-	-	-	-	-	-
Ammonia	mg/L	-	-	-	-	-	-	-
Ortho-P	mg/L	-	-	-	-	-	-	-
Total P	mg/L	-	-	-	-	-	-	-
Arsenic	µg/L	2.83	2.65	3.08	2.93	2.96	2.79	5.6
Cadmium	µg/L	0.095	0.091	0.127	0.14	0.111	0.116	-4.1
Chromium	µg/L	1.28	1.05	1.25	1.42	1.27	1.24	2.4
Copper	µg/L	67.72	50.7	65.23	51.1	66.475	50.9	23.4
Mercury	µg/L	-	-	-	-	-	-	-
Nickel	µg/L	1.32	1.25	1.13	0.48	1.23	0.87	29.4
Lead	µg/L	2.41	2	2.17	2.85	2.29	2.43	-5.9
Selenium	µg/L	1.23	1.23	1.4	1.75	1.32	1.49	-13.3
Silver	µg/L	0	0	0	0	0	0	0.0
Zinc	µg/L	49.57	112.02	32.49	110.96	41.03	111.49	-171.7
Total PAH	ng/L	-	-	-	-	-	-	-
Total Pyrethroid	ng/L	-	-	-	-	-	-	-
Total PBDE	ng/L	-	-	-	-	-	-	-
Total DDT	ng/L	-	-	-	-	-	-	-
Enterococcus	Log_{10} MPN/100mL	-	-	-	-	-	-	-
E. coli	Log_{10} MPN/100mL	-	-	-	-	-	-	-
Total Coliforms	Log_{10} MPN/100mL	-	-	-	-	-	-	-

Table 3.3-3. CY2013 influent loads, effluent loads, and load reduction for the Shorecliff Infiltration BMP in the Robert Badham ASBS.

Parameter	Units	Annual Load		Load Reduction	% Reduction
		Influent	Effluent		
Volume	10^6 L	0.74	0.28	0.46	61.8
TSS	kg	-	-	-	-
Turbidity	NTU	-	-	-	-
Oil and Grease	kg	-	-	-	-
Nitrate	kg	-	-	-	-
Ammonia	kg	-	-	-	-
Ortho-P	kg	-	-	-	-
Total P	kg	-	-	-	-
Arsenic	g	2.19	0.79	1.40	63.9
Cadmium	g	0.08	0.03	0.05	60.2
Chromium	g	0.94	0.35	0.59	62.7
Copper	g	49.24	14.41	34.83	70.7
Mercury	g	-	-	-	-
Nickel	g	0.91	0.24	0.66	73.0
Lead	g	1.70	0.69	1.01	59.5
Selenium	g	0.97	0.42	0.55	56.7
Silver	g	0.00	0.00	0.00	0.0
Zinc	g	30.39	31.57	-1.18	-3.9
Total PAH	mg	-	-	-	-
Total Pyrethroid	mg	-	-	-	-
Total PBDE	mg	-	-	-	-
Total DDT	mg	-	-	-	-
Enterococcus	10^6 Log_{10} MPN	-	-	-	-
E. coli	10^6 Log_{10} MPN	-	-	-	-
Total Coliforms	10^6 Log_{10} MPN	-	-	-	-

Table 3.3-4. Sampling inventory for the Buck Gully Treatment Wetland BMP in the Robert Badham ASBS. Five sites were sampled at different locations through the BMP sequence, but only two sites were used for this report: the site immediately upstream and the site immediately downstream of the BMP.

Parameter	Number of Wet Weather Samples	Number of Dry Weather Samples	Total Number of Samples
TSS	5(2)	5(2)	10(4)
Turbidity	5(2)	5(2)	10(4)
Oil and Grease	0	0	0
Nitrate	0	0	0
Ammonia	0	0	0
Ortho-P	0	0	0
Total P	0	0	0
Arsenic	5(2)	5(2)	10(4)
Cadmium	5(2)	5(2)	10(4)
Chromium	5(2)	5(2)	10(4)
Copper	5(2)	5(2)	10(4)
Mercury	0	0	0
Nickel	5(2)	5(2)	10(4)
Lead	5(2)	5(2)	10(4)
Selenium	5(2)	5(2)	10(4)
Silver	5(2)	5(2)	10(4)
Zinc	5(2)	5(2)	10(4)
Total PAH	0	0	0
Total Pyrethroid	5(2)	5(2)	10(4)
Total PBDE	0	0	0
Total DDT	0	0	0
Enterococcus	5(2)	5(2)	10(4)
E. coli	5(2)	5(2)	10(4)
Total Coliforms	5(2)	5(2)	10(4)

Table 3.3-5. Chemistry results for the Buck Gully Treatment Wetland BMP in the Robert Badham ASBS.

Parameter	Units	Dry Weather (Jun 13, 2013)		Concentration Reduction (%)	Wet Weather (Oct 9, 2013)		Concentration Reduction (%)
		Influent	Effluent		Influent	Effluent	
TSS	mg/L	2.1	1.8	14.3	72.8	680.7	-835.0
Turbidity	NTU	0.2	1.5	-650.0	36.1	37.1	-2.8
Oil & Grease	mg/L	-	-	-	-	-	-
Nitrate	mg/L	-	-	-	-	-	-
Ammonia	mg/L	-	-	-	-	-	-
Ortho-P	mg/L	-	-	-	-	-	-
Total P	mg/L	-	-	-	-	-	-
Arsenic	µg/L	1.19	1.94	-63.0	2.93	13.36	-356.0
Cadmium	µg/L	2.73	1	63.4	5.07	23.06	-354.8
Chromium	µg/L	0.08	0.13	-62.5	1.87	23.34	-1148.1
Copper	µg/L	1.96	1.69	13.8	8.23	111.19	-1251.0
Mercury	µg/L	-	-	-	-	-	-
Nickel	µg/L	9.43	7.28	22.8	30.63	66.49	-117.1
Lead	µg/L	0.058	0.08	-37.9	7.71	16.83	-118.3
Selenium	µg/L	15.29	13.39	12.4	6.66	14.74	-121.3
Silver	µg/L	0	0	0	0.02	0	100.0
Zinc	µg/L	5.17	6.61	-27.9	681.43	447.48	34.3
Total PAH	ng/L	-	-	-	-	-	-
Total Pyrethroid	ng/L	0	14.7		327.2	636.1	-94.4
Total PBDE	ng/L	-	-	-	-	-	-
Total DDT	ng/L	-	-	-	-	-	-
Enterococcus	Log_{10} MPN/100mL	3.23	2.85	11.9	4.15	5.23	-26.2
E. coli	Log_{10} MPN/100mL	3.04	2.48	18.6	4.04	4.69	-16.1
Total Coliforms	Log_{10} MPN/100mL	3.85	4.90	-27.5	4.52	5.11	-13.2

Table 3.3-6. CY2013 influent loads, effluent loads, and load reduction for the Buck Gully Treatment Wetland BMP in the Robert Badham ASBS.

Parameter	Units	Annual Dry Weather Load		Load Reduction	% Reduction	Annual Wet Weather Load		Load Reduction	% Reduction
		Influent	Effluent			Influent	Effluent		
Volume	$Lx10^6$	450.6	165.2	285.4	63.3	62.5	121.4	-58.9	-94.2
TSS	kg	946.2	297.3	648.9	68.6	4,550.5	82,642.6	-78091.8	-1716.1
Turbidity	NTU	90.1	247.7	-157.6	-174.9	2,256.5	4,504.2	-2247.7	-99.6
Oil&Grease	kg	-	-	-	-	-	-	-	-
Nitrate	kg	-	-	-	-	-	-	-	-
Ammonia	kg	-	-	-	-	-	-	-	-
Ortho-P	kg	-	-	-	-	-	-	-	-
Total P	kg	-	-	-	-	-	-	-	-
Arsenic	g	536.2	320.4	215.7	40.2	183.1	1,622.0	-1438.9	-785.6
Cadmium	g	1230.0	165.2	1064.9	86.6	316.9	2,799.7	-2482.8	-783.4
Chromium	g	36.0	21.5	14.6	40.4	116.9	2,833.7	-2716.8	-2324.2
Copper	g	883.1	279.1	604.0	68.4	514.4	13,499.4	-12984.9	-2524.1
Mercury	g	-	-	-	-	-	-	-	-
Nickel	g	4248.8	1202.4	3046.3	71.7	1,914.6	8,072.4	-6157.8	-321.6
Lead	g	26.1	13.2	12.9	49.4	481.9	2,043.3	-1561.4	-324.0
Selenium	g	6889.0	2211.6	4677.4	67.9	416.3	1,789.6	-1373.3	-329.9
Silver	g	0.0	0.0	0.0	0.0	1.3	-	1.3	100.0
Zinc	g	2329.4	1091.7	1237.6	53.1	42,594.3	54,327.8	-11733.3	-27.5
Total PAH	mg	-	-	-	-	-	-	-	-
Total Pyrethroid	mg	0.0	2427.9	-2427.9	NC	20,452.4	77,227.8	-56775.2	-277.6
Total PBDE	mg	-	-	-	-	-	-	-	-
Total DDT	mg	-	-	-	-	-	-	-	-
Enterococcus	10^6 Log_{10} MPN	1455.5	469.9	985.6	67.7	259.2	635.0	-375.9	-145.0
E. coli	10^6 Log_{10} MPN	1370.3	409.1	961.2	70.1	252.6	569.4	-316.8	-125.4
Total Coliforms	10^6 Log_{10} MPN	1732.4	809.8	922.6	53.3	282.4	620.9	-338.4	-119.8

NC = not calculable

3.4 La Jolla Infiltration

BMP Description

This project focused on reducing pollution to the La Jolla ASBS located in San Diego County (Figure 3.4-1). The La Jolla ASBS, which covers approximately 1.8 km^2, stretches from La Jolla Shores to Point La Jolla, and includes a Marine Conservation Area. Habitats include tide pools, kelp beds, and the La Jolla caves, a popular destination for paddlers and divers.

The La Jolla ASBS is an extremely heavily used recreational area, with a focal point being Kellogg Park, located directly adjacent to La Jolla Shores. Kellogg Park, with its grassy play and picnic areas, restrooms, and playground, quickly fills its parking lot with nearly 400 vehicles nearly every day.

The BMP constructed at the La Jolla ASBS was designed to capture and infiltrate stormwater runoff from the Kellogg Park parking lot utilizing porous pavement and an infiltration trench (Figure 3.4-2). From its middle, the parking lot gently slopes to the north and south, draining stormwater to the turn-abouts at each end. The turn-abouts were retrofitted with approximately 1,670 m^2 of pervious pavers underlain with aggregate for volume storage. The stored volume then passes through geotechnical fabric to perforated pipe, and is drained to an infiltration trench located under the beach boardwalk. Catch basins and trench drains capture any overflow and are also connected to the infiltration trench. In addition, the parking lot receives run-on from the adjacent residential street at the north and south parking lot entrances. These flows are also captured by catch basins and trench drains that are connected to the infiltration trench. The infiltration trench is allowed to percolate into the substratum.

Design, Sample Inventory and Flow Estimates

This BMP utilized an influent-effluent monitoring design. There were three influent sampling sites located at the north parking entrance, the south parking lot entrance, and at the end of the ribbon gutter running down the middle of the parking lot parkway. The sampling sites at the north and south parking lot entrances captured influent from the adjacent neighborhood. The ribbon gutter captured influent generated within the parking lot. Because the infiltration trench was allowed to percolate into the substratum, there was no effluent.

This grantee collected samples during three storm events (March 7, October 28, and November 21, 2013), consistent with the goals in their Monitoring Plan (Figure 3.4-3). No samples were collected during dry weather because there was minimal to no flow without precipitation. Precipitation measurements for sampled storms were collected at nearby rain gauges on Scripps Pier or Miramar Naval Air Station. The three sampled storms included one large (25.4 mm on March 7-8, 2014), one median (12.8 mm on November 21, 2013), and one small (4.3 mm on October 29, 2013) for the monitoring period. PRISM daily rainfall estimated 19 discrete storm events at the BMP location for CY2013.

In total, nine samples were collected across the three storm events corresponding to three storms at three sites each (Table 3.4-1). Each sample was comprised of up to five individual grab samples, collected across the duration of the storm event, and combined to create one composite sample per site per storm event. The grantee measured 12 of the 24 parameters identified in this report for load reduction.

In order to estimate treated flow, the volume within the infiltration trench was calculated based on level data loggers and design capacity. The grantee used the USEPA Stormwater Management Model (SWMM) to estimate stormwater runoff volumes to the BMP. From the model predictions, a rainfall-runoff volume translator was developed for estimating unmeasured storms (Table 3.4-2). The grantee also estimated bypass volumes as the difference from modeled flows and design capacity of the BMP. From these data a BMP design capacity of 400,000 L was calculated by the grantee. For the remaining calculations, it was assumed that the BMP infiltrated all influent prior to the next storm event.

Concentration and Load Reduction

Average influent concentrations consistently ranged less than a factor of three for trace metals, less than a factor of five for TSS, and by a factor of 10 or more for pyrethroid pesticides and *E. coli* (Table 3.4-3). For example, average copper concentrations ranged from 197 to 291 µg/L among the three events. The variation in pyrethroids pesticides was a result of several non-detectable values. Of the 12 constituents in this report, 10 had their greatest concentration in the largest event of the year (March 7-8, 2013). Only four of the 12 constituents had their lowest concentration in the smallest storm of the year, but this storm (October 29, 2013) followed a six-week dry period.

Since this BMP infiltrated all effluent (no surface discharge), effluent concentrations were always assumed to be zero. However, storm flows were predicted to have bypassed the BMP for two large storm events (January 26-27 and March 6-7, 2013; Figure 3.4-1). The remaining storms were assumed to have no bypassed flows.

Since this BMP had no effluent (no surface discharge), the reduction of influent concentrations and resulting load reductions was assumed to be 100% (Table 3.4-4). This BMP removed an estimated 2.4 million L of runoff, 358 kg of TSS, 0.5 kg of copper, and 1.5 g of pyrethroid pesticides from entering the La Jolla ASBS during CY2013. However, the bypassed flows, at concentrations equivalent to influent, did produce some loading to the ASBS. This BMP captured 82% of the flows for CY2013 and, as a result, 82% of the load for all measured constituents from entering the La Jolla ASBS.

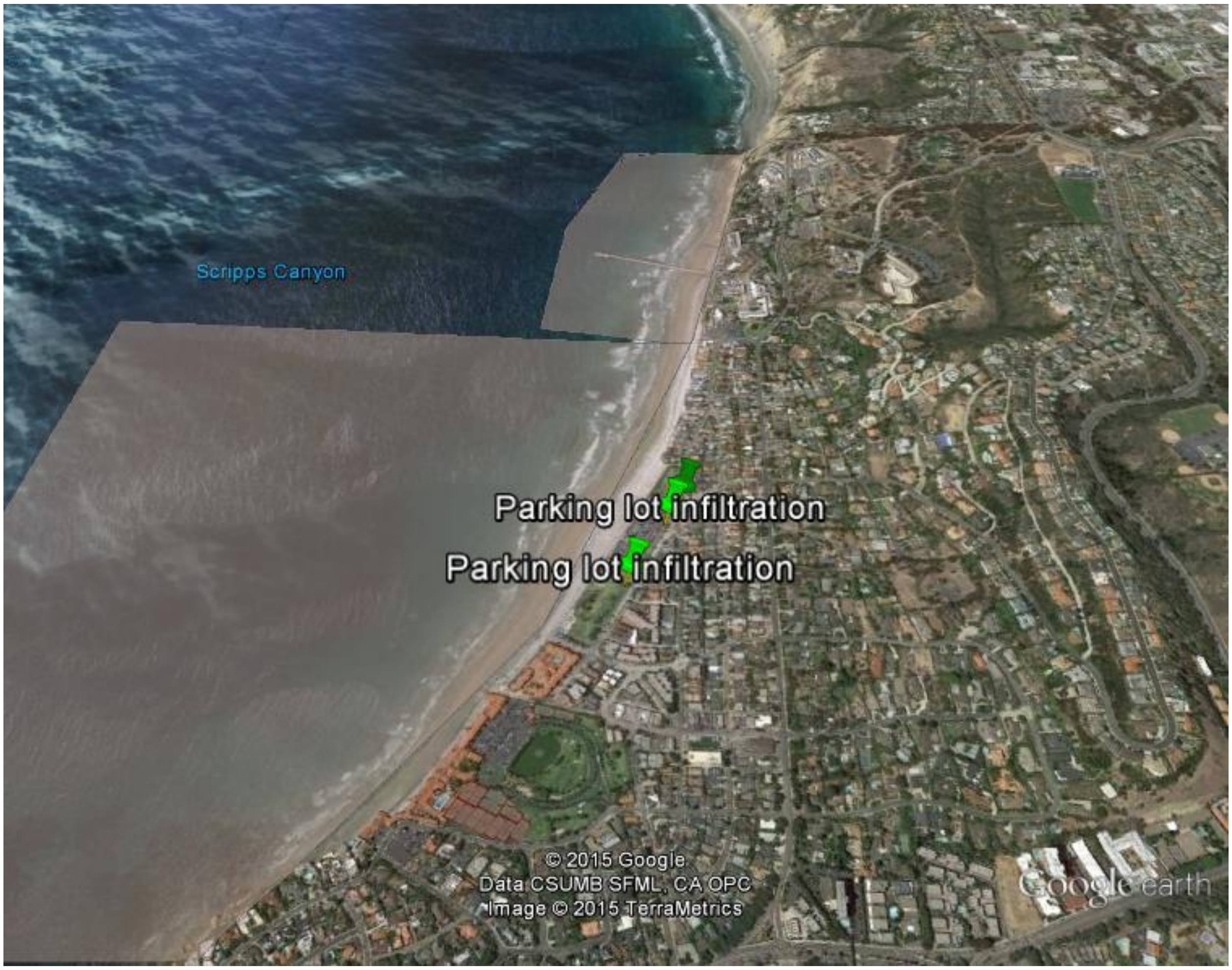

Figure 3.4-1. Map of the La Jolla ASBS stormwater BMP at Kellogg Park. Shaded area represents the ASBS.

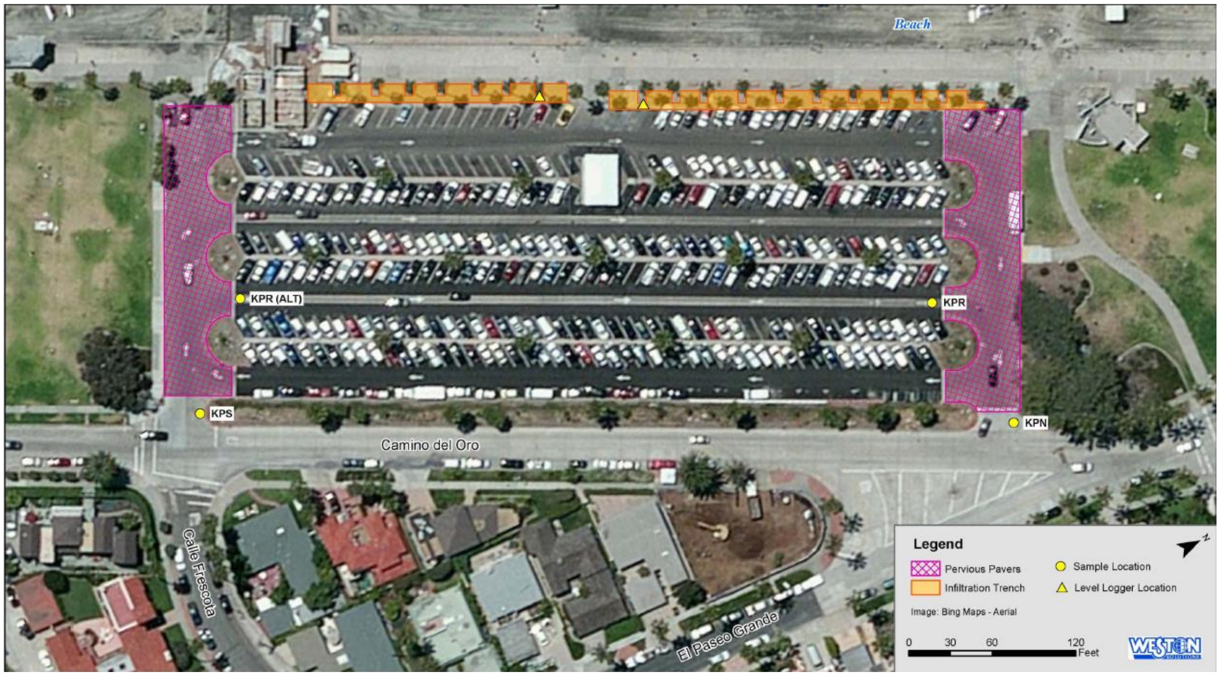

Figure 3.4-2. Aerial view of BMP design and oblique photo of pervious pavers in the Kellogg Park BMP.

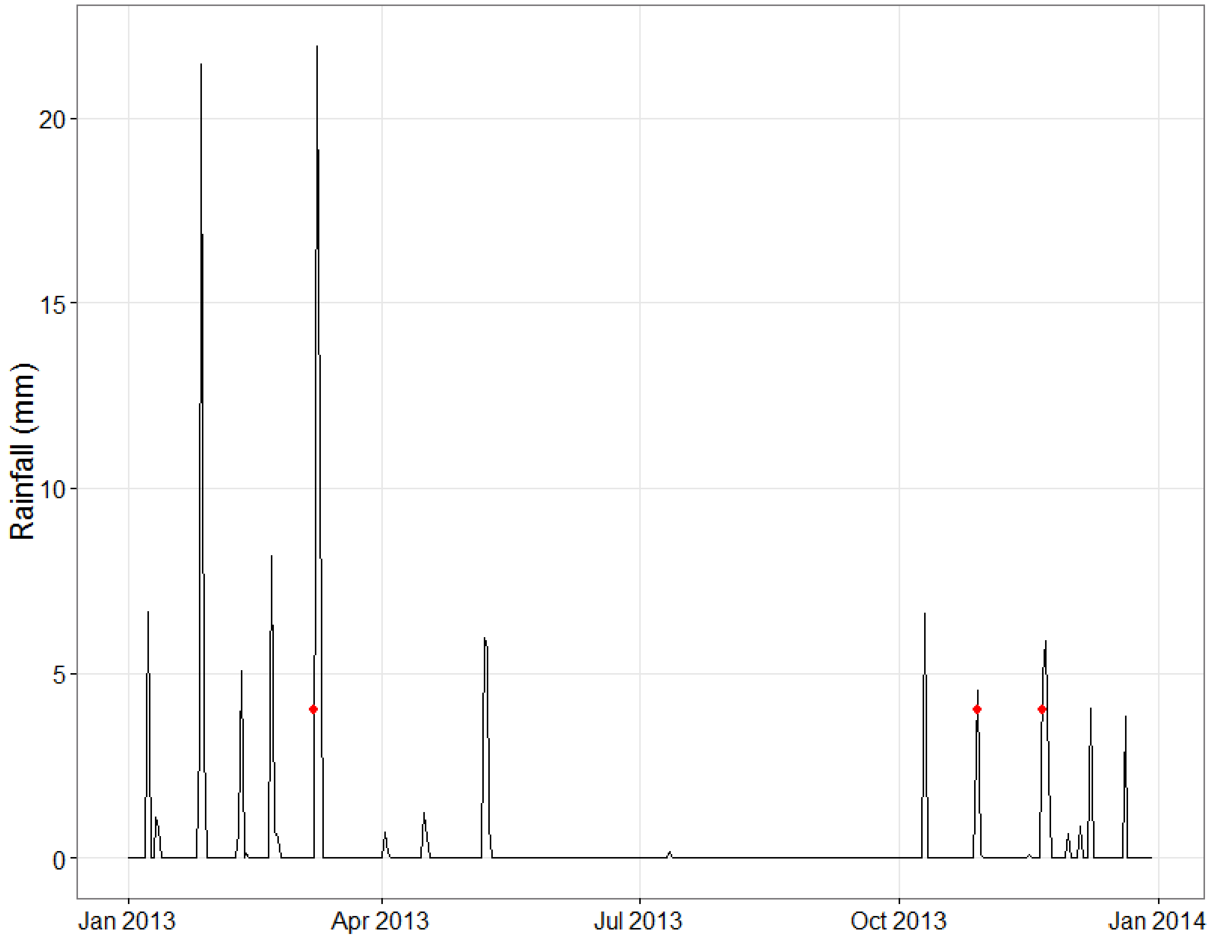

Figure 3.4-3. PRISM daily precipitation at the La Jolla ASBS. Red dots represent sampled storm events.

Table 3.4-1. Sampling inventory for the La Jolla ASBS.

Parameter	Number of Wet Weather Samples	Number of Dry Weather Samples	Total Number of Samples
TSS	9	0	9
Turbidity	0	0	0
Oil and Grease	0	0	0
Nitrate	0	0	0
Ammonia	0	0	0
Ortho-P	0	0	0
Total P	0	0	0
Arsenic	9	0	9
Cadmium	9	0	9
Chromium	9	0	9
Copper	9	0	9
Mercury	0	0	0
Nickel	9	0	9
Lead	9	0	9
Selenium	9	0	9
Silver	9	0	9
Zinc	9	0	9
Total PAH	0	0	0
Total Pyrethroid	9	0	9
Total PBDE	0	0	0
Total DDT	0	0	0
Enterococcus	0	0	0
E. coli	9	0	9
Total Coliforms	0	0	0

Table 3.4-2. Runoff to rainfall ratio for the La Jolla ASBS BMP.

Sample Dates	Volume (L)	Rain (mm)	Ratio (L/mm)
March 7-8, 2013	1066106	25.4	41,973
October 29, 2013	49248	4.3	11,453
November 21, 2013	149643	12.8	11,691
Average			21,706

Table 3.4-3. Influent and effluent concentrations for the Kellogg Park BMP in the La Jolla ASBS.

Parameter	Units	Storm 1 Mean Concentration (3/7-8/2013)		Storm 2 Mean Concentration (10/29/2013)		Storm 3 Mean Concentration (11/21/2013)		Wet Season Mean Concentration (95% CI)		Concentration Reduction (%)
		Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	
TSS	mg/L	268	-	56.4	-	122	-	149 (122)	-	100
Turbidity	NTU	-	-	-	-	-	-	-	-	-
Oil & Grease	mg/L	-	-	-	-	-	-	-	-	-
Nitrate	mg/L	-	-	-	-	-	-	-	-	-
Ammonia	mg/L	-	-	-	-	-	-	-	-	-
Ortho-P	mg/L	-	-	-	-	-	-	-	-	-
Total P	mg/L	-	-	-	-	-	-	-	-	-
Arsenic	µg/L	6.11	-	8	-	12.5	-	8.86 (9.7)	-	100
Cadmium	µg/L	0.428	-	0.287	-	0.228	-	0.914 (0.116)	-	100
Chromium	µg/L	19.2	-	17.8	-	10.2	-	19.7 (4.92)	-	100
Copper	µg/L	291	-	270	-	197	-	219 (77.6)	-	100
Mercury	µg/L	-	-	-	-	-	-	-	-	-
Nickel	µg/L	17.8	-	12.8	-	5.94	-	12.2 (6.76)	-	100
Lead	µg/L	18	-	5.64	-	11.7	-	11.8 (6.97)	-	100
Selenium	µg/L	1.49	-	0.854	-	0.159	-	0.815 (0.721)	-	100
Silver	µg/L	0.050	-	0.001	-	0.001	-	0.017 (0.092)	-	100
Zinc	µg/L	691	-	244	-	242	-	979 (254)	-	100
Total PAH	ng/L	-	-	-	-	-	-	-	-	-
Total Pyrethroid	ng/L	559	-	119	-	1170	-	619 (599)	-	100
Total PBDE	ng/L	-	-	-	-	-	-	-	-	-
Total DDT	ng/L	-	-	-	-	-	-	-	-	-
Enterococcus	Log_{10} MPN/100mL	-	-	-	-	-	-	-	-	-
E. coli	Log_{10} MPN/100mL	9.09	-	8.94	-	9.46	-	9.22 (0.102)	-	100
Total Coliforms	Log_{10} MPN/100mL	-	-	-	-	-	-	-	-	-

Table 3.4-4. Influent loads, effluent loads, and load reduction for the Kellogg Park BMP during CY2013 to the La Jolla ASBS.

Parameter	Units	Annual Influent Load		Annual Effluent Load		Annual Load Reduction	
		Load	95% CI	Load	95% CI	Load	%
Volume	$Lx10^6$	2.91		0.51		2.40	82.4
TSS	kg	434.02	355.37	76.46	62.61	357.55	82.4
Turbidity	NTU	-	-	-	-	-	-
Oil and Grease	g	-	-	-	-	-	-
Nitrate	g	-	-	-	-	-	-
Ammonia	g	-	-	-	-	-	-
Ortho-P	g	-	-	-	-	-	-
Total P	g	-	-	-	-	-	-
Arsenic	g	25.81	28.25	4.55	4.98	21.26	82.4
Cadmium	g	2.66	0.34	0.47	0.06	2.19	82.4
Chromium	g	57.38	14.33	10.11	2.52	47.27	82.4
Copper	g	637.92	226.04	112.39	39.82	525.53	82.4
Mercury	g	-	-	-	-	-	-
Nickel	g	35.54	19.69	6.26	3.47	29.28	82.4
Lead	g	34.37	20.30	6.06	3.58	28.32	82.4
Selenium	g	2.37	2.10	0.42	0.37	1.96	82.4
Silver	g	0.05	0.27	0.01	0.05	0.04	82.4
Zinc	g	2851.71	739.87	502.41	130.35	2349.30	82.4
Total PAH	mg	-	-	-	-	-	-
Total Pyrethroid	mg	1803.07	1744.82	317.66	307.40	1485.41	82.4
Total PBDE	mg	-	-	-	-	-	-
Total DDT	mg	-	-	-	-	-	-
Enterococcus	10^6 Log_{10} MPN	-	-	-	-	-	-
E. coli	10^6 Log_{10} MPN	4.85	0.0	4.73	0.05	0.12	82.4
Total Coliforms	10^6 Log_{10} MPN	-	-	-	-	-	-

3.5 Heisler Park Diversion

BMP Description

This project focused on reducing pollution to the Heisler Park ASBS located in Orange County (Figure 3.5-1). The Heisler Park ASBS, which covers approximately 0.13 km^2, extends across nearly 1 km of coastline along the coastal art enclave of Laguna Beach. The Heisler Park ASBS includes tide pools and kelp beds, and includes a Marine Conservation Area.

The Heisler Park ASBS, in part because of its proximity to downtown Laguna Beach, is a heavily used recreational area. With its inviting beaches, and grassy areas with restrooms on the coastal bluffs above, Heisler Park receives millions of visitors each year. Heisler Park ASBS receives both wet and dry weather runoff from the nearby residential and commercial areas.

The City of Laguna Beach has a multi-phased preservation project for Laguna Beach to reduce the amount of sediment, bacteria, and runoff related pollutants. The proposed BMP for the Heisler Park ASBS under this Proposition 84 ASBS grant was to infiltrate dry weather runoff through grassy swales and landscaping, then reroute any remaining dry weather run-on or runoff to multiple CDS® units for removal of trash, and subsequent diversion to the sanitary sewer (Figure 3.5-2). The BMPs in other phases of the project include computer-controlled irrigation and drought resistant landscaping to reduce water consumption, and upgrade of restroom facilities (and associated sewer lift station).

Design, Sample Inventory and Flow Estimates

This BMP utilized an influent-effluent monitoring design. The influent was sampled at three sanitary sewer diversions installed at the foot of Aster, Jasmine, and Myrtle Streets. Because all of the dry weather flows were diverted to sanitary sewers, there was no effluent and this BMP was assumed to have 100% capture. It is important to note that there was not a sampling location upstream of the grassy swales installed to capture and infiltrate dry weather (mostly irrigation) surface runoff. Therefore, the swales are not evaluated independent of the diversions.

This grantee collected samples during three dry weather events (October 12, 2012, February 25 and June 17, 2013), consistent with the goals in their Monitoring Plan (Figure 3.5-2). No samples were collected during wet weather because this was designed as a dry weather BMP and diversions are shut off during storms to prevent overwhelming the sanitary system. The three sampling events were preceded with at least 72 hours of no rainfall.

In total, there were the nine influent samples, three from each of the diversions at Aster, Jasmine, and Myrtle Streets. The reported pump volumes from each diversion was used to estimate daily dry weather flow (Table 3.5-2). The grantee measured 9 of the 24 parameters identified in this report for load reduction (Table 3.5-1).

Concentration and Load Reduction

Mean influent concentrations consistently ranged by a factor of two to three amongst the three diversion BMPs at Heisler Park (Table 3.5-3). For example, copper concentrations ranged from 61 µg/L at the Myrtle diversion to 180 µg/L at the Aster diversion. The primary exception was total PAH and total pyrethroid pesticide concentrations, which were uniformly non-detectable at all three BMPs. The Aster diversion had the greatest average concentration for six of the nine constituents. The Jasmine diversion consistently had the lowest concentrations of the three BMPs.

Since this BMP had no effluent (100% capture), the reduction of influent concentrations and resulting load reductions was assumed to be 100% (Table 3.5-4). Cumulatively, these BMPs removed an estimated 10.7 x 10^6 L of dry weather runoff, 330 kg of TSS, 91 kg of nitrate, and 1.0 kg of chromium from entering the Heisler Park ASBS during CY2013. The loads from Aster diversion were greater, at times substantially greater, than the other two diversions. For example, Aster diverted double the volume of the Jasmine BMP and triple the volume of the Myrtle BMP. Subsequently, Aster diverted double the nitrate load of the Jasmine BMP and triple the load of nitrate from the Myrtle BMP. Where Aster had greater influent concentrations than Jasmine or Myrtle, load reductions also increased. For example, Aster reduced the loads of zinc by a factor of six, and the loads of chromium by a factor of nine, relative to the Jasmine and Myrtle BMPs.

Figure 3.5-1. Map of the three dry weather diversions at Aster, Jasmine, and Myrtle streets in the Heisler Park ASBS. Shaded area represents the ASBS.

Figure 3.5-2. Photos of Heisler Park ASBS BMPs from top left in clockwise order; grassy swale for runoff irrigation, manhole to sanitary sewer diversion, bluff top view of the ASBS from Aster Street, and replanting with native plants.

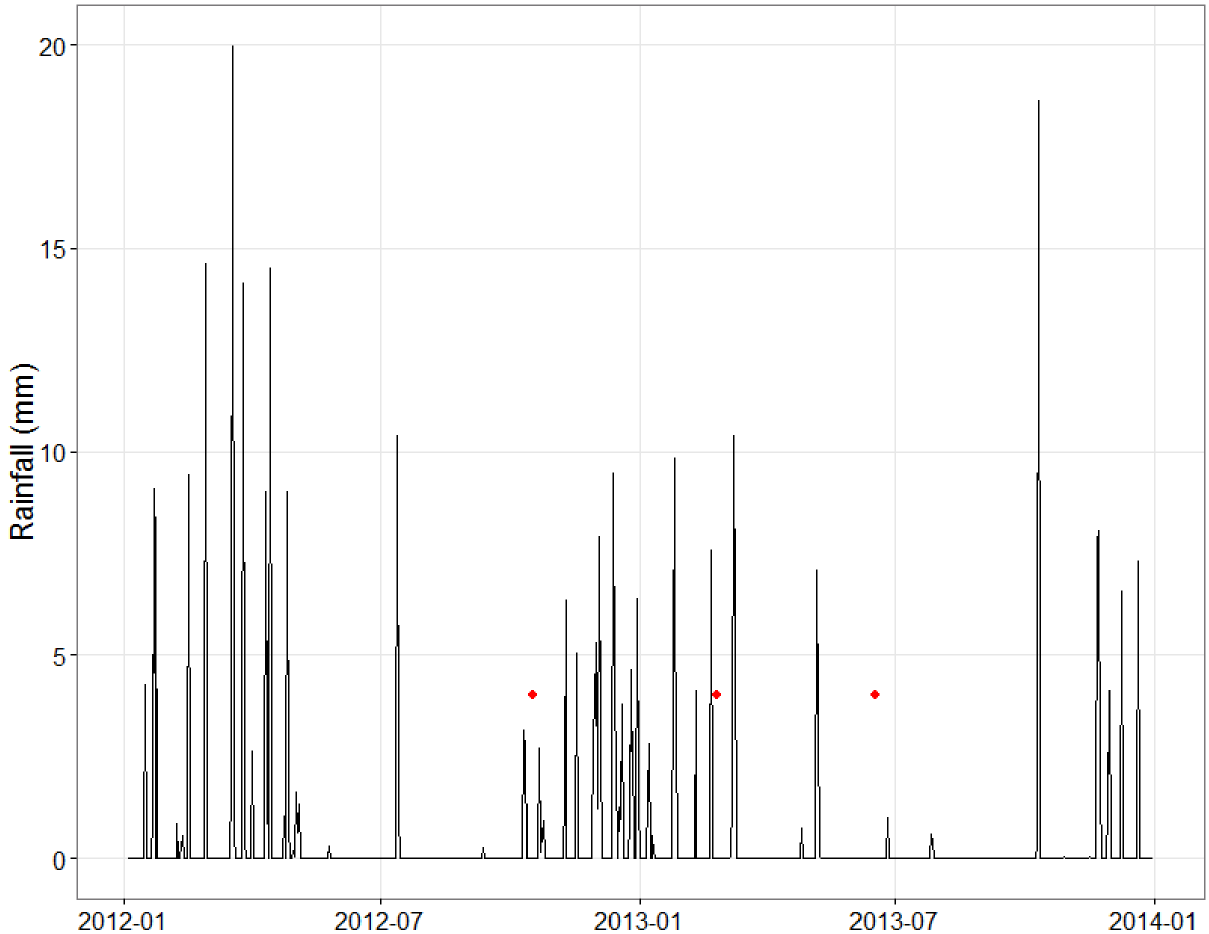

Figure 3.5-3. Daily rainfall at Heisler Park BMP January 1, 2013 through January 1, 2014. Red symbols indicate dry weather sampled events.

Table 3.5-1. Sample inventory for Heisler Park ASBS BMPs. Diversions were located at the foot of Aster, Jasmine and Myrtle Streets.

Parameter	Number of Wet Weather Samples	Number of Dry Weather Samples			Total Number of Samples
		Aster	Jasmine	Myrtle	
TSS	0	3	3	3	9
Turbidity	0	0	0	0	0
Oil and Grease	0	0	0	0	0
Nitrate	0	3	3	3	9
Ammonia	0	3	3	3	9
Ortho-P	0	3	3	3	9
Total P	0	0	0	0	0
Arsenic	0	3	3	3	9
Cadmium	0	3	3	3	9
Chromium	0	3	3	3	9
Copper	0	3	3	3	9
Mercury	0	3	3	3	9
Nickel	0	3	3	3	9
Lead	0	3	3	3	9
Selenium	0	3	3	3	9
Silver	0	3	3	3	9
Zinc	0	3	3	3	9
Total PAH	0	3	3	3	9
Total Pyrethroid	0	0	0	0	0
Total PBDE	0	0	0	0	0
Total DDT	0	0	0	0	0
Enterococcus	0	0	0	0	0
E. coli	0	3	3	3	9
Total Coliforms	0	0	0	0	0

Table 3.5-2. Reported average daily pump volumes from the three diversions.

Diversion	Volume (Average Daily Liters)
Myrtle	5564
Jasmine	8479
Aster	16693

Table 3.5-3. Influent and effluent concentrations at the three diversion BMPs at the Heisler Park ASBS. Average and 95% confidence intervals represent three sampling events on October 12, 2012, February 15 and June 17, 2013. There was no effluent discharged to the ASBS, so these diversions have a 100% concentration reduction.

Parameter	Units	Dry Weather Influent								Dry Weather Effluent	Concentration Reduction (%)
		Aster		Jasmine		Myrtle		Combined			
		Average	95% CI	Average	95% CI	Average	95% CI	Average	95% CI		
TSS	mg/L	48	10	25	21	20	8	31	11	0	100
Turbidity	NTU	-	-	-	-	-	-	-	-	-	-
Oil and Grease	mg/L	-	-	-	-	-	-	-	-	-	-
Nitrate	mg/L	7.70	3.74	5.40	2.43	12.40	5.90	8.50	2.94	0	100
Ammonia	mg/L	-	-	-	-	-	-	-	-	-	-
Ortho-P	mg/L	1.93	1.03	1.17	0.86	2.80	0.61	1.97	0.63	0	100
Total P	mg/L	-	-	-	-	-	-	-	-	-	-
Arsenic	µg/L	-	-	-	-	-	-	-	-	-	-
Cadmium	µg/L	-	-	-	-	-	-	-	-	-	-
Chromium	µg/L	43	85	7	7	4	8	18	28	0	100
Copper	µg/L	180	148	52	57	61	49	98	63	0	100
Mercury	µg/L	-	-	-	-	-	-	-	-	-	-
Nickel	µg/L	-	-	-	-	-	-	-	-	-	-
Lead	µg/L	-	-	-	-	-	-	-	-	-	-
Selenium	µg/L	-	-	-	-	-	-	-	-	-	-
Silver	µg/L	-	-	-	-	-	-	-	-	-	-
Zinc	µg/L	327	405	137	96	246	289	237	156	0	100
Total PAH	ng/L	0	0	0	0	0	0	0	0	0	-
Total Pyrethroid	ng/L	0	0	0	0	0	0	0	0	0	-
Total PBDE	ng/L	-	-	-	-	-	-	-	-	-	-
Total DDT	ng/L	-	-	-	-	-	-	-	-	-	-
Enterococcus	Log_{10} MPN/100mL	3.052	1.333	3.089	1.231	2.924	1.296	3.022	0.645	0	100
E. coli	Log_{10} MPN/100mL	3.050	0.592	2.800	0.619	2.992	0.945	2.947	0.375	0	100
Total Coliforms	Log_{10} MPN/100mL	4.145	0.952	3.996	1.022	3.970	0.932	4.037	0.488	0	100

Table 3.5-4. Load reductions for dry weather runoff at the Heisler Park ASBS.

Parameter	Units	Individual BMP Load Reduction			Combined BMP Load Reduction		Combined Load Reduction (%)
		Aster	Jasmine	Myrtle	Total	95% CI	
Volume	L x 10^6	5.81	2.95	1.94	10.70	2.27	100
TSS	kg	278.8	72.8	38.7	330.4	118.2	100
Turbidity	NTU	-	-	-	-	-	-
Oil and Grease	kg	-	-	-	-	-	-
Nitrate	kg	44.7	15.9	24.0	90.9	31.4	100
Ammonia	kg	-	-	-	-	-	-
Ortho-P	kg	11.2	3.4	5.4	21.0	6.7	100
Total P	kg	-	-	-	-	-	-
Arsenic	g	-	-	-	-	-	-
Cadmium	g	251.7	19.7	7.7	192.5	295.9	-
Chromium	g	1045.6	154.4	117.5	1044.7	669.8	100
Copper	g	-	-	-	-	-	100
Mercury	g	-	-	-	-	-	-
Nickel	g	-	-	-	-	-	-
Lead	g	-	-	-	-	-	-
Selenium	g	-	-	-	-	-	-
Silver	g	-	-	-	-	-	-
Zinc	g	1897.7	404.2	477.0	2531.4	1667.2	100
Total PAH	mg	0.0	0.0	0.0	0.0	0.0	-
Total Pyrethroid	mg	0.0	0.0	0.0	0.0	0.0	-
Total PBDE	mg	-	-	-	-	-	-
Total DDT	mg	-	-	-	-	-	-
Enterococcus	10^6 Log_{10} MPN	17.7	9.1	5.7	32.3	6.9	100
E. coli	10^6 Log_{10} MPN	17.7	8.3	5.8	31.5	4.0	100
Total Coliforms	10^6 Log_{10} MPN	24.1	11.8	7.7	43.2	5.2	100

3.6 Zuma Beach Septic Replacement

BMP Description

This project focused on reducing pollution to the Laguna Point to Latigo Point ASBS located in Ventura and Los Angeles Counties (Figure 3.6-1). The Laguna Point to Latigo Point ASBS is one of the largest ASBS in the state, covering approximately 48 km^2 and extending across nearly 40 km of coastline. This ASBS includes tide pools and kelp beds, and includes a Marine Conservation Area.

The Laguna Point to Latigo Point ASBS, is a well-used recreational area including both County and State Beaches for public access. Of these, perhaps the most heavily used is Zuma and Point Dume beaches, which attracts millions of beach-goers every year. With its plentiful parking, restrooms, playgrounds and volleyball courts, and snack bars, tens of thousands of visitors can be found here on a warm summer weekend. The Laguna Point to Latigo Point ASBS receives urban and commercial runoff from Los Angeles County, City of Malibu, and portions of the Point Mugu Naval Base.

Partly because of the heavy beach usage, the County proposed replacing 12 existing failing septic systems and leach fields at Zuma and Pt. Dume beaches. At each location, the County removed existing septic tanks and pumps, abandoned disposal leach fields, and then installed advanced treatment septic systems including pumps, tanks, telemetry monitoring systems, filter pods, and disposal fields.

Design, Sample Inventory and Flow Estimates

This BMP utilized a preconstruction-postconstruction monitoring design. The septic tank replacement occurred in 2012, so the design focused on measurements from 2011 compared to 2013. There were four unique study design elements for this BMP relative to the other BMPs in this report, necessitated by the type of BMP installed. The first unique study design element was its focus on receiving water as opposed to discharges. Because the discharge pre- and postconstruction was to a leach field, and the leach field was designed to reduce pollutant inputs to the ocean, a focus was placed on measuring reduced pollutant concentrations in the ocean. A second unique study design was a focus on bacteria. The discharge was from a public restroom, so bacteria is the primary pollutant of concern and other pollutants (e.g., trace metals or pesticides) were not examined. The third unique study design element was a focus on reductions in concentrations and water quality objective exceedances, as opposed to a focus on load reductions. Load could not be calculated based on measurements collected in the ocean, and it was assumed that toilet flushing was comparable among years. Water quality exceedance days were evaluated based on single samples for each day according to the California Department of Public Health single sample thresholds for *Enterococcus* (104 MPN/100 ml), fecal coliforms/*E. coli* (400 MPN/100 ml), and total coliforms (10,000 MPN/100 ml). A fourth study design focus was on dry weather during the swimming season (April 1 to October 31), because this is the time of greatest restroom use and potential for swimmer exposure.

The monitoring data was conducted by the Los Angeles County Department of Public Health as part of their ongoing public health monitoring network. There were three sites sampled weekly at Zuma Beach (Sites 007, 008, 008B) during the swimming season. There was a total of 172 samples: 86 samples in 2011 and 86 samples in 2013 (Table 3.6-1). The County Health Department measures three fecal indicator bacteria identified in this report for load reduction; *Enterococcus*, *E. coli* (reported for fecal coliforms), and total coliforms.

Concentration and Load Reduction

Geometric mean concentrations for all three fecal indicator bacteria at stations 007 and 008 declined from 2011 to 2013 (Table 3.6-2). However, only the geometric mean concentrations of total coliform were statistically significantly different between years representing preconstruction and postconstruction time periods. *Enterococcus* and *E. coli* geomean concentrations at station 008B increased from 2011 to 2013, although not significantly.

Similar to decreases in concentrations, exceedance days of water quality objectives also decreased at stations 007 and 008 from pre- to postconstruction time periods. For example, station 007 had five exceedance days for *Enterococcus* in 2011, but only one exceedance day in 2013. While there were very few exceedance days for total coliform in 2011, there was no exceedances of total coliform water quality objectives at any site in 2013.

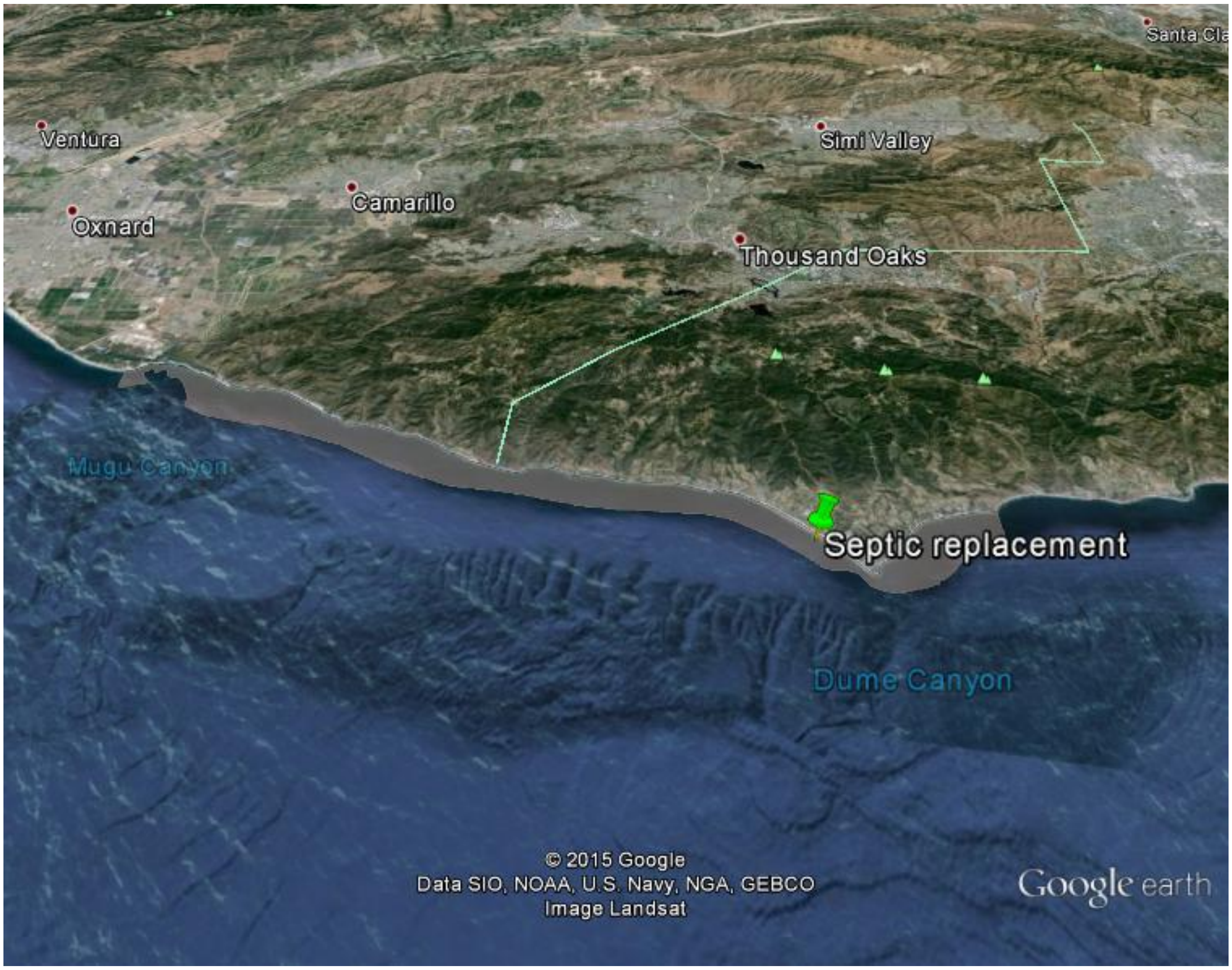

Figure 3.6-1. Map of the Zuma Beach restroom replacement BMP at the Laguna Point to Latigo Point ASBS. Shaded area represents the ASBS.

Figure 3.6-2. Photo of Zuma Beach restrooms. New leach field is in fenced area.

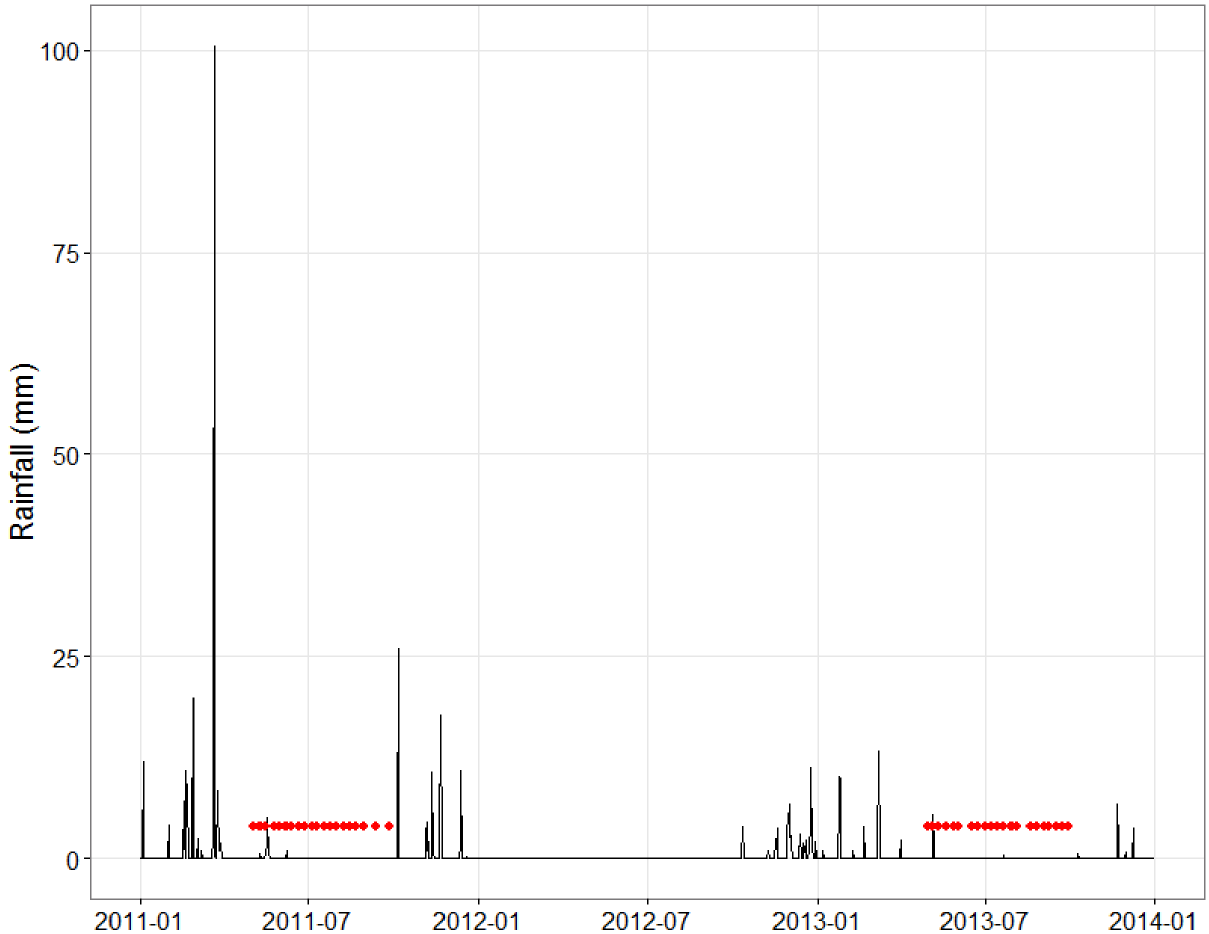

Figure 3.6-3. Daily rainfall at Zuma Beach BMP January 1, 2013 through January 1, 2014. Red symbols indicate dry weather sampled events.

Table 3.6-1. Zuma Beach BMP monitoring inventory.

Parameter	Number of Samples of 2011		Number of Samples of 2013		Total Number of Samples
	Dry Weather	Wet Weather	Dry Weather	Wet Weather	
TSS	0	0	0	0	0
Turbidity	0	0	0	0	0
Oil and Grease	0	0	0	0	0
Nitrate	0	0	0	0	0
Ammonia	0	0	0	0	0
Ortho-P	0	0	0	0	0
Total P	0	0	0	0	0
Arsenic	0	0	0	0	0
Cadmium	0	0	0	0	0
Chromium	0	0	0	0	0
Copper	0	0	0	0	0
Mercury	0	0	0	0	0
Nickel	0	0	0	0	0
Lead	0	0	0	0	0
Selenium	0	0	0	0	0
Silver	0	0	0	0	0
Zinc	0	0	0	0	0
Total PAH	0	0	0	0	0
Total Pyrethroid	0	0	0	0	0
Total PBDE	0	0	0	0	0
Total DDT	0	0	0	0	0
Enterococcus	0	86	0	86	172
E. coli	0	86	0	86	172
Total Coliforms	0	86	0	86	172

Table 3.6-2. Average fecal indicator bacteria concentrations at the beach preconstruction and postconstruction at Zuma Beach.

Parameter		Units	2011 Concentration (preconstruction)		Average 2013 Concentration (postconstruction)		P value
			Average	95% CI	Average	95% CI	
Enterococcus	DHS007	Log_{10} MPN/100mL	1.355	0.205	1.122	0.137	0.07
	DHS008	Log_{10} MPN/100mL	1.147	0.126	1.096	0.110	0.55
	DHS008B	Log_{10} MPN/100mL	1.063	0.074	1.169	0.203	0.35
E. coli	DHS007	Log_{10} MPN/100mL	1.420	0.239	1.168	0.139	0.08
	DHS008	Log_{10} MPN/100mL	1.125	0.127	1.085	0.109	0.64
	DHS008B	Log_{10} MPN/100mL	1.063	0.074	1.150	0.163	0.35
Total Coliforms	DHS007	Log_{10} MPN/100mL	1.678	0.380	1.245	0.164	**0.05**
	DHS008	Log_{10} MPN/100mL	1.640	0.402	1.256	0.163	0.09
	DHS008B	Log_{10} MPN/100mL	1.380	0.256	1.239	0.193	0.39

Table 3.6-3. Exceedance days of fecal indicator bacteria preconstruction compared to postconstruction at Zuma Beach.

Parameter	Site	Exceedence Days	
		2011 Swimming Season (preconstruction)	2013 Swimming Season (postconstruction)
Enterococcus	DHS007	5	1
	DHS008	1	1
	DHS008B	0	2
E. coli	DHS007	1	0
	DHS008	0	0
	DHS008B	0	1
Total Coliforms	DHS007	1	0
	DHS008	2	0
	DHS008B	0	0

3.7 James Fitzgerald Swale and Media Filter

BMP Description

This project focused on reducing pollutant inputs to the James V. Fitzgerald ASBS located in San Mateo County (Figure 3.7-1). The Fitzgerald ASBS, which covers approximately 2.1 km^2, extending along 9 km of coastline from Pillar Point to Montara Beach. The Fitzgerald ASBS includes unique underwater habitat, extensive tide pools in shale geological formations, and a harbor seal rookery. The Fitzgerald ASBS includes a Marine Park and is completely within the Monterey Bay National Marine Sanctuary.

The Fitzgerald ASBS drains the unincorporated communities of Montara Beach, Moss Beach, and Half Moon Bay. The ASBS also receives runoff from rural residential (i.e., horse properties) and agricultural land uses. The shoreline receives some visitation, particularly near the public access areas.

San Mateo County has a phased-implementation system for reducing pollutant inputs from Montara and Moss Beach communities to the Fitzgerald ASBS. The proposed Proposition 84 grant supported the Pilot Phase, consisting of constructing and monitoring four types of BMPs (Figure 3.7-2), then using this information for future decision-making about effective city-wide BMP selection and implementation. The first type of BMP was a vegetated swale, which is a linear channel with sides and bottom lined with native plants. The bottom of the swale included a subdrain with rock and gravel to promote filtration. Weirs throughout the length of the swale slows flow to enhance the natural treatment processes. The second BMP was a grassy swale, similar to the vegetated swale, but without an underdrain and planted with drought tolerant sod. The third BMP was a BioClean® flume filter, comprised of BioMediaGREEN® (a proprietary sorbent) to trap stormwater pollutants as runoff passes through it. The fourth BMP was a Stormwater Management StormFilter®, designed to remove sediments, nutrients, metals, and organic contaminants using a proprietary filter media composed of zeolite, perlite, and granular activated carbon. Although only one of each BMP type was monitored, 14 swales with underdrains, 3 swales without underdrains, 2 BioClean® filters, and one StormFilter® were installed. Therefore, the data from the monitored BMPs were extrapolated to the unmonitored BMPs assuming that BMPs of the same type had comparable effectiveness.

Design, Sample Inventory and Flow Estimates

These BMPs utilized an influent-effluent monitoring design. At each of the test sites, the influent was sampled at the inlet to the BMP and the effluent sampled at the exit of the BMP. Flow was only measured at the downstream (effluent) end of each BMP, so the grantee assumed that there was a negligible reduction in flow for any of the four BMPs during storm conditions.

The grantee collected samples during two wet weather events (March 5-6, 2012, and April 10-12, 2012), consistent with the goals in their Monitoring Plan (Figure 3.7-3). No samples were collected during dry weather. In total across both storms, there were 28 influent and effluent samples, with 22 collected at the swale BMPs and 6 at the filter BMPs. However, the grantee did not report individual data, so averaged data as reported by the grantee was used, resulting in a total of 8 data points (Table 3.7-1). The grantee used the rational model for estimating flow data for the sampled storm events (Table 3.7-2). The grantee measured 15 of the 24 parameters identified in this report for load reduction.

Concentration and Load Reduction

No single BMP had consistently greater influent concentrations than the other BMPs (Table 3.7-3). For example, the grassy swale had the greatest concentration of TSS, but the lowest concentration of copper amongst the four BMPs. In contrast, The StormFilter® had the greatest concentration of copper, but the lowest concentration of TSS amongst the four BMPs. The vegetated swale had the greatest concentration of lead, but the lowest concentration of nitrate amongst the four BMPs. Likewise, the BioClean® filter had the greatest concentration of nitrate, but the lowest concentration of *E. coli* amongst the four BMPs.

While influent concentrations were variable among the BMPs, the effluent concentrations were comparable, typically within a factor of two or three amongst BMPs (Table 3.7-3). Although the concentrations were relatively similar among BMPs, the BioClean® filter had the highest effluent concentrations for 11 of the 15 parameters. The primary exception was fecal indicator bacteria where the BioClean® filter had the lowest *Enterococcus* and *E. coli* effluent concentrations of all four BMPs.

Concentration reductions varied by BMP among the different parameter groups (Table 3.7-3). The grassy swale and BioClean® filter had the greatest concentration reductions for TSS. The grassy swale had the greatest concentration reductions for nutrients. The grassy swale had the greatest and most consistent effluent concentration reductions for trace metals. The grassy swale and BioClean® filter had the greatest concentration reductions for total PAH and total pyrethroids pesticides. None of the BMPs were effective at reducing bacterial concentrations.

The grantee did not measure flow at both influent and effluent monitoring locations assuming that there was no reduction in volume (Table 3.7-4). Although some infiltration likely occurs in the swales, particularly with underdrains, there was no data to support this calculation. Therefore, no volume reduction was allocated to these flow-through BMPs. Cumulatively, these BMPs removed an estimated 4,500 kg of TSS, 2.2 kg of nitrate, and 0.17 kg of copper from entering the Fitzgerald ASBS during CY2013.

The grassy swales reduced the greatest pollutant loads of any of the four BMPs for TSS, nitrate, PAHs, pyrethroids pesticides, and several metals (Table 3.7-4). At times, the grassy swale reductions represented the majority of the load reductions. For example, the grassy swale reduced TSS loads by 3,735 kg, comprising over 80% of the load from all BMPs combined. While substantially more volume was treated at the grassy swale compared to the media filters, it was less than the volume that was treated by the vegetated swales. The grassy swale's proficiency at load reductions owes to its load reduction efficiency, which was greater than 80% for TSS, total PAH, and pesticides, greater than 75% for nutrients, and between 35 and 85% for trace metals. While the vegetated swale and BioClean® filter did reduce loads, their efficiency was less than the grassy swale. The StormFilter® had the lowest load reduction efficiency of the four BMP types evaluated.

Figure 3.7-1. Map of the four types of BMPs in the Fitzgerald ASBS. Shaded area represents the ASBS.

Figure 3.7-2. Photos of the four Fitzgerald ASBS BMPs from top to bottom: BioClean® flume filter box (in grey, with effluent sampling); Stormwater Management StormFilter® (foreground opened, background closed); vegetated swale (ASBS in background); grassy swale.

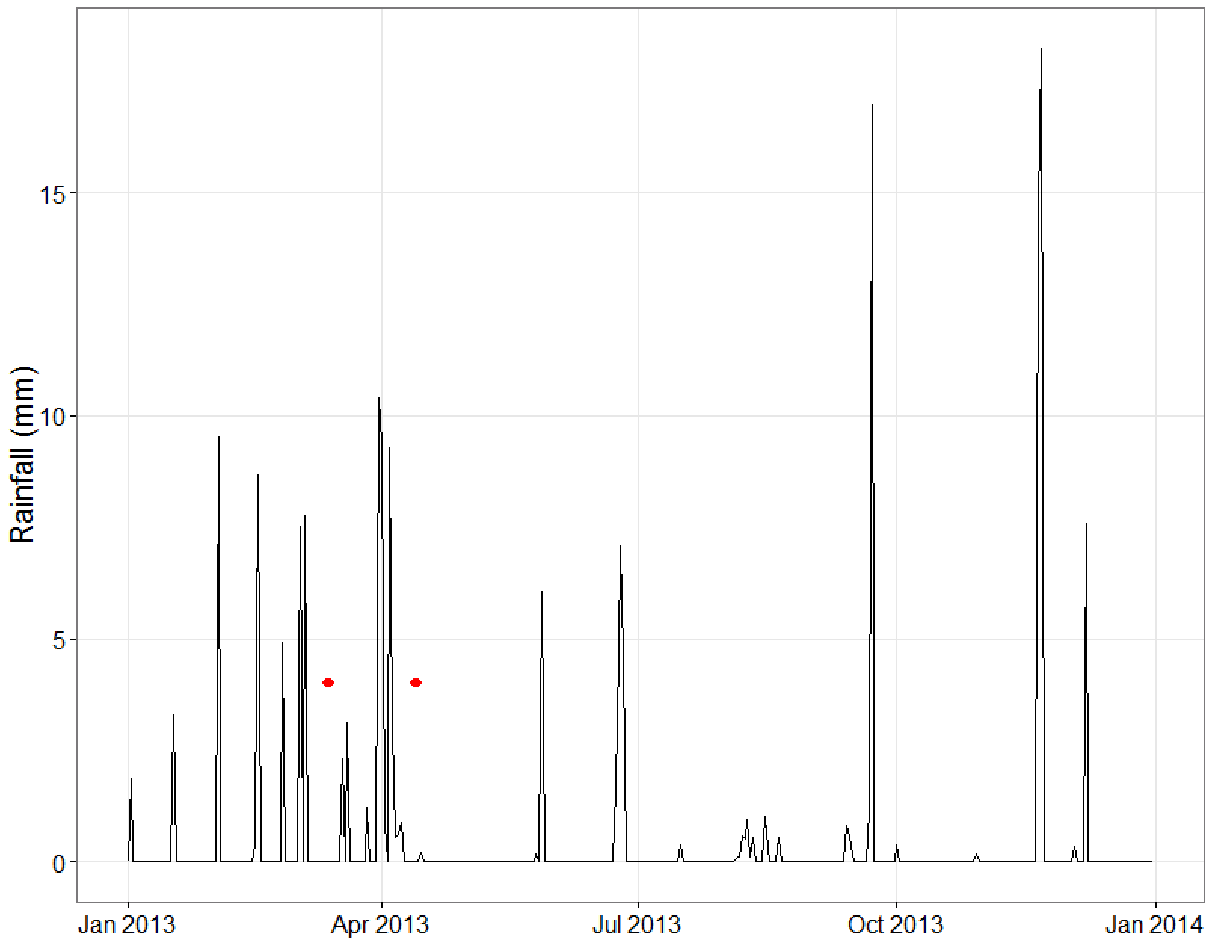

Figure 3.7-3. Daily PRISM rainfall at the Fitzgerald ASBS January 1, 2013 through January 1, 2014. Red symbols indicate sampling events.

Table 3.7-1. Fitzgerald BMP inventory. Only mean values were reported.

Parameter	Number of Wet Samples								Total Number Samples
	Grassy Swale		Vegetated Swale		StormFilter®		BioClean® filter		
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	
TSS	1	1	1	1	1	1	1	1	8
Turbidity	-	-	-	-	-	-	-	-	-
Oil and Grease	-	-	-	-	-	-	-	-	-
Nitrate	1	1	1	1	1	1	1	1	8
Ammonia	1	1	1	1	1	1	1	1	8
Ortho-P	-	-	-	-	-	-	-	-	-
Total P	-	-	-	-	-	-	-	-	-
Arsenic	-	-	-	-	-	-	-	-	-
Cadmium	1	1	1	1	1	1	1	1	8
Chromium	1	1	1	1	1	1	1	1	8
Copper	1	1	1	1	1	1	1	1	8
Mercury	-	-	-	-	-	-	-	-	-
Nickel	1	1	1	1	1	1	1	1	8
Lead	1	1	1	1	1	1	1	1	8
Selenium	1	1	1	1	1	1	1	1	8
Silver	-	-	-	-	-	-	-	-	-
Zinc	1	1	1	1	1	1	1	1	8
Total PAH	1	1	1	1	1	1	1	1	8
Total Pyrethroid	1	1	1	1	1	1	1	1	8
Total PBDE	-	-	-	-	-	-	-	-	-
Total DDT	-	-	-	-	-	-	-	-	-
Enterococcus	1	1	1	1	1	1	1	1	8
E. coli	1	1	1	1	1	1	1	1	8
Total Coliforms	1	1	1	1	1	1	1	1	8

Table 3.7-2. Rainfall to runoff volume translator for the four Fitzgerald ASBS BMPs.

Sample Dates	PRISM Storm Precipitation (mm)	Storm Runoff Volume (L)	Ratio (L/mm)
Grassy swale	30.1	341000	11329
Vegetated swale	30.1	164300	5458
StormFilter®	8.16	155000	18995
BioGreen®	30.1	3990	133

Table 3.7-3. Fitzgerald Chemistry results.

Parameter	Units	Grassy Swale BMP			Vegetative Swale BMP			StormFilter® BMP			BioClean® filter BMP		
		Influent	Effluent	%	Influent	Effluent	%	Influent	Effluent	%	Influent	Effluent	%
TSS	mg/L	650	71.9	88.9	118	74	37.3	100	76	24.0	340	88	74.1
Turbidity	NTU	-	-	-	-	-	-	-	-	-	-	-	-
Oil and Grease	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate	mg/L	0.24	0.058	75.8	0.095	0.027	71.6	0.2	0.2	0.0	0.33	0.19	42.4
Ammonia	mg/L	0.15	0.037	75.3	0.0077	0.0065	15.6	0.1	0.1	0.0	0.018	0.049	-172.2
Ortho-P	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Total P	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	µg/L	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	µg/L	0.12	0.04	66.7	0.096	0.039	59.4	0.11	0.07	36.4	0.14	0.08	42.9
Chromium	µg/L	2.41	0.96	60.2	2.51	2.52	-0.4	1.61	1.62	-0.6	3.45	2.32	32.8
Copper	µg/L	11.4	3.92	65.6	14.4	9.57	33.5	57.9	49.9	13.8	23.9	17.6	26.4
Mercury	µg/L	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	µg/L	6.99	2.71	61.2	3.13	2.94	6.1	5.4	5.66	-4.8	9.22	6.03	34.6
Lead	µg/L	2.65	0.62	76.6	4.56	3.05	33.1	1.81	1.91	-5.5	4.22	2.2	47.9
Selenium	µg/L	0.75	0.49	34.7	1.71	1.32	22.8	-	-	-	3.47	3.48	-0.3
Silver	µg/L	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	µg/L	61.3	9.46	84.6	32.1	11.6	63.9	47.2	41.3	12.5	95.2	66.6	30.0
Total PAH	ng/L	517	72	86.1	70.5	43.5	38.3	-	-	-	300	91.7	69.4
Total Pyrethroid	ng/L	77.2	5.8	92.5	0.5	0.4	20.0	4.9	2.3	53.1	3.6	0	100.0
Total PBDE	ng/L	-	-	-	-	-	-	-	-	-	-	-	-
Total DDT	ng/L	-	-	-	-	-	-	-	-	-	-	-	-
Enterococcus	Log_{10} MPN/100mL	3.370	4.095	-21.5	3.167	2.838	10.4	2.248	1.924	14.4	2.623	2.803	-6.8
E. coli	Log_{10} MPN/100mL	2.425	4.086	-68.5	2.646	2.509	5.2	1.875	1.716	8.5	1.176	1.556	-32.3
Total Coliforms	Log_{10} MPN/100mL	4.384	4.384	0.0	4.384	4.384	0.0	4.384	4.384	0.0	4.384	4.384	0.0

Table 3.7-4. Fitzgerald ASBS load reductions for CY2013.

Parameter	Units	Grassy Swale BMP				Vegetative Swale BMP				StormFilter® BMP			
		Influent	Effluent	Load Reduction	%	Influent	Effluent	Load Reduction	%	Influent	Effluent	Load Reduction	%
Volume	10^6 L	6.46	6.46	0.0	0.0	14.53	14.53	0.0	0.0	6.70	6.70	0.0	0.0
TSS	kg	4200.0	464.6	3735.4	88.9	1714.4	1075.1	639.3	37.3	670.2	509.4	160.9	24.0
Turbidity	NTU	-	-	-	-	-	-	-	-	-	-	-	-
Oil and Grease	kg	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate	kg	1.6	0.4	1.2	75.8	1.4	0.4	1.0	71.6	1.3	1.3	0.0	0.0
Ammonia	kg	1.0	0.2	0.7	75.3	0.1	0.1	0.0	15.6	0.7	0.7	0.0	0.0
Ortho-P	kg	-	-	-	-	-	-	-	-	-	-	-	-
Total P	kg	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	g	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	g	0.8	0.3	0.5	66.7	1.4	0.6	0.8	59.4	0.7	0.5	0.3	36.4
Chromium	g	15.6	6.2	9.4	60.2	36.5	36.6	-0.1	-0.4	10.8	10.9	-0.1	-0.6
Copper	g	73.7	25.3	48.3	65.6	209.2	139.0	70.2	33.5	388.1	334.4	53.6	13.8
Mercury	g	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	g	45.2	17.5	27.7	61.2	45.5	42.7	2.8	6.1	36.2	37.9	-1.7	-4.8
Lead	g	17.1	4.0	13.1	76.6	66.3	44.3	21.9	33.1	12.1	12.8	-0.7	-5.5
Selenium	g	4.8	3.2	1.7	34.7	24.8	19.2	5.7	22.8	0.0	0.0	0.0	
Silver	g	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	g	396.1	61.1	335.0	84.6	466.4	168.5	297.8	63.9	316.3	276.8	39.5	12.5
Total PAH	mg	3340.6	465.2	2875.4	86.1	1024.3	632.0	392.3	38.3	0.0	0.0	0.0	0.0
Total Pyrethroid	mg	498.8	37.5	461.4	92.5	7.3	5.8	1.5	20.0	32.8	15.4	17.4	53.1
Total PBDE	mg	-	-	-	-	-	-	-	-	-	-	-	-
Total DDT	mg	-	-	-	-	-	-	-	-	-	-	-	-
Enterococcus	Log_{10} MPN/100mL	21.8	26.5	-4.7	-21.5	46.0	41.2	4.8	10.4	15.1	12.9	2.2	14.4
E. coli	Log_{10} MPN/100mL	15.7	26.4	-10.7	-68.5	38.4	36.5	2.0	5.2	12.6	11.5	1.1	8.5
Total Coliforms	Log_{10} MPN/100mL	28.3	28.3	0.0	0.0	63.7	63.7	0.0	0.0	29.4	29.4	0.0	0.0

Table 3.7-4. Continued.

Parameter	Units	BioGreen® filter BMP				Combined			
		Influent	Effluent	Load Reduction	%	Influent	Effluent	Load Reduction	%
Volume	10^6 L	0.03	0.03	0.0	0.0	27.72	27.72	0.0	0.0
TSS	kg	8.57	2.22	6.4	74.1	6593.19	2051.30	4541.9	68.9
Turbidity	NTU	-	-	-	-	-	-	-	-
Oil and Grease	kg	-	-	-	-	-	-	-	-
Nitrate	kg	0.01	0.00	0.0	42.4	4.28	2.11	2.2	50.6
Ammonia	kg	0.00	0.00	0.0	-172.2	1.75	1.00	0.7	42.6
Ortho-P	kg	-	-	-	-	-	-	-	-
Total P	kg	-	-	-	-	-	-	-	-
Arsenic	g	-	-	-	-	-	-	-	-
Cadmium	g	0.00	0.00	0.0	42.9	2.91	1.30	1.6	55.5
Chromium	g	0.09	0.06	0.0	32.8	62.92	53.73	9.2	14.6
Copper	g	0.60	0.44	0.2	26.4	671.54	499.25	172.3	25.7
Mercury	g	-	-	-	-	-	-	-	-
Nickel	g	0.23	0.15	0.1	34.6	127.07	98.31	28.8	22.6
Lead	g	0.11	0.06	0.1	47.9	95.61	61.18	34.4	36.0
Selenium	g	0.09	0.09	0.0		29.78	22.43	7.3	24.7
Silver	g	-	-	-	-	-	-	-	-
Zinc	g	2.40	1.68	0.7	30.0	1181.21	508.14	673.1	57.0
Total PAH	mg	7.56	2.31	5.2	69.4	4372.46	1099.54	3272.9	74.9
Total Pyrethroid	mg	0.09	0.00	0.1	100.0	539.03	58.70	480.3	89.1
Total PBDE	mg	-	-	-	-	-	-	-	-
Total DDT	mg	-	-	-	-	-	-	-	-
Enterococcus	10^6 Log_{10} MPN	0.07	0.07	0.0	-6.8	82.93	80.66	2.3	2.7
E. coli	10^6 Log_{10} MPN	0.03	0.04	0.0	-32.3	66.71	74.40	-7.7	-11.5
Total Coliforms	10^6 Log_{10} MPN	0.11	0.11	0.0	0.0	121.51	121.51	0.0	0.0

3.8 La Jolla Diversion

BMP Description

This project focused on reducing pollution to the La Jolla ASBS located in San Diego County (Figure 3.8-1). The La Jolla ASBS, which covers approximately 1.8 km^2, stretches from La Jolla Shores to Point La Jolla, and includes a Marine Conservation Area. Habitats include tide pools, kelp beds, and the La Jolla caves, a popular destination for paddlers and divers.

The city of La Jolla, with a population exceeding 30,000, is composed largely of residential, commercial, and light industrial land use, as well as the University of California San Diego. In roughly 2 km, La Jolla rises steeply from sea level to a maximum elevation of 250 m. This series of small, steep watersheds transport dry weather runoff – assumed to be mostly excess irrigation – quickly to the La Jolla ASBS.

The proposed BMP for the La Jolla ASBS was to divert low flows from four of the watersheds through a trash screen and into the sanitary sewer for treatment (Figure 3.8-2). Each diversion is controlled electronically so that it will close during storm conditions and not overwhelm the sanitary system. However, the electronic controllers open the diversion during non-storm conditions and the BMP was designed to capture all of the dry weather flow.

Design, Sample Inventory and Flow Estimates

This BMP utilized an influent-effluent monitoring design for low flow. There were four influent sampling sites, one each for the four diversions. The sampling sites were located in enclosed space at the mouth of each diversion. There was no reported overflow, so this BMP was assumed to have 100% capture for dry weather. Since the diversion is closed during rainfall, no wet weather sampling was conducted.

This grantee collected samples during three dry weather events (July 16, July 22, and August 22, 2014), consistent with the goals in their Monitoring Plan. In total, there were 12 effluent samples at the La Jolla low flow diversion system (Table 3.8-1); three dry weather sampling events at each of the four diversions. The grantee measured 13 of the 24 parameters identified in this report for load reduction, including TSS, trace metals, and bacteria.

In order to estimate treated flow, the grantee installed a depth logger and v-notch weir in the stormdrain prior to the diversion. Continuous flow was estimated using a weir equation for the time period July 16 to August 22. It was assumed that all dry weather flow was diverted and treated. For load calculations, average daily low flow was applied to every day without rainfall. There were 348 days without rainfall at the La Jolla ASBS in CY2013.

Concentration and Load Reduction

The influent to Outfall 2 consistently had the greatest average concentrations of TSS and trace metals of the four outfalls (Table 3.8-2). For example, the TSS concentration at Outfall 2 was 98 mg/L, while the TSS concentrations at the other three outfalls ranged from 48 to 74 mg/L. The copper concentration at Outfall 2 was 492 µg/L, while the copper concentrations at the other three outfalls ranged from 13 to 77 µg/L. The large concentrations at Outfall 2 were the result of one highly concentrated sample (July 22, 2014), which also resulted in the relatively large confidence intervals compared to the other outfalls. The reasons for this elevated sample on July 22 is unknown. Additional sampling would be needed to know if this sample was a unique outlier. In contrast to TSS and trace metals, Outfall 12 consistently had the greatest concentrations of bacteria. For example, the *E. coli* concentration at Outfall 12 was 5.70 $\log_{10}$ MPN/100 ml, while the *E. coli* concentrations at the other three outfalls ranged from 3.46 to 5.35 $\log_{10}$ MPN/100 ml.

Since this BMP diverted all low flow influent (no surface discharge), the reduction of influent concentrations and resulting dry weather load reductions was assumed to be 100% (Table 3.8-3). This BMP removed an estimated 1.1 million L of dry weather runoff, 79 kg of TSS and 0.2 kg of copper from entering the La Jolla ASBS during CY2013. This BMP would have captured all of the low flows for CY2013 and, as a result, 100% of the dry weather load for all measured constituents would have been diverted from entering the La Jolla ASBS.

Figure 3.8-1. Map of the dry weather diversions at the La Jolla ASBS BMP. Shaded area represents the ASBS.

Figure 3.8-2. Photographs of low flow diversions at the La Jolla ASBS that directs dry weather storm drain flows to the sanitary sewer system.

Table 3.8-1. Sampling inventory for the La Jolla ASBS.

Parameter	Number of Wet Weather Samples	Number of Dry Weather Samples	Total Number of Samples
TSS	0	12	12
Turbidity	0	0	0
Oil and Grease	0	0	0
Nitrate	0	0	0
Ammonia	0	0	0
Ortho-P	0	0	0
Total P	0	0	0
Arsenic	0	12	12
Cadmium	0	12	12
Chromium	0	12	12
Copper	0	12	12
Mercury	0	0	0
Nickel	0	12	12
Lead	0	12	12
Selenium	0	12	12
Silver	0	12	12
Zinc	0	12	12
Total PAH	0	0	0
Total Pyrethroid	0	0	0
Total PBDE	0	0	0
Total DDT	0	0	0
Enterococcus	0	12	12
E. coli	0	12	12
Total Coliforms	0	12	12

Table 3.8-2. Chemistry results for the La Jolla Low Flow Diversions. Average and 95% confidence interval from three sampling events at each outfall diversion in the La Jolla ASBS.

Parameter	Units	Outfall 2		Outfall 11		Outfall 12		Outfall 13		Combined outfalls		Concentration
		Average	95% CI	Average	95% CI	Average	95% CI	Average	95% CI	Average	95% CI	Reduction (%)
TSS	mg/L	97.80	151.63	73.23	70.14	74.30	133.01	47.80	71.32	73.28	49.12	100
Turbidity	NTU	-	-	-	-	-	-	-	-	-	-	-
Oil & Grease	mg/L	-	-	-	-	-	-	-	-	-	-	-
Nitrate	mg/L	-	-	-	-	-	-	-	-	-	-	-
Ammonia	mg/L	-	-	-	-	-	-	-	-	-	-	-
Ortho-P	mg/L	-	-	-	-	-	-	-	-	-	-	-
Total P	mg/L	-	-	-	-	-	-	-	-	-	-	-
Arsenic	µg/L	3.86	0.97	3.10	1.69	3.59	0.53	2.60	0.74	3.29	0.54	100
Cadmium	µg/L	0.16	0.11	0.18	0.20	0.17	0.26	0.25	0.17	0.19	0.08	100
Chromium	µg/L	2.18	1.43	3.05	3.37	0.82	0.42	3.72	3.02	2.44	1.20	100
Copper	µg/L	491.49	865.46	76.77	104.37	12.82	7.79	38.25	29.52	154.83	218.99	100
Mercury	µg/L	-	-	-	-	-	-	-	-	-	-	-
Nickel	µg/L	10.60	8.44	6.63	6.99	3.23	2.33	6.14	2.83	6.65	2.91	100
Lead	µg/L	1.51	0.81	8.92	9.02	1.11	0.60	9.22	11.86	5.19	3.92	100
Selenium	µg/L	0.80	0.24	6.92	6.89	0.52	0.06	0.62	0.11	2.21	2.18	100
Silver	µg/L	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	100
Zinc	µg/L	71.30	31.08	204.61	286.08	47.35	46.34	128.98	145.99	113.06	78.19	100
Total PAH	ng/L	-	-	-	-	-	-	-	-	-	-	-
Total Pyrethroid	ng/L	-	-	-	-	-	-	-	-	-	-	-
Total PBDE	ng/L	-	-	-	-	-	-	-	-	-	-	-
Total DDT	ng/L	-	-	-	-	-	-	-	-	-	-	-
Enterococcus	Log_{10} MPN/100mL	3.76	0.27	3.88	0.35	3.94	0.47	3.42	0.14	3.749	0.184	100
E. coli	Log_{10} MPN/100mL	4.04	1.13	5.35	1.17	5.70	0.87	3.46	0.69	4.638	0.688	100
Total Coliforms	Log_{10} MPN/100mL	6.16	0.69	6.10	0.73	6.24	0.59	5.19	0.50	5.922	0.369	100

Table 3.8-3. Influent loads, effluent loads, and load reduction for the Kellogg Park BMP in the La Jolla ASBS.

Parameter	Units	Annual Influent Load		Annual Effluent Load		Annual Load Reduction		% Reduction
		Load	95% CI	Load	95% CI	Load	95% CI	
Volume	$Lx10^6$	1.08	0.28	-	-	1.08	0.28	100
TSS	kg	79.45	13.99	-	-	79.45	13.99	100
Turbidity	NTU	-	-	-	-	-	-	-
Oil and Grease	g	-	-	-	-	-	-	-
Nitrate	g	-	-	-	-	-	-	-
Ammonia	g	-	-	-	-	-	-	-
Ortho-P	g	-	-	-	-	-	-	-
Total P	g	-	-	-	-	-	-	-
Arsenic	g	3.57	0.15	-	-	3.57	0.15	100
Cadmium	g	0.21	0.02	-	-	0.21	0.02	100
Chromium	g	2.65	0.34	-	-	2.65	0.34	100
Copper	g	167.85	62.38	-	-	167.85	62.38	100
Mercury	g			-	-			-
Nickel	g	7.21	0.83	-	-	7.21	0.83	100
Lead	g	5.63	1.12	-	-	5.63	1.12	100
Selenium	g	2.40	0.62	-	-	2.40	0.62	100
Silver	g	0.00	0.00	-	-	0.00	0.00	100
Zinc	g	122.57	22.27	-	-	122.57	22.27	100
Total PAH	mg			-	-			-
Total Pyrethroid	mg			-	-			-
Total PBDE	mg			-	-			-
Total DDT	mg			-	-			-
Enterococcus	10^6 Log_{10} MPN	4.06	0.05	-	-	4.06	0.05	100
E. coli	10^6 Log_{10} MPN	5.03	0.20	-	-	5.03	0.20	100
Total Coliforms	10^6 Log_{10} MPN	6.42	0.11	-	-	6.42	0.11	100

3.9 Carmel Bay Diversion

BMP Description

This project focused on reducing pollution to the Carmel Bay ASBS located in Monterey County (Figure 3.9-1). The Carmel Bay ASBS, which covers approximately 6.3 km^2, stretches across Pebble Beach and the City of Carmel. This ASBS is part of the Monterey Bay National Marine Sanctuary and includes a Marine Conservation Area.

The Carmel Bay ASBS receives urban runoff from the City of Carmel and Pebble Beach with its world famous golf courses. The proposed BMP for the Carmel Bay ASBS was to divert low flows from up to 23 different outfalls, capturing 100% of the low flows during dry weather between April 1 and September 30. The gravity-fed diversions incorporated percolation beds to infiltrate the discharge prior to entering the ocean, or a bulkhead plate that retained the discharge until regularly scheduled pump-outs by Vactor truck (Figure 3.9-2). The diversions are removed prior to the rainy season to reduce flooding and allow wet weather flows to discharge.

Design, Sample Inventory and Flow Estimates

This BMP utilized an influent-effluent monitoring design for low flow. There were three influent sampling sites (Outfalls C1, C3, and C18), which incorporated varying sources and flows, and was assumed to be representative of all 23 outfalls Carmel was planning to divert. Because the diversions retained all discharge volume, and there was no reported overflows, this BMP was assumed to have 100% capture for low flows during dry weather between April 1 and September 30, 2013. Since the diversion is not implemented during rainfall, no wet weather sampling was conducted.

This grantee collected grab samples during three dry weather events (April 1, June 25, and September 17, 2011). In total, there were nine possible influent samples at the Carmel low flow diversion system (Table 3.9-1); three dry weather sampling events at each of the three representative outfalls. However, between four and six samples were collected, varying by parameter type, depending on flow at the time of sampling. The grantee measured 9 of the 24 parameters identified in this report for load reduction including TSS, trace metals, nutrients, and bacteria.

In order to estimate treated flow, the grantee made visual estimates of flow at each of the 23 outfalls during the three sampling events (Table 3.9-2). Average flows varied widely among outfalls, ranging from near zero to over 3,500 L/day. The combined daily flow was extrapolated to all dry weather days between April 1 and September 30, 2013, or 153 days. It was assumed that all dry weather flow was diverted and treated. For load calculations, the dry weather volume was applied to the average concentrations of the three representative outfalls.

Concentration and Load Reduction

No single outfall had the greatest average concentration for all pollutants (Table 3.9-2). All three outfalls had nondetectable concentrations of TSS. Amongst the three outfalls, Outfall C3 had the greatest average concentration of nutrients, Outfall C1 had the greatest average concentration of zinc, and Outfall C18 had the greatest average concentration of copper.

Because this BMP diverted all low flow influent (no surface discharge), the reduction of influent concentrations and resulting dry weather load reductions was assumed to be 100% (Tables 3.9-3 and 3.9-4). This BMP removed an estimated 6.7 million L of dry weather runoff 0.07 kg of copper and 0.17 kg of zinc from entering the Carmel Bay ASBS during CY2013. No TSS was removed because no sample had detectable levels of TSS. This BMP would have captured all of the low flows for CY2013 between April 1 and September 30, resulting in a 100% concentration and load reduction for all measured constituents.

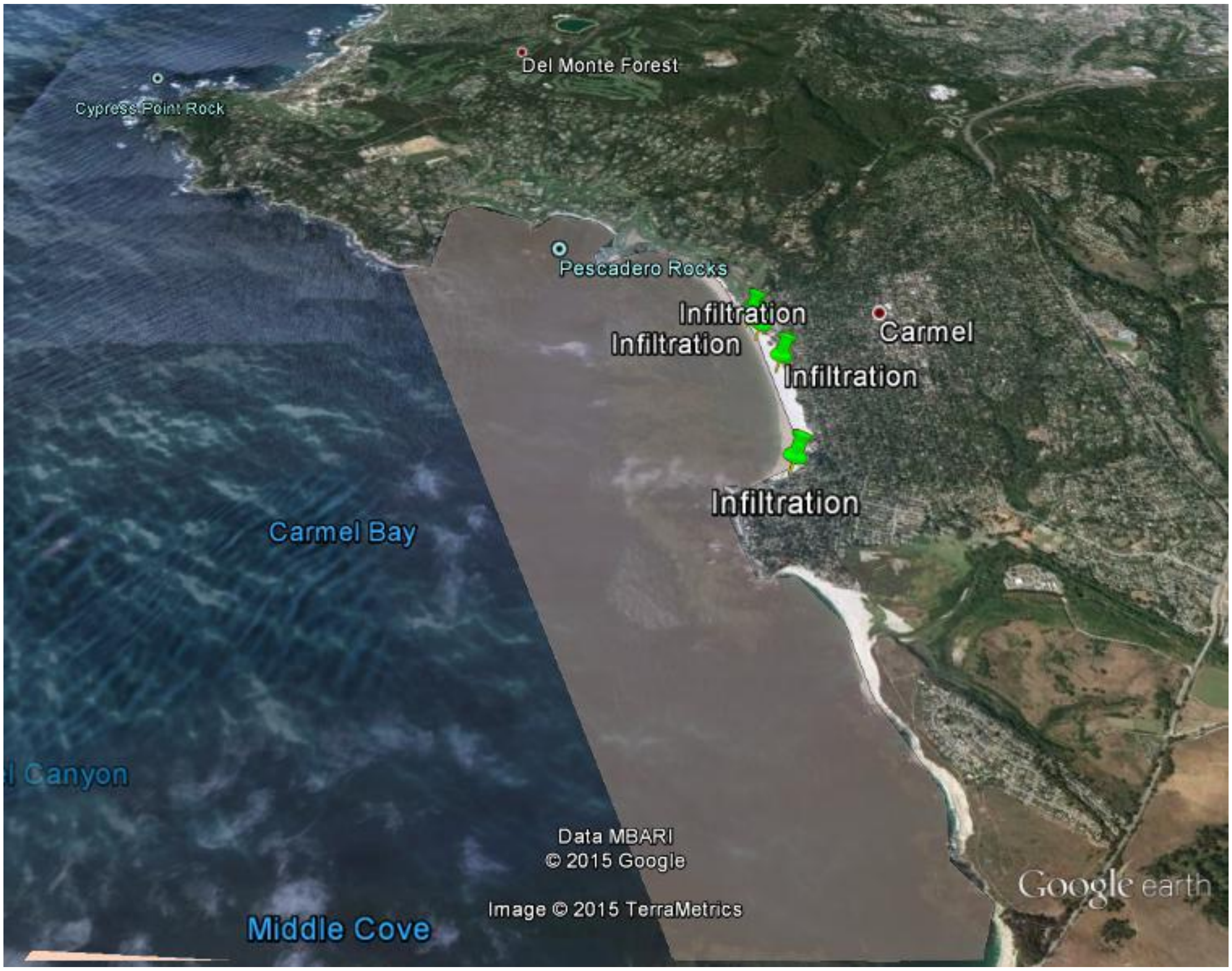

Figure 3.9-1. Map of Carmel ASBS. Shaded area represents the ASBS.

a)

b)

c)

d)

Figure 3.9-2. Photos of the Carmel Bay ASBS (a), installation of a manhole diversion (b), diversion plate inside of manhole (c), and construction of the percolation bed for the manhole diversion (d).

Table 3.9-1. Carmel diversion BMP sampling inventory. Samples were collected from three outfalls on three separate sampling events. Sample sizes less than nine indicate missing samples due to lack of flow.

Parameter	Number of Wet Weather Samples	Number of Dry Weather Samples	Total Number of Samples
TSS	0	5	5
Turbidity	0	0	0
Oil and Grease	0	0	0
Nitrate	0	6	6
Ammonia	0	0	0
Ortho-P	0	6	6
Total P	0	0	0
Arsenic	0	0	0
Cadmium	0	0	0
Chromium	0	0	0
Copper	0	6	6
Mercury	0	0	0
Nickel	0	0	0
Lead	0	6	6
Selenium	0	0	0
Silver	0	0	0
Zinc	0	6	6
Total PAH	0	0	0
Total Pyrethroid	0	0	0
Total PBDE	0	0	0
Total DDT	0	0	0
Enterococcus	0	6	6
E. coli	0	4	4
Total Coliforms	0	5	5

Table 3.9-2. Dry weather flow estimates for outfalls diverted from the Carmel ASBS. Assumes that flows are only diverted during dry days between May 1 to September 30, 2013, or 153 dry weather days.

Outfall No.	Average Daily Flow (L/day)
C-1	8.7
C-2	1658.3
C-3	4898.9
C-4	0.0
C-6	4.9
C-7	1.5
C-8	0.0
C-9	0.8
C-10	4.9
C-12	35721.0
C-13	3.4
C-14	8.7
C-17	0.0
C-18	2.6
C-19	18.9
C-20	0.0
C-21	0.0
C-24	1088.6
C-25	0.0
C-26	0.0
Combined Daily Flow (L/day)	**43,421.2**
2013 Dry Weather Volume (L x 10^6)	**6.66**

Table 3.9-3. Concentrations of pollutants from influent and effluent of Carmel Bay ASBS low flow diversions for CY2013.

Parameter	Units	Average Influent Concentration (N=3 per outfall)			Dry Season Concentration			Concentration Reduction (%)
		Outfall C1	Outfall C3	Outfall C18	Influent		Effluent	
					Avg.	95% CI		
TSS	mg/L	0	0	0	0.0	-	-	100
Turbidity	NTU	-	-	-	-	-	-	-
Oil and Grease	mg/L	-	-	-	-	-	-	-
Nitrate	mg/L	0.26	2.85	0	1.5	1.2	-	100
Ammonia	mg/L	-	-	-	-	-	-	-
Ortho-P	mg/L	0	0.48	0	0.2	0.5	-	100
Total P	mg/L	-	-	-	-	-	-	-
Arsenic	µg/L	-	-	-	-	-	-	-
Cadmium	µg/L	-	-	-	-	-	-	-
Chromium	µg/L	-	-	-	-	-	-	-
Copper	µg/L	10.5	6	28	11.2	6.9	-	100
Mercury	µg/L	-	-	-	-	-	-	-
Nickel	µg/L	-	-	-	-	-	-	-
Lead	µg/L	0	0	0	0.0	-	-	-
Selenium	µg/L	-	-	-	-	-	-	-
Silver	µg/L	-	-	-	-	-	-	-
Zinc	µg/L	57.5	13	0	25.7	31.5	-	100
Total PAH	ng/L	-	-	-	-	-	-	-
Total Pyrethroid	ng/L	-	-	-	-	-	-	-
Total PBDE	ng/L	-	-	-	-	-	-	-
Total DDT	ng/L	-	-	-	-	-	-	-
Enterococcus	Log_{10} MPN/100mL	0.00	2.62	2.24	1.7	1.1	-	100
E. coli	Log_{10} MPN/100mL	2.10	1.66	0.0	1.4	1.0	-	100
Total Coliforms	Log_{10} MPN/100mL	1.68	3.74	4.04	3.0	1.5	-	100

Table 3.9-4. Carmel Bay ASBS diversion load reductions for CY2013.

Parameter	Units	Load		Load Reduction	Reduction %
		Influent	Effluent		
Volume	10^6 L	6.66	0	6.66	100
TSS	kg	0	0	0.00	-
Turbidity	NTU	-	-	-	-
Oil and Grease	kg	-	-	-	-
Nitrate	kg	10.07	0	10.07	100
Ammonia	kg	-	-	-	-
Ortho-P	kg	1.60	0	1.60	100
Total P	kg	-	-	-	-
Arsenic	g	-	-	-	-
Cadmium	g	-	-	-	-
Chromium	g	-	-	-	-
Copper	g	74.38	0	74.38	100
Mercury	g	-	-	-	-
Nickel	g	-	-	-	-
Lead	g	0.00	0	0.00	-
Selenium	g	-	-	-	-
Silver	g	-	-	-	-
Zinc	g	170.97	0	170.97	100
Total PAH	mg	-	-	-	-
Total Pyrethroid	mg	-	-	-	-
Total PBDE	mg	-	-	-	-
Total DDT	mg	-	-	-	-
Enterococcus	10^6 Log_{10} MPN	11.19	0	11.19	100
E. coli	10^6 Log_{10} MPN	9.02	0	9.02	100
Total Coliforms	10^6 Log_{10} MPN	19.84	0	19.84	100

3.10 Duxbury Reef Infiltration and Swale

BMP Description

This project focused on reducing pollution to the Duxbury Reef ASBS located in Marin County (Figure 3.10-1). The Duxbury Reef ASBS, which covers approximately 3.5 km^2, extends across 5.6 km of coastline from Duxbury Point to the Arroyo Hondo Creek. This ASBS is part of the Gulf of the Farallones National Marine Sanctuary and includes a Marine Conservation Area.

The Duxbury Reef ASBS receives runoff from a rural residential area near the town of Bolinas in the southern portion of the ASBS, where much of the coastal access occurs. The BMP for the Duxbury Reef ASBS re-designed the parking lot at Agate Beach, a popular County Park. The parking lot was re-graded, porous pavement was installed to help infiltrate runoff, and then excess runoff was diverted to a vegetated swale adjacent to the parking lot for additional biotreatment (Figure 3.10-2).

Design, Sample Inventory and Flow Estimates

This BMP utilized a preconstruction-postconstruction monitoring design for storm flows. Re-grading of the parking lot, in addition to run-on from the adjacent residential street, complicated the monitoring design. The preconstruction site (STORM3) was collected from sheet flow near one end of the parking lot, while the postconstruction site (STORM2) was located at the terminus of the swale. For this BMP, it was assumed that there was no flow unless it was raining.

This grantee collected a total of four preconstruction samples during Water Year (WY)2012 and WY2013 and eight postconstruction samples during WY2014, for a total of 12 samples all collected during wet weather events (Table 3.10-1). The samples were a combination of grabs and composites, with mostly composite samples postconstruction. The grantee measured 17 of the 24 parameters identified in this report for load reduction including TSS, trace metals, nutrients, PAH, and bacteria.

In order to estimate treated volume, the grantee estimated depth using a level data logger in a stilling well, installed in the vegetated swale. Then, the grantee created a rating curve to translate depth to flow. The grantee noted challenges in estimating flow including software issues, run-on from the adjacent residential street, and changes in the swale cross section. Ultimately, one storm was used for creating the preconstruction rainfall to runoff volume translator and three storms were used for creating the postconstruction rainfall to runoff volume translator (Table 3.10-2). The translator was approximately 2.5 times greater preconstruction than postconstruction.

Concentration and Load Reduction

In general, TSS and turbidity were routinely detectable in the effluent from the Duxbury Reef parking lot BMP (Table 3.10-3). However, concentrations of other constituents in the effluent from the Duxbury Reef parking lot BMP were very low or non-detectable. For example, cadmium, copper, nickel, selenium, silver, and total PAH measurements were not detected. Only a single sample for oil and grease, chromium, lead, and zinc were detected either pre- or postconstruction.

Seven of the 15 parameters had reduced effluent concentrations from preconstruction to postconstruction (Table 3.10-3). These reductions ranged from 38% (chromium) to 100% (oil and grease, lead, zinc). Six parameters had no change, but that was because they were non-detectable both preconstruction and postconstruction. Two parameters increased in concentration from preconstruction to postconstruction, the largest being nitrate. Nitrate increased from essentially nondetectable to an average 7 mg/L. While there was some variation in nitrate concentration between storms postconstruction, every storm had detectable quantities of nitrate. The source of this nitrate is uncertain from the data collected, but the grantee suspects the source was the hydroseed mixture used to plant the swale.

This BMP removed an estimated 0.3 million L of wet weather runoff, 42 kg of TSS, and 0.1 kg of oil and grease from entering the Duxbury Reef ASBS during CY2013 (Table 3.10-4). Relatively small amounts of trace metals were removed because concentrations were so low preconstruction. There was a 1 kg increase in nitrate loading, despite the 58% reduction in volume, because of the large concentration increase for this nutrient.

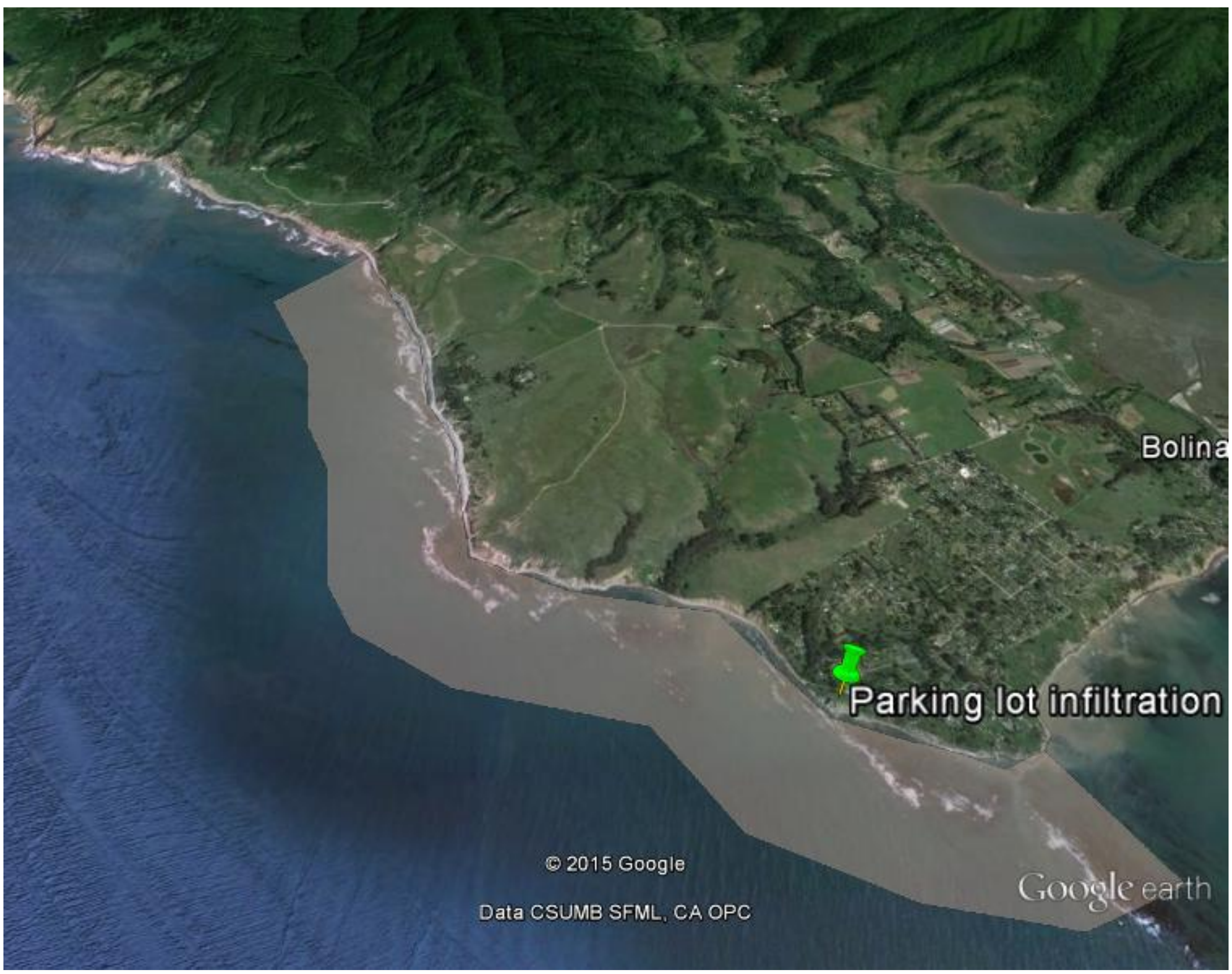

Figure 3.10-1. Map of Duxbury Reef ASBS parking lot infiltration and swale BMP. Te shaded area represents the ASBS.

Figure 3.10-2. Photos of the Duxbury Reef ASBS parking lot and swale at Agate Beach.

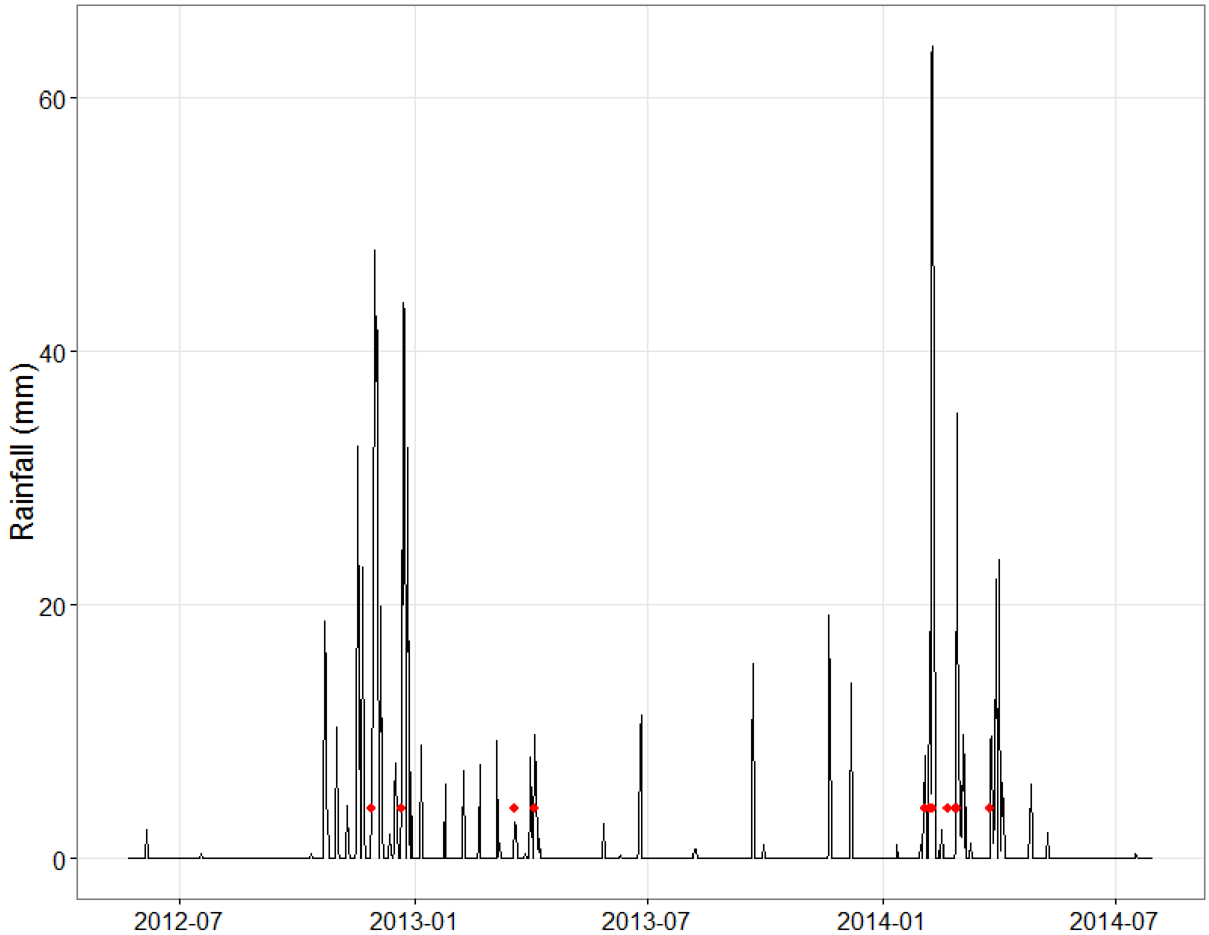

Figure 3.10-3. Daily rainfall at Duxbury Reef parking lot retrofit BMP January 1, 2013 through January 1, 2014. Red symbols indicate wet weather sampled events.

Table 3.10-1. Sample inventory for the Duxbury Reef parking lot retrofit project. There four sampling events for preconstruction and eight sampling events for postconstruction.

Parameter	Number of Wet Weather Samples	Number of Dry Weather Samples	Total Number of Samples
TSS	12	0	12
Turbidity	12	0	12
Oil and Grease	12	0	12
Nitrate	12	0	12
Ammonia	12	0	12
Ortho-P	0	0	0
Total P	0	0	0
Arsenic	12	0	12
Cadmium	12	0	12
Chromium	12	0	12
Copper	12	0	12
Mercury	12	0	12
Nickel	12	0	12
Lead	12	0	12
Selenium	12	0	12
Silver	12	0	12
Zinc	12	0	12
Total PAH	12	0	12
Total Pyrethroid	0	0	0
Total PBDE	0	0	0
Total DDT	0	0	0
Enterococcus	0	0	0
E. coli	1	0	1
Total Coliforms	1	0	1

Table 3.10-2. Rainfall to volume translator for the Duxbury Reef ASBS parking lot retrofit BMP.

	Storm Date	Volume (L)	Rainfall (mm)	Rainfall to Runoff Translator (L/mm)
Preconstruction	3/20/2013	7196	2.86	**2516.1**
Postconstruction	2/8/2024	50777	63.1	804.7
	2/9/2014	133871	64.1	2088.5
	2/28/2014	6177	20.2	305.8
			Average	**1066.3**
			95%CI	**1040.7**

Table 3.10-3. Average preconstruction and postconstruction concentrations, and concentration reduction at the Duxbury Reef parking lot BMP.

Parameter	Units	Preconstruction (WY 2012-13)		Postcontruction (WY 2014)		Concentration Reduction (%)
		Avg.	95% CI	Avg.	95% CI	
TSS	mg/L	103.6	93.7	22.6	16.5	78.2
Turbidity	NTU	75.1	48.8	11.5	3.9	84.7
Oil and Grease	mg/L	0.1	0.3	0.0	-	100.0
Nitrate	mg/L	0.0	0.1	7.1	2.9	-19656.9
Ammonia	mg/L	0.1	0.1	0.0	0.1	64.7
Ortho-P	mg/L	-	-	-	-	-
Total P	mg/L	-	-	-	-	-
Arsenic	µg/L	0.0	-	1.7	1.4	-100.0
Cadmium	µg/L	0.0	-	0.0	-	0.0
Chromium	µg/L	2.2	4.3	1.4	2.7	37.5
Copper	µg/L	0.0	-	0.0	-	0.0
Mercury	µg/L	-	-	-	-	-
Nickel	µg/L	0.0	-	0.0	-	0.0
Lead	µg/L	1.3	2.5	0.0	-	100.0
Selenium	µg/L	0.0	-	0.0	-	0.0
Silver	µg/L	0.0	-	0.0	-	0.0
Zinc	µg/L	16.4	32.1	0.0	-	100.0
Total PAH	ng/L	0.0	-	0.0	-	0.0
Total Pyrethroid	ng/L	-	-	-	-	-
Total PBDE	mg/L	-	-	-	-	-
Total DDT	mg/L	-	-	-	-	-
Enterococcus	Log_{10} MPN/100mL	-	-	-	-	-
E. coli	Log_{10} MPN/100mL	1.991	-	-	-	-
Total Coliforms	Log_{10} MPN/100mL	4.384	-	-	-	-

Table 3.10-4. Preconstruction and postconstruction loads for CY2013 and load reduction efficiency for the Duxbury Reef ASBS parking lot BMP.

Parameter	Units	Preconstruction		Postconstruction		Load Reduction	Reduction (%)
		Avg.	95%CI	Avg.	95%CI		
Voumel	10^6 L	0.446	-	0.189	0.186	0.257	57.6
TSS	kg	46.2	-	4.3	3.1	41.9	90.7
Turbidity	NTU	33.5	-	2.2	0.7	31.3	93.5
Oil and Grease	kg	0.1	-	0.0	-	0.1	100.0
Nitrate	kg	0.0	-	1.3	0.5	-1.3	-8273.0
Ammonia	kg	0.0	-	0.0	0.0	0.0	85.1
Ortho-P	kg	-	-	-	-	-	-
Total P	kg	-	-	-	-	-	-
Arsenic	g	0.0	-	0.3	0.3	-0.3	-100.0[a]
Cadmium	g	0.0	-	0.0	-	-	-
Chromium	g	1.0	-	0.3	0.5	0.7	73.5
Copper	g	0.0	-	0.0	-	-	-
Mercury	g	-	-	-	-		
Nickel	g	0.0	-	0.0	-	-	-
Lead	g	0.6	-	0.0	-	0.6	100.0
Selenium	g	0.0	-	0.0	-	-	-
Silver	g	0.0	-	0.0	-	-	-
Zinc	g	7.3	-	0.0	-	7.3	100.0
Total PAH	mg	0.0	-	0.0	-	-	-
Total Pyrethroid	mg	-	-	-	-	-	-
Total PBDE	mg	-	-	-	-	-	-
Total DDT	mg	-	-	-	-	-	-
Enterococcus	10^6 Log_{10} MPN	-	-	-	-	-	-
E. coli	10^6 Log_{10} MPN	-	-	-	-	-	-
Total Coliforms	10^6 Log_{10} MPN	-	-	-	-	-	-

[a] Increase of 100% estimated because influent was nondetectable.

4.0 SYNTHESIS OF RESULTS

4.1 Grantees Ability to Collect Data

Although 14 grantees were awarded Proposition 84 ASBS funds, only eight implemented their structural BMPs and collected monitoring data to evaluate their BMP's effectiveness. Lack of data was partly a delay in construction for at least half of the missing BMPs. The primary rationale for delayed construction included contractor selection, project redesign, and public process for plan approval. One grantee completed construction, but had not completed their wet weather monitoring. The rationale for this delay was partly a response to the statewide drought. The lack of data for the last two grantees was largely administrative. The first was a grantee that withdrew their proposal. The second grantee used their funds largely on public education, including a small demonstration project on private property, and wasn't designed as a full-scale load reduction BMP. Perhaps if replicated across many properties, this strategy could reduce loads, but no monitoring was conducted to test this hypothesis.

Part of the challenge for the grantees that did not provide data was the relatively short time frame for completing their scope of work. The standard length of a grant agreement is three years, which makes planning and design, construction, and monitoring difficult. This is particularly true if the monitoring is focused on wet weather, where sampling is seasonal. It does appear that grantees with more detailed project plans in their proposal were more capable of completing their work loads.

4.2 Summary of BMP Effectiveness

Proposition 84 ASBS grants cumulatively removed an estimated 250 to 300 million L of discharge volume in CY2013 for both wet and dry weather (Table 4.2-1). In addition, the Proposition 84 ASBS grants cumulatively removed an estimated 6,150 kg of suspended sediments. For context, the volume captured would roughly half-fill the Rose Bowl in Pasadena and require five Ford F-150 pick-up trucks to haul that much sediment. Finally, the Proposition 84 grants cumulatively removed nearly 20 kg of trace metals, with zinc, selenium, nickel and copper comprising over 85% of this load. Changes in loads for organic constituents, including PAHs and pyrethroids pesticides, were more modest because of a universally high frequency of non-detectable values in both influent and effluent.

The cumulative load reduction estimates in the previous paragraph do not include wet weather measurements from the Robert Badham treatment wetland because, while this BMP was the single most effective BMP for removing loads in dry weather, it was the single worst effective BMP for wet weather (Table 4.2-2). For dry weather, the treatment wetland removed 285 million L and nearly 650 kg of suspended sediments. Part of this success had to do with the subdrain design of the system, removing approximately two-thirds of the low flow volume and suspended solids content. The dry weather load reductions were also the result of the tremendously larger influent volumes it received. The low flow volumes at the Robert Badham treatment wetland, averaging over one million liters per day, were much larger than even the wet weather volumes from most other BMPs evaluated in this study. The large decrease in effectiveness for wet weather at the Robert Badham treatment wetland was a result of the system being overwhelmed with flood flows from its 4.8 km^2 (1,200 acre) catchment. Most other BMPs were collecting runoff from a parking lot, a small residential area comprised of a block or two, or a pier. Clearly, the Robert Badham treatment wetland BMP was undersized for wet weather. The runoff volume and loads of every parameter increased from influent to effluent during wet weather, indicating inputs of unmonitored flows that potentially contributed additional pollutants or generated instream erosion and remobilization.

The wet weather BMPs that had the lowest effluent concentrations were the full-capture devices, such as those at the La Jolla parking lot and the Trinidad Pier. Of the flow through systems, which can treat more volume than full-capture systems, swales had the lowest effluent concentrations followed closely by the proprietary filter BMPs (Table 4.2-3). For example, the TSS effluent concentrations ranged from 72 to 74 mg/L in the swales, and the proprietary filters ranged from 76 to 88 mg/L. The grassy swale had the lowest effluent concentrations of TSS and four of the six trace metals measured in common with the other wet weather flow through BMPs. In fact, concentration percent removal during wet weather averaged around 70% for the grassy swale, substantially better than the other BMPs evaluated in this study.

The dry weather BMPs that had the lowest effluent concentrations were the full-capture devices, such as those at the La Jolla and Heisler Park diversions (Table 4.2-3). The Robert Badham treatment wetland was the only flow-through BMP in dry weather evaluated during this study. The dry weather effluent TSS concentrations from the Robert Badham treatment wetland was an order of magnitude lower than the best performing BMP and two orders of magnitude lower than the effluent TSS at the Robert Badham treatment wetland during wet weather. The concentration reduction at the Robert Badham treatment wetland fluctuated wildly among constituents during dry weather. For example, the concentration of cadmium decreased by 63% after passing through the treatment wetland, but concentrations of arsenic and chromium increased by 63%. This once again suggests either unmonitored inputs such as resurfacing groundwater or additional stormdrains, or perhaps a source of these pollutants within the BMP. Despite the fluctuating effluent concentration reductions, load reductions were uniformly positive, averaging near 60%. Clearly, much of this dry weather reduction at the Robert Badham treatment wetland was due to reductions in flow.

The effluent concentrations from flow-through BMPs evaluated in this study were comparable to other flow-through BMPs installed in California (Figure 4.2-1). The effluent concentrations from other California BMPs were parsed from the International BMP database (Strecker et al. 2001; http://www.bmpdatabase.org/index.htm). Both the media filters and the treatment wetlands fell within the range of results from thousands of measurements taken around the state. This provides an independent check of performance to evaluate grant implementation success. The only exception was the Robert Badham treatment wetland. During wet weather, TSS effluent concentration from the Robert Badham treatment wetland were greater than the range observed from other California biotreatment BMPs. At the same time, TSS effluent concentration from the Robert Badham treatment wetland was lower than the range observed from other California biotreatment BMPs during dry weather. These results are consistent with the findings of this study, both in terms of effluent concentrations and load reductions, for the Robert Badham treatment wetland.

Pollutant reductions should continue as these BMPs function in future years. This provides additional value to the Proposition 84 investments, and likely increases load reductions substantially. However, every BMP evaluated in this study was essentially brand new, which means they were working at maximum efficiency. BMP performance wanes over time if not appropriately maintained. For example, storm filters need to be cleaned or replaced, infiltration basins need sediment removed and media replaced, biotreatment systems need thinning or replanting, and diversions need to be cleared of fouling debris such as trash or organic material. Because there is currently no monitoring specifically required to ensure maintenance occurs, and there is no sampling to quantify future pollutant reductions, estimates of pollutant reductions for out-years were not made.

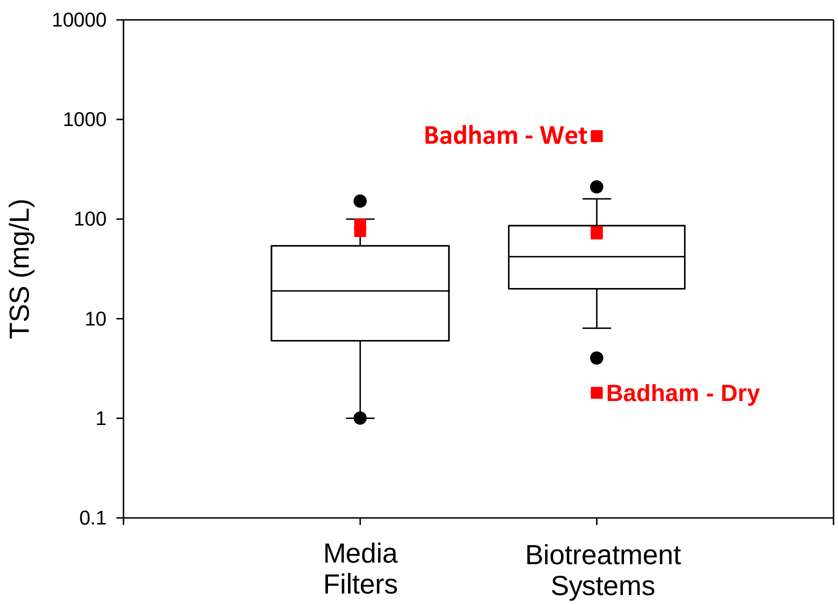

Figure 4.2-1. Comparison of the Proposition 84 ASBS flow-through BMPs with similar BMPs in California. Box plots indicate the 5, 25, 50, 75, and 95 percentiles of the distribution from California BMPs parsed the International BMP database. Red squares represent average effluent concentrations from the Proposition 84 ASBS BMPs. The Robert Badham treatment wetland – in dry vs wet weather - is labeled for identification.

Table 4.2-1. Summary of wet weather load reduction estimates for all Proposition 84 ASBS grants for CY2013.

Parameter	Units	Trinidad Pier Infiltration	Robert Badham Infiltration	Robert Badham Wetland	La Jolla Infiltration	Heisler Park Diversion	Fitzgerald Grassy Swale	Fitzgerlad Vegetated Swale	Fitzgerald StormFilter	Fitzgerald BioClean Filter	La Jolla Diversion	Carmel Diversion	Duxbury Infiltration + Swale	TOTAL ALL BMPS	TOTAL ALL BMP (less Badham)
WET WEATHER															
Volume	$Lx10^6$	0.8	0.5	-58.9	2.4	-	0.0	0.0	0.0	0.0	-	-	0.3	-55.0	3.6
TSS	kg	33.0	-	-78091.8	357.6	-	1245.1	45.7	80.4	6.4	-	-	41.9	-76281.8	1768.1
Turbidity	NTU	21.6	-	-2247.7	-	-	-	-	-	-	-	-	31.3	-2194.8	21.6
Oil & Grease	kg	-	-	-	-	-	-	-	-	-	-	-	0.1	0.1	0.0
Nitrate	kg	0.0	-	-	-	-	0.4	0.1	0.0	0.0	-	-	-1.3	-0.8	0.5
Ammonia	kg	6.0	-	-	-	-	0.2	0.0	0.0	0.0	-	-	0.0	6.2	6.2
Ortho-P	kg	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0
Total P	kg	0.8	-	-	-	-	-	-	-	-	-	-	-	0.8	0.8
Arsenic	g	5.0	1.4	-1438.9	21.3	-	-	-	-	-	-	-	-0.3	-1411.6	27.6
Cadmium	g	0.8	0.1	-2482.8	2.2	-	0.2	0.1	0.1	0.0	-	-	-	-2479.4	3.4
Chromium	g	2.3	0.6	-2716.8	47.3	-	3.1	0.0	0.0	0.0	-	-	0.7	-2663.5	53.3
Copper	g	339.7	34.8	-12984.9	525.5	-	16.1	5.0	26.8	0.2	-	-	-	-12036.8	948.1
Mercury	g	0.0	-	-	-	-					-	-		0.0	0.0
Nickel	g	4.7	0.7	-6157.8	29.3	-	9.2	0.2	-0.9	0.1	-	-	-	-6114.5	43.3
Lead	g	8.2	1.0	-1561.4	28.3	-	4.4	1.6	-0.3	0.1	-	-	0.6	-1517.5	43.3
Selenium	g	0.9	0.6	-1373.3	2.0	-	0.6	0.4	0.0	0.0	-	-	-	-1368.9	4.4
Silver	g	1.9	0.0	1.3	0.0	-	-	-	-	-	-	-	-	3.2	1.9
Zinc	g	155.3	-1.2	-11733.3	2349.3	-	111.7	21.3	19.8	0.7	-	-	7.3	-9076.4	2656.9
Total PAH	mg	0.1	-	-	-	-	958.5	28.0	0.0	5.2	-	-	-	991.8	991.8
Total Pyrethroid	mg	-	-	-56775.2	1485.4	-	153.8	0.1	8.7	0.1	-	-	-	-55127.1	1648.1
Total PBDE	mg	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0
Total DDT	mg	-	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0
Enterococcus	10^6 Log_{10} MPN	-	-	-375.9	-	-	-1.6	0.3	1.1	0.0	-	-	-	-376.1	-0.2
E. coli	10^6 Log_{10} MPN	-	-	-316.8	0.1	-	-3.6	0.1	0.5	0.0	-	-	-	-319.7	-2.9
Total Coliforms	10^6 Log_{10} MPN	-	-	-338.4	-	-	0.0	0.0	0.0	0.0	-	-	-	-338.4	0.0

Table 4.2-1. Continued.

Parameter	Units	Trinidad Pier Infiltration	Robert Badham Infiltration	Robert Badham Wetland	La Jolla Infiltration	Heisler Park Diversion	Fitzgerald Grassy Swale	Fitzgerlad Vegetated Swale	Fitzgerald StormFilter	Fitzgerald BioClean Filter	La Jolla Diversion	Carmel Diversion	Duxbury Infiltration + Swale	TOTAL ALL BMPS	
DRY WEATHER															
Volume	$Lx10^6$	-	-	285.4	-	10.7	-	-	-	-	1.1	6.7	-	303.8	
TSS	kg	-	-	648.9	-	330.4	-	-	-	-	79.5	0.0	-	1058.8	
Turbidity	NTU	-	-	-157.6	-	-	-	-	-	-	-	-	-	-157.6	
Oil and Grease	kg	-	-	-	-	-	-	-	-	-	-	-	-	0.0	
Nitrate	kg	-	-	-	-	90.9	-	-	-	-	-	10.1	-	101.0	
Ammonia	kg	-	-	-	-	-	-	-	-	-	-	-	-	0.0	
Ortho-P	kg	-	-	-	-	21.0	-	-	-	-	-	1.6	-	22.6	
Total P	kg	-	-	-	-	-	-	-	-	-	-	-	-	0.0	
Arsenic	g	-	-	215.7	-	-	-	-	-	-	3.6	-	-	219.3	
Cadmium	g	-	-	1064.9	-	192.5	-	-	-	-	0.2	-	-	1257.6	
Chromium	g	-	-	14.6	-	1044.7	-	-	-	-	2.7	-	-	1062.0	
Copper	g	-	-	604.0	-	-	-	-	-	-	167.9	74.4	-	846.2	
Mercury	g	-	-		-	-	-	-	-	-	-	-	-	0.0	
Nickel	g	-	-	3046.3	-	-	-	-	-	-	7.2	-	-	3053.5	
Lead	g	-	-	12.9	-	-	-	-	-	-	5.6	0.0	-	18.5	
Selenium	g	-	-	4677.4	-	-	-	-	-	-	2.4	-	-	4679.8	
Silver	g	-	-	0.0	-	-	-	-	-	-	0.0	-	-	0.0	
Zinc	g	-	-	1237.6	-	2531.4	-	-	-	-	122.6	171.0	-	4062.5	
Total PAH	mg	-	-	-	-	0.0	-	-	-	-	-	-	-	0.0	
Total Pyrethroid	mg	-	-	-2427.9	-	0.0	-	-	-	-	-	-	-	-2427.9	
Total PBDE	mg	-	-	-	-	-	-	-	-	-	-	-	-	0.0	
Total DDT	mg	-	-	-	-	-	-	-	-	-	-	-	-	0.0	
Enterococcus	10^6 Log_{10} MPN	-	-	985.6	-	32.3	-	-	-	-	4.1	11.2	-	1033.2	
E. coli	10^6 Log_{10} MPN	-	-	961.2	-	31.5	-	-	-	-	5.0	9.0	-	1006.8	
Total Coliforms	10^6 Log_{10} MPN	-	-	922.6	-	43.2	-	-	-	-	6.4	19.8	-	992.1	

Table 4.2-2. Wet and dry weather relative load reduction efficiencies for Prop 84 ASBS BMPs.

Parameter	Units	Trinidad Pier Infiltration	Robert Badham Infiltration	Robert Badham Wetland	La Jolla Infiltration	Heisler Park Diversion	Fitzgerald Grassy Swale	Fitzgerlad Vegetated Swale	Fitzgerald StormFilter	Fitzgerald BioClean Filter	La Jolla Diversion	Carmel Diversion	Duxbury Infiltration + Swale
WET WEATHER													
Volume	%	100	61.8	-94.2	82.4	-	0	0	0	0	-	-	57.6
TSS	%	100	-	-1716.1	82.4	-	88.9	37.3	24	74.1	-	-	90.7
Turbidity	%	100	-	-99.6	-	-	-	-	-	-	-	-	93.5
Oil and Grease	%	-	-	-	-	-	-	-	-	-	-	-	100.0
Nitrate	%	100	-	-	-	-	75.8	71.6	0	42.4	-	-	-8273.0
Ammonia	%	100	-	-	-	-	75.3	15.6	0	-172.2	-	-	85.1
Ortho-P	%	-	-	-	-	-	-	-	-	-	-	-	-
Total P	%	100	-	-	-	-	-	-	-	-	-	-	-
Arsenic	%	100	63.9	-785.6	82.4	-	-	-	-	-	-	-	-
Cadmium	%	100	60.2	-783.4	82.4	-	66.7	59.4	36.4	42.9	-	-	-
Chromium	%	100	62.7	-2324.2	82.4	-	60.2	-0.4	-0.6	32.8	-	-	73.5
Copper	%	100	70.7	-2524.1	82.4	-	65.6	33.5	13.8	26.4	-	-	-
Mercury	%	100	-			-					-	-	
Nickel	%	100	73	-321.6	82.4	-	61.2	6.1	-4.8	34.6	-	-	-
Lead	%	100	59.5	-324	82.4	-	76.6	33.1	-5.5	47.9	-	-	100.0
Selenium	%	100	56.7	-329.9	82.4	-	34.7	22.8			-	-	-
Silver	%	100	0	100	82.4	-					-	-	-
Zinc	%	100	-3.9	-27.5	82.4	-	84.6	63.9	12.5	30	-	-	100.0
Total PAH	%	100	-			-	86.1	38.3	0	69.4	-	-	-
Total Pyrethroid	%	-	-	-277.6	82.4	-	92.5	20	53.1	100	-	-	-
Total PBDE	%	-	-	-		-	-	-			-	-	-
Total DDT	%	-	-	-		-	-	-			-	-	-
Enterococcus	%	-	-	-145		-	-21.5	10.4	14.4	-6.8	-	-	-
E. coli	%	-	-	-125.4	82.4	-	-68.5	5.2	8.5	-32.3	-	-	-
Total Coliforms	%	-	-	-119.8		-	0	0	0	0	-	-	-
DRY WEATHER													
Volume	%	-	-	63.3	-	100	-	-	-	-	100	100	-
TSS	%	-	-	68.6	-	100	-	-	-	-	100	100	-
Turbidity	%	-	-	-174.9	-	-	-	-	-	-	-	-	-
Oil and Grease	%	-	-		-	-	-	-	-	-	-	-	-
Nitrate	%	-	-		-	100	-	-	-	-	-	100	-
Ammonia	%	-	-		-	-	-	-	-	-	-	-	-
Ortho-P	%	-	-		-	100	-	-	-	-	-	100	-
Total P	%	-	-		-	-	-	-	-	-	-	-	-
Arsenic	%	-	-	40.2	-	-	-	-	-	-	100	-	-
Cadmium	%	-	-	86.6	-	-	-	-	-	-	100	-	-
Chromium	%	-	-	40.4	-	100	-	-	-	-	100	-	-
Copper	%	-	-	68.4	-	100	-	-	-	-	100	100	-
Mercury	%	-	-		-	-	-	-	-	-	-	-	-
Nickel	%	-	-	71.7	-	-	-	-	-	-	100	-	-
Lead	%	-	-	49.4	-	-	-	-	-	-	100	100	-
Selenium	%	-	-	67.9	-	-	-	-	-	-	100	-	-
Silver	%	-	-	0	-	-	-	-	-	-	100	-	-
Zinc	%	-	-	53.1	-	100	-	-	-	-	100	100	-
Total PAH	%	-	-		-	-	-	-	-	-	-	-	-
Total Pyrethroid	%	-	-	NC	-	-	-	-	-	-	-	-	-
Total PBDE	%	-	-		-	-	-	-	-	-	-	-	-
Total DDT	%	-	-		-	-	-	-	-	-	-	-	-
Enterococcus	%	-	-	67.7	-	100	-	-	-	-	100	100	-
E. coli	%	-	-	70.1	-	100	-	-	-	-	100	100	-
Total Coliforms	%	-	-	53.3	-	100	-	-	-	-	100	100	-

Table 4.2-3. Wet and dry weather effluent concentrations from Proposition 84 ASBS BMPs.

Parameter	Units	Trinidad Pier Infiltration	Robert Badham Infiltration	Robert Badham Wetland	La Jolla Infiltration	Heisler Park Diversion	Fitzgerald Grassy Swale	Fitzgerlad Vegetated Swale	Fitzgerald StormFilter	Fitzgerald BioClean Filter	La Jolla Diversion	Carmel Diversion	Duxbury Infiltration + Swale
WET WEATHER													
TSS	mg/L	0	-	681	0	-	71.9	74	76	88	-	-	23
Turbidity	NTU	0	-	37.1	-	-	-	-	-	-	-	-	11.5
Oil & Grease	mg/L		-	-	-	-	-	-	-	-	-	-	0.0
Nitrate	mg/L	0	-	-	-	-	0.058	0.027	0.2	0.19	-	-	7.113
Ammonia	mg/L	0	-	-	-	-	0.037	0.0065	0.1	0.049	-	-	0.028
Ortho-P	mg/L		-	-	-	-	-	-	-	-	-	-	-
Total P	mg/L	0	-	-	-	-	-	-	-	-	-	-	-
Arsenic	µg/L	0	2.79	13.36	0	-	-	-	-	-	-	-	1.7
Cadmium	µg/L	0	0.116	23.06	0	-	0.04	0.039	0.07	0.08	-	-	0.0
Chromium	µg/L	0	1.24	23.34	0	-	0.96	2.52	1.62	2.32	-	-	1.4
Copper	µg/L	0	50.9	111.19	0	-	3.92	9.57	49.9	17.6	-	-	0.0
Mercury	µg/L	0	-	-	-	-	-	-	-	-	-	-	-
Nickel	µg/L	0	0.87	66.49	0	-	2.71	2.94	5.66	6.03	-	-	0.0
Lead	µg/L	0	2.43	16.83	0	-	0.62	3.05	1.91	2.2	-	-	0.0
Selenium	µg/L	0	1.49	14.74	0	-	0.49	1.32	-	3.48	-	-	0.0
Silver	µg/L	0	0	0	0	-	-	-	-	-	-	-	0.0
Zinc	µg/L	0	111.49	447.48	0	-	9.46	11.6	41.3	66.6	-	-	0.0
Total PAH	ng/L	0	-		-	-	72	43.5	-	91.7	-	-	0.0
Total Pyrethroid	ng/L		-	636.1	0	-	5.8	0.4	2.3	0	-	-	-
Total PBDE	ng/L		-		-	-	-	-	-	-	-	-	-
Total DDT	ng/L		-		-	-	-	-	-	-	-	-	-
Enterococcus	Log_{10} MPN/100mL		-	5.23	-	-	4.095	2.838	1.924	2.803	-	-	-
E. coli	Log_{10} MPN/100mL		-	4.69	0	-	4.086	2.509	1.716	1.556	-	-	-
Total Coliforms	Log_{10} MPN/100mL		-	5.11	-	-	4.384	4.384	4.384	4.384	-	-	-
DRY WEATHER													
TSS	mg/L	-	-	1.8	-	0	-	-	-	-	0	0	-
Turbidity	NTU	-	-	1.5	-	-	-	-	-	-	-	-	-
Oil & Grease	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate	mg/L	-	-	-	-	0	-	-	-	-	-	0	-
Ammonia	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Ortho-P	mg/L	-	-	-	-	0	-	-	-	-	-	0	-
Total P	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	µg/L	-	-	1.94	-	-	-	-	-	-	0	-	-
Cadmium	µg/L	-	-	1	-	-	-	-	-	-	0	-	-
Chromium	µg/L	-	-	0.13	-	0	-	-	-	-	0	-	-
Copper	µg/L	-	-	1.69	-	0	-	-	-	-	0	0	-
Mercury	µg/L	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	µg/L	-	-	7.28	-	-	-	-	-	-	0	-	-
Lead	µg/L	-	-	0.08	-	-	-	-	-	-	0	0	-
Selenium	µg/L	-	-	13.39	-	-	-	-	-	-	0	-	-
Silver	µg/L	-	-	0	-	-	-	-	-	-	0	-	-
Zinc	µg/L	-	-	6.61	-	0	-	-	-	-	0	0	-
Total PAH	ng/L	-	-	-	-	0	-	-	-	-	-	-	-
Total Pyrethroid	ng/L	-	-	14.7	-	0	-	-	-	-	-	-	-
Total PBDE	ng/L	-	-	-	-	-	-	-	-	-	-	-	-
Total DDT	ng/L	-	-	-	-	-	-	-	-	-	-	-	-
Enterococcus	Log_{10} MPN/100mL	-	-	2.85	-	0	-	-	-	-	0	0	-
E. coli	Log_{10} MPN/100mL	-	-	2.48	-	0	-	-	-	-	0	0	-
Total Coliforms	Log_{10} MPN/100mL	-	-	4.9	-	0	-	-	-	-	0	0	-

4.3 Limitations to Study Conclusions

There are quite a number of limitations to the results identified in this report. The limitations revolve largely around the assumptions necessary for consolidating the site-specific grantee monitoring data and making regionwide comparisons. The limitations fall into two major categories. The first category is assumptions required for flow data. Not a single grantee measured flow for the entire index period of CY2013. Therefore, it was necessary to estimate flow data by utilizing PRISM-modeled rainfall instead of local rainfall and creating rainfall-runoff volume ratios; these assumptions had several sources of error in addition to measurement error from the flow monitoring itself.

The second category of error is sample size for assessing effluent concentrations and reduction efficiencies. No grantee measured more than three storms or dry weather events, and several measured only a single event. We then extrapolated this limited data to an entire year. The data submitted by the grantees indicated that storm to storm variability in water quality can be extreme with influent concentrations ranging an order of magnitude or more.

4.4 Conclusions and Recommendations

The goal of this project was to address the question: What is the reduction in pollutant loads to ASBS as a result of the Proposition 84 grant program? This study was able to answer this question and provide the following conclusions and recommendation:

- **Of the 14 grants awarded, only eight grantees successfully completed their construction and monitoring requirements.**

  The primary reasons for lack of success included delays in engineering design and challenges selecting contractors. Grantees that already had well-developed engineering designs and processes, and those who had experience with monitoring, were best able to accomplish their grant requirements. The SWRCB should require this information when reviewing future grants.

- **In general, full-capture BMPs were the most effective, consistently reducing discharge volumes and pollutant loads by 100%.**

  Full-capture BMPs include diversions either to the sanitary sewer or for infiltration. Full-capture BMPs also best comply with the ASBS narrative requirements for “no discharge of waste”. However, full-capture BMPs are generally small because full-capture of large volumes is much more difficult. Annual volumes for full-capture devices in this study ranged from 0.5 – 6.7 million L for CY2013. The SWRCB can use this guidance when examining proposals for small volume discharges.

- **Of the flow-through BMPs, grassy swales had the greatest load reduction efficiency for wet and dry weather.**

  Grassy swales in this study had the lowest effluent concentrations for most constituents and the greatest load reduction efficiencies (averaging 70 - 80%) for larger volumes that occur during wet weather. The grantee that installed this BMP used them in a distributed fashion, spread throughout their watershed. Based on these results, and the ease of construction, the SWRCB might prioritize grantees that propose this technology.

- **BMP sizing is critically important for successful grantee implementation.**

  One grantee installed a large flow-through biotreatment wetland system at the end of their watershed. This BMP was exceptionally effective during dry weather low flows, outperforming swales and reducing volumes and loads more than any other BMP during dry weather. However, this BMP was dramatically overwhelmed during wet weather and provided no benefit during storm conditions. The SWRCB should be reviewing BMP sizing goals and designs as part of their contract milestones.

- **Although the Proposition 84 BMPs will continue to provide load reduction potential in future years, estimates of these future pollutant load reductions were not estimated in this report.**

  The BMPs we evaluated in this study were brand new and operating at maximum design efficiency. However, BMPs require ongoing maintenance to be effective at reducing loads. Although each grantee is obligated to maintain their BMP, the current grants do not require maintenance reporting or ongoing discharge monitoring of BMPs. The SWRCB should consider mechanisms to ensure ongoing BMP operations and maintenance in order to optimize pollutant reductions for years to come.

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